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An analysis of international, national and local literature and the formulation of criteria, for the development of holistic sustainable Arctic coastal infrastructure.

Master's thesis

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Abstract

Rapid change in the Arctic social-ecological system is both negatively impacting existing built infrastructure and increasing interest for its further development. Fuelled by expanding industries and unique sensitivities, the Arctic is seen to stand at a balance point between holistic sustainable development, and development detrimental to both the Arctic and the wider world. As such, there is a need for guidance on how built infrastructure should be developed, which raises the research question: What is holistic sustainable Arctic coastal infrastructure, and how can it be achieved in future developments?

A desk top review, along with surveys and interviews of built infrastructure professionals have been used to consider the current literature defined direction of Arctic development, along with the limits and gaps of that literature. Through this process it is concluded that there is a significant need for increased knowledge transfer and guidance for decision makers at all levels across the Arctic. There is a particular lack of knowledge within the coastal zones.

A general and Arctic review of the historical and current understanding of sustainable development is undertaken, and indicators of sustainability and development determined. It is recognised that Arctic development is currently humancentric, and a new sustainable development model is envisaged. It is identified that built infrastructure is a key link between humanity and nature, and that the role of built infrastructure is to achieve an existence within ecological limits, thus prioritisation of mitigating the worldly limiting problems over tackling worldly growth problems.

It is concluded that holistic sustainable Arctic coastal infrastructure development is infrastructure in the coastal zone that pursues well-being through seeking harmony with nature and the reduction of inequality. Built infrastructure can in the future be developed through the assessment of a set of common considerations within a decision-making framework based on a holistic sustainable development model, all established herein.

Abstract

Hurtige endringer i det arktiske sosialøkologiske system påvirker eksisterende bygd infrastruktur i en negativ grad, i tillegg til å øke interessen for dens videre utvikling. Grunnet ekspanderende næringer, samt Arktis' ømfintlige økosystem, står Arktis på et balansepunkt mellom bærekraftig utvikling og utvikling som er skadelig for både Arktis og resten av verden. Det er derfor et behov for veiledning om hvordan bygd infrastruktur bør utvikles, som igjen gir opphav til forskningsspørsmålet: Hva er bærekraftig arktisk kystinfrastruktur som en helhet, og hvordan kan dette oppnås i fremtidig utvikling?

Litteraturstudie, i tillegg til undersøkelser og intervjuer med fagfolk innenfor bygd infrastruktur, har blitt brukt til å vurdere den nåværende litteraturdefinerte retningen innen arktisk utvikling, samt fremtredende mangler og begrensninger i denne litteraturen. Gjennom denne prosessen konkluderes det med at det er et betydelig behov for økt veiledning og kunnskapsoverføring til beslutningstakere på alle nivåer på tvers av Arktis. Det er særlig mangel på kunnskap innen kystsonene.

Det foretas en generell og arktisk gjennomgang av den historiske og nåværende forståelsen av bærekraftig utvikling, og indikatorer for utvikling og bærekraft bestemmes. Man anerkjenner at den arktiske utviklingen i dag er antroposentrisk, og en ny bærekraftig utviklingsmodell er tenkt ut. Bygd infrastruktur identifiseres som en essensiell kobling mellom menneskeheten og naturen, samt at den bygde infrastrukturens rolle er å oppnå en eksistens innenfor økologiske rammer, og dermed prioritere verdens begrensninger fremfor å takle verdens vekstproblemer.

Det konkluderes med at en helhetlig bærekraftig utvikling innen arktisk kystinfrastruktur er infrastruktur i kystsonen som fremmer trivsel og velvære gjennom å søke harmoni med naturen og redusere ulikheter. Bygget infrastruktur kan i fremtiden utvikles i en beslutningsramme basert på en helhetlig bærekraftig utviklingsmodell, hvilket er etablert i denne avhandlingen.

Preface

This dissertation has been carried out in support of the Nordic Master in Cold Climate Engineering – Land Track. The study was undertaken whilst seated at the University Centre in Svalbard (UNIS) for the achievement of the double degree title: Master of Science in Civil Engineering; and Master of Science in Cold Climate Engineering. These degree titles are awarded by the Technical University of Denmark (DTU), and the Norwegian University of Science and Technology (NTNU) respectively.

Given the semi-abstract nature of the subject considered herein, this dissertation takes a holistic approach through broad consideration supported with more detailed examples and case studies. The dissertation seeks to assess literature surrounding the topic, deduce and present relevant arguments contained therein, and produce criteria and conclusions of practical relevance to those people responsible for Arctic development, specifically in relation to built infrastructure. The intended audience includes all of politicians, scientists, and engineers.

My motivation for this study stemmed originally from a frustration at the lack of practical guidance on how to design polar infrastructure. As I became aware of the literature that is available to practicing engineers, I also became aware of its gaps, and the need to revert to academic literature to inform design – to engineer in the truest sense of the word – 'to design and build something using scientific principles' (Cambridge University Press, 2020). Unfortunately, much of this academic literature deals with complex subjects, and is not conducive to engineers and other practitioners without a polar scientific background.

This being the case, it is possible to identify examples of built infrastructure throughout the Arctic, where failures have occurred that could have been avoided had there been increased knowledge of the practitioners, and indeed the higher decision makers informing the direction of development. My mind thus turned towards the questions that should be asked when developing polar built infrastructure. I thus ultimately realised the need for a common set of considerations across the political (decision making), scientific (academic) and practitioner (engineering) spheres, to promote the asking of common questions to ensure not only workable infrastructure solutions, but holistic sustainable infrastructure solutions.

Infrastructure by its nature forms networks, networks which often transgress geopolitical boundaries. As such, common questions, and thus considerations need to be asked at a pan-Arctic level, as well as national, municipal, and local levels. Infrastructure is used to build civilisation, and thus built assets are inextricably linked to both humanity and nature, underlining the need for a common approach to development. At the very least engineering is the connection between science and practice, and it is the responsibility of engineers and other practitioners to understand how one's work affects the future of the planet we call home.

The above work undertaken herein is primarily through desk-based literature research. Secondary to this however, information has been gained through surveys and interviews. The surveys were

undertaken anonymously via online media prior to the commencement of this dissertation. Likewise, some background information used here, gained from national and international literature, was previously reviewed and summarised in an unpublished report. Two key interviews were undertaken of built environment professional's resident in Longyearbyen, Svalbard, whose knowledge has contributed to Longyearbyen case studies. I therefore extend my thanks to Liisa Wickström of LPO Architects, and Kjetil Bråten, director of the Port of Longyearbyen for their invaluable local insight.

In addition, I would also like to thank my three supervisors for their interest, and support in allowing me to undertake this self-propositioned dissertation, namely Knut Høyland of NTNU, Thomas Ingeman-Nielsen of DTU, and Arne Aalberg of UNIS.

Section one of this dissertation considers available literature and the lessons learnt from it. Conclusions are drawn throughout the assessment and are summarised at the end of the section. Section two focusses on sustainability, development, and sustainable development as a whole, with conclusions again drawn throughout. The overall learning from the chapters is summarised and orientated for practical use in sections three and four.

Table of contents

Table of figures

Table of tables

1   Introduction

With the Arctic experiencing substantial changes in its environmental and developmental stability, it is of great concern that there is a severe lack of knowledge pertaining to the construction of Arctic built infrastructure. Not only is there a lack of knowledge surrounding the physical construction and adaptation of Arctic built infrastructure, there is also a substantial lack of knowledge surrounding the questions that should be asked when considering development of Arctic infrastructure as a whole. The development of Arctic built infrastructure is thus a shared challenge of politics, science, and engineering.

Environmental changes are being experienced in the Arctic regions at a rate in excess of the rest of the world (ACIA, 2004). Resultant of these changes, the Arctic is opening up for development. Environmentally, the Arctic is experiencing the effects of both direct and indirect change. Directly, sea ice is receding, permafrost is thawing and the frequency of extreme weather events is changing (AMAP, 2017e). Indirectly, the Arctic is experiencing the effects of global climate change, resource depletion, and pollution. Development of the Arctic is in part necessary and in part opportunistic. Necessary development extends to adaptation for resilience of existing communities, whilst opportunistic development extends to the facilitation of increased shipping, mineral extraction, and tourism.

The Arctic is unique. Environmentally it is remote, extreme and in many respects inhospitable, whilst its communities are fragile, small, and sparce. None the less, the Arctic and its people are also beautiful, resilient, and full of life. Unfortunately, it is however the uniqueness of the Arctic that could lead it to its own devastation. Due to its uniqueness, historically the Arctic has remained fairly undeveloped. It has a low population scattered across settlements few and far between, riddled with fragile societies and infrastructure, and a yearning for identity. Against this backdrop, the environment is already quickly changing, and the doors of the Arctic now stand open for development. These two factors could together either elevate the Arctic to a more holistic sustainable existence of global benefit, or they could ruin the Arctic to the detriment of all.

With Arctic stakes so high, and the power of built infrastructure to inflict change on nature and humanity so great, the risk of not having a cohesive understanding of appropriate Arctic development is too large. It is therefore the purpose of this study to break ground on understanding what is appropriate Arctic development, how this is experienced in built infrastructure, and how this knowledge can be shared such that a cohesive understanding across politics, science, and practice is gained and the correct questions asked of Arctic development prior to it facilitating irreversible damage.

1.1   The Arctic

The Arctic is a social-ecological system. An integrated system in which The Arctic Resilience Action Framework Review Committee, (2017) tell us, human societies and the remaining ecosystem components coexist in 'reciprocal feedback'. Given the sensitivity and fragility of Arctic nature and Arctic communities 'social and ecological systems are particularly linked'. Arctic community's strong environmental link to nature ensures their co-dependence and demands balance for continued co-existence.

Balance between humanity and nature is a theme that has been appreciated by society more or less since the 12th century utopian stream of thought around the concept of environmental stewardship. Unfortunately, since the commencement of the first industrial revolution in the early 19th century, humanities consideration of environmental stewardship has been diminished. Rather, the focus of humanity has been on human fulfilment, and the elevation of humanity away from the concerns of basic survival, through necessary fulfilment to a point of self-gratification. Technological advancement, economic growth and globalisation are but some of the factors that are seen to have elevated humanity, on a global scale, to a point of dis-harmony with nature, where humanities global ecological footprint is in far excess of global biocapacity.

The Arctic is currently in a developmental state similar to the early stages of the first industrial revolution. With low population, minimal industrial development and a low consumption of non-renewable resources, the Arctic, as suggested by Sherwin and Bishop, (2019) stands on a developmental fulcrum. The Arctic resides at a point in time where it could either develop along the same, ultimately unsustainable path as that of the rest of the world, or where it could charter a new truly holistic and sustainable model for development. In this way, the Arctic can secure both its own future and in part that of the world, both environmentally physically, and in setting a positive example for the rest of the world to follow.

It is thus in part the purpose of this dissertation to explore and conclude some of the steps required to redefine humanities focus for development and identify how built infrastructure can contribute to stimulating an Arctic ecosystem revolution.

1.2   Development

Development at its core is 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020). The path of development is complex and does not adhere to one set direction, rather it changes as a result of its surroundings. In reference to built infrastructure, the path of development is influenced by the needs and limits imposed by people and nature. A common path of development is that reflective of human motivation. As established by Maslow (1943), human motivation is the fulfilment of ones pre-potent needs. Initially this is food and water for basic survival. However, as these needs are fulfilled higher needs dominate, and humanity

develops towards their fulfilment. Fulfilment can represent itself in ways such as the reduction of poverty, environmental degradation, and social strife. Fulfilment can also however soon turn to greed and self-gratification in material wealth and the pursuit of peak experiences.

Thus, different areas of the world experience development differently, and require different approaches for its implementation. The Arctic for example has a different development profile from that of the global north or global south and requires different considerations.

The majority of global development focus is currently on the global south, as per the United Nations Agenda 2030 and sustainable development goals (SDGs) (United Nations General Assembly, 2015), despite the development agenda supposedly having applicability to and acceptance by all countries. This raises the question of whether the current global understanding of sustainable development is in fact holistic and sustainable at all, when the global south is not the primary culprit of self-gratification, or for the resultant transgression of natural limits and biodiversity loss that is ultimately undermining humanities existence.

With an estimated US $1 trillion of Arctic infrastructure investment identified over a 15 year period post 2016 (Guggenheim Partners, 2016), the need for a truly applicable pan-Arctic understanding of holistic sustainable development is clear. The Arctic however faces unique challenges, and thus requires a bespoke guide outlining the questions that should be asked by politicians, scientists, and engineers etc. when considering Arctic infrastructure construction and adaptation.

Indeed. the Arctic can be characterised by a need for adaptation. Necessary adaptation of existing Arctic infrastructure subject to environmental change, and adaptation of the focus of infrastructure to build Arctic resilience and community well-being. There is a need for enhanced well-being in the Arctic, for the fact that it is lacking. Resilience is required to successfully weather the storm of increasing global interest in the Arctic regions.

To understand the need for adaptation and resilience of Arctic built infrastructure, it is important to remember that the Arctic is a social-ecological system (The Arctic Resilience Action Framework Review Committee, 2017). This dissertation therefore starts from scratch in review of sustainable development to identify what is sustainability and what is development. It explores the concept of development in relation to people and nature, considers how the Arctic experiences development, its unique challenges, and alternative considerations for future development.

1.3 Infrastructure

Infrastructure development is seen to be intensifying across the Arctic with increased development of coastal infrastructure in particular. Examples include the extensive development of port infrastructure within the Russian Federation for the export of natural resources and facilitation of trans-Arctic shipping. Also, the development of Canadian road infrastructure, such as that from Inuvik to

Tuktoyaktuk, to connect the heart of Canada to its Arctic coastline, and a principle port of the Beaufort Sea.

Infrastructure is important, for the fact that it forms a significant proportion of the wider built environment, where the built environment relates human development to nature. As such, infrastructure is a key component of development in general, and it can either be used to facilitate a true holistic sustainable form of development, or it can more easily facilitate something less than that. Of infrastructure, it is built infrastructure in particular that is most at threat from Arctic environmental changes, and built infrastructure that is of greatest importance for the implementation of future development interests. Thus, it is built infrastructure that is the primary focus of this investigation.

Built infrastructure can be considered as a network of built physical assets, and includes physical systems such as roads, railways, energy and power networks, and networks of standalone assets such as airports, hospitals, and schools. Infrastructure development then is the creation or enhancement of such assets, not for the sake of enhancement itself, but for the betterment of humanity and nature. Thus, although infrastructure is most often considered as a physical network, it is also part of the social-ecological system, of which the Arctic component is so sensitive. Arctic infrastructure therefore necessitates consideration of its development, both horizontally across national, municipal, and local boundaries, and vertically between, politics, science, and practice. Baring this in mind, this dissertation focuses on identifying themes of critical importance for consideration for the development of holistic sustainable Arctic built infrastructure.

1.4   The coastal zone

'Coastal zones make up just 4% of the earths total land, yet they contain more than 1/3 of the worlds human population' (Barry, 2020b). For many animals, such as migratory birds, intertidal habitats are extremely important for food and rest. Unfortunately, around the world these habitats are increasingly disappearing with mounting pressure from increasing populations of people. Separately, a warming Arctic climate is bringing change both seaward and landward, and thus the Arctic coastal zones are changing particularly rapidly. On the seaward side, the extent of sea ice is retreating year on year. This not only reduces landfast ice, which fastens to the coastline preventing erosion from the sea, it is also reducing the sea ice area, resulting in more open water, thus waves, and ultimately an additional increase in coastal erosion. On the landward side, the permafrost is thawing, and thus again causing soil instability.

Together, these, amongst other issues are not only causing difficulties for some wildlife, but also for coastal human communities and coastal infrastructure. Such infrastructure problems include buildings literally falling into the sea, ports becoming shallower because of sedimentation and isostatic readjustment, pipelines cracking because of shifting ground, and the disappearance of water supplies because of draining or salting of taliks and surface water ponds.

The Arctic coastal zones then are at the forefront of social-ecological changes in the Arctic and require increased consideration, especially for the fact that Arctic shipping is on the rise. Consideration is required of the coastal zone in its own right, rather than there being an immediate change from marine to terrestrial. In relation to shipping, thought is required as to both how the coastal zone will have to adapt to provide safety and security measures, and how shipping could cause huge damage to the Arctic coastal zone environment and peoples. In other words, management of the coastal social-ecological zone is required, or ecosystem-based management. Throughout this dissertation, coastal zone infrastructure is a common theme, and conclusions are drawn in relation to it.

1.5   Holism and sustainability

Ecosystem-based management (EBM) is a concept of key consideration in this study for the enactment of holistic sustainable built infrastructure development. Consideration of a piece of built infrastructure as an element within ecosystems of different scale allows effective holistic sustainable consideration of 'commercial, social, cultural and ecological values' (Expert Group on Ecosystem-Based Management, 2013). EBM is effective as it is considered that 'the ecosystem aspect is "first among equals" because ecosystem failure would compromise all other values or goals' (Expert Group on Ecosystem-Based Management, 2013).

As an element of an ecosystem considered at different spatial and temporal scales, built infrastructure must also be considered at local, regional, and transboundary scales. Given that ecosystems do not respect geopolitical boundaries, neither can holistic sustainable infrastructure. I.e., there is a requirement for consideration of built infrastructure at pan-regional and pan-Arctic levels.

Other than EBM, there are many interpretations of holism, sustainability, and sustainable development. As per development, this dissertation studies the historical understanding of sustainable development to extract the array of sustainability concepts, and thus deduce what it means in the Arctic. However, the fundamental understanding of sustainability is 'The quality of being able to continue over a period of time' (Cambridge University Press, 2020). Of the many sustainable development concepts, by far the most commonly referenced definition, given its continued use, is that of the World Commission on Environment and Development, (1987) report, 'Our Common Future':

'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'

The Arctic Council, (2000), the premier top level pan-Arctic intergovernmental forum for Arctic collaboration, utilises and expands this definition to consider economic, social and cultural and environmental aspects:

'Sustainable Development must meet the needs of the present without compromising the ability of future generations to meet their own needs. Economic, social and cultural development are, along with

environmental protection, interdependent and mutually reinforcing aspects of Sustainable Development and are all part of the Council s focus in this regard'.

The Arctic Council's understanding of sustainable development is thus founded on the triple bottom line, or three pillars of sustainability concept – considering balanced economic, social and environmental dimensions (Alhaddi, 2015). This dissertation studies the identified sustainability concepts and asks if there is a better alternative for the Arctic. Although the Arctic is far less developed than much of the rest of the world, it also resides within some of the most developed countries on the planet. As such, whilst the Arctic has fewer limitations to development, such as social ideals of globalisation, it boasts large resources for development, such as political and economic strength. The arctic is therefore in a better position than much of the world to capitalise on its uniqueness to establish a more enlightened sustainable path to well-being.

1.6   Knowledge for development

An underlying principle of sustainable design is interconnectivity, and thus the relationship between politics, science and engineering practice is an important one. The successful transfer of knowledge between the component players of built infrastructure development is key. Without it, the lessons learnt and understanding gained at any level is wasted and insightful implementation of holistic infrastructure is neigh impossible.

Knowledge sharing in relation to the Arctic is most pronounced at the scientific level, with academia successful in lateral knowledge transfer – that is knowledge sharing to other scientists through the medium of published papers and conferences etc. However unless one resides within academic circles having the time and sufficient background to understand and/or appreciate the subjects discussed, then the knowledge and lessons learnt can easily be lost and likely not acted upon by either practitioners of polar development or those in political decision making positions. There is limited transfer of knowledge from the scientific level to the political and practitioner levels.

Although there is literature at the political and practitioner levels, such as National Arctic Development Strategies and technical standards, it is limited. What there is, is specific and limited in topic, and mostly not holistic. A lack of holism stems from a lack of consensus across political, scientific and practitioner literature on the approach to development. This dissertation therefore reviews current political, scientific and practitioner literature in relation to built infrastructure development – focussing primarily on the political for its relatively greater influence over the direction of development. All the form, function and focus of primary national and international literature is identified for the ultimate determination of where there are gaps in knowledge focus, and the transfer of that knowledge. From this, the needs of enhanced literature to stimulate commonality and cohesiveness between the political, scientific and practitioner level approach to Arctic built infrastructure development, is determined.

Ultimately, the lessons learnt from current national and international literature, sustainability, and development are combined to identify themes for holistic sustainable Arctic coastal built infrastructure development, applicable for common consideration across political, scientific and practitioner levels, and at local, municipal, national, and pan-Arctic scale.

1.7   Research question

The aim of this research is to conclude:

What is holistic sustainable Arctic coastal infrastructure, and how can it be achieved in future developments?

The research question is answered through concluding the following objectives:

1. Understand the scope of current applicable literature for the development of Arctic coastal infrastructure.
2. Understand the concept of sustainable development, its current manifestation, and future applicability to Arctic built infrastructure.
3. Identify the themes for sustainable Arctic development, and a framework through which they can be considered to achieve holistic sustainable Arctic coastal infrastructure

1.8   Research methodology

In fulfilment of objective one, this investigation shall:

- Consider international, national, and local literature to identify trends in its type, its focus, and its consideration of infrastructure, the coastal zone, and sustainable development.
- Assess the importance of knowledge, the extent and means by which it is transferred, and how it is used for Arctic development.
- Analyse the gaps, limitations, and risks in the current literature to the development of future Arctic infrastructure.

In fulfilment of objective two, this investigation shall:

- Review the historical understanding of sustainable development to identify its key components.
- Establish indicators of sustainability and development.
- Consider the applicability of the current understanding of sustainable development globally and within the Arctic.

In fulfilment of objective three, this investigation shall:

- Collate into themes, the conclusions from the consideration of current literature, and the concepts of sustainability and development.
- Structure the identified themes for sustainable Arctic development into a framework for future application to construction of Arctic built infrastructure.

2 Definitions and terminology

Prior to the consideration and assessment of available literature that deals with the development of infrastructure in cold climates, we must first be able to define the focus of that literature. Why was it written, who was it written by and who was it written for? To allow this we must understand and be able to characterize literature within specific definitions and terminology. Only through this characterisation is the purpose and content of the literature then able to be objectively assessed and the limitations deduced. Likewise, in order to understand the focus of literature and the components and understanding of holistic sustainable Arctic coastal infrastructure, then its descriptive terminology must be understood.

Policy

Policy is a complex subject given the fact, that to be whole, it relies upon an interdisciplinary viewpoint. This is especially the case for the implementation of holistic sustainable development. Too often policy if focused within a specific area or limited by the perspective of those drafting the policy. In addition the purpose of policy can be confused by the evaluation of that policy (Yinger, 1980). The development of policy is ultimately resultant of, or should be resultant of holistic integration between sources of knowledge, sustainably driven decision making and enactment viability. With this in mind, three definitions of policy are presented.

1. In regards to scientific and research based decision making capacity, 'science policy creates a de facto contract between science and society involving the provision of public resources to pay for research, while requiring honoring a regulatory system and creating the institutions to perform research' (Caplan and Redman, 2018).
2. In regards to political actors, public policy can be defined as 'a set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them within a specified situation where these decisions should, in principle, be within the power of these actors to achieve' (Yinger, 1980).
3. In regards to business and business activities, 'a set of policies are principles, rules and guidelines formulated or adopted by an organization to reach its long-term goals' (BusinessDictionary.com, 2019).

Procedures

As is noted in (Yinger, 1980), the implementation of goals and principles is not included within policy itself. Albeit the measure of implementation success is included within policy analysis. The implementation of policy therefore can be defined through procedures.

Procedures can be defined as the 'specific methods to express policies in action in day-to-day operations of the organization' (BusinessDictionary.com, 2019), or in other words, modes of action employed to implement policy.

As suggested by BusinessDictionary.com, (2019), 'together, policies and procedures ensure that a point of view held by the governing body of an organization is translated into steps that result in an outcome compatible with that view.'

Policy Framework

In terms of development of built infrastructure, a policy framework would be used in the context of a planning policy framework. In this context a policy framework constitutes a set of procedures used in the planning of development. The policy framework forms the basis on which guidelines and rules are developed.

A planning policy framework can vary in its extent of scale. It could for example either focus on international, national, or local policy. Separately, a framework at any level could divest planning control to encompassed regions. For example, an international framework could have a nationalism agenda, whereby increased control of planning in placed in the hands of national actors. Likewise, a national planning policy framework could have a localism agenda.

Guidelines

By one definition, a guideline is 'information intended to advise people on how something should be done or what something should be' (Cambridge University Press, 2020). It is a 'principle that provides direction to action or behaviour' (WikiDiff, no date). A guideline targets a specific objective. However, a guideline is non-regulatory. I.e. it is not enforceable.

In relation to a planning policy framework, guidelines are often constructed by the authors of the framework – for example, a government – to aid in the fulfilment of the framework. Guidelines produced in this manner are not only polarized to the viewpoint of the author, but also often escape critical appraisal with guidelines being published without prior consultation. This is in difference to a planning policy framework itself which would usually be put to public consultation prior to finalization.

Herein, guidelines are considered to act in a downstream direction. For example, to provide direction to the action of implementing policy.

Guidance

Guidance is 'help and advice about how to do something or about how to deal with problems connected with your work' (Cambridge University Press, 2020). Guidance is less dictating than guidelines and is more suggestive. Guidance is general. As such guidance provides less direction.

Herein, guidance is assumed to act either in the upstream or downstream direction. For example, guidance may be produced by those in the possession of knowledge, such as academics, to help inform and guide those in policy producing positions, or practitioners.

Regulation

Beyond guidelines, control of a development process becomes regulated. As mentioned, a policy framework forms the basis on which both guidelines and rules are developed. In the context of a development policy framework, a rule is assumed to be 'an accepted principle or instruction that states the way things are or should be done, and tells you what you are allowed or are not allowed to do'(Cambridge University Press, 2020).

Regulation can then be defined as 'an official rule' (Cambridge University Press, 2020), 'with or without the coercive power of law'(BusinessDictionary.com, 2019). Laws are written rules and regulations derived either from a country's constitution, or legislative assemblies. Regulations are subordinate details of laws added by the responsible administrative departments and agencies of the governing structure to help implementation of the laws (DifferenceBetween.com, 2018). As such both laws and regulations can be legally enforced, although enforcement is not necessarily always undertaken. Failure of compliance to a regulation is commonly penalised with a fine, whereas the breaking of the overarching legislation can result in stiffer penalties (MacLeod, 2019).

In consideration of regulation enacted across multiple states, the stipulation presented in Article 288 of the Treaty on the Functioning of the European Union (TFEU) is a good example. It states that 'a regulation shall have general application. It shall be binding in its entirety and directly applicable in all Member States' (Official Journal of the European Union, 2012). I.e. a regulation becomes immediately enforceable in all member states.

Directive

In difference to regulation, directives are transposed into national law, through legislation at national level. Article 288 of the Treaty on the Functioning of the European Union (TFEU) states that 'a directive shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods' (Official Journal of the European Union, 2012).

Standards

In relation to the built environment, a standard can be defined as 'an agreed, repeatable way of doing something' (Health and Safety Executive, no date). Similar to guidelines, standards provide defined consistent practice to be adhered to. Standards are usually technically focused and used both for design, specification, and compliance. Standards themselves are voluntary, although become legally binding if stipulated within a piece of legislation (Health and Safety Executive, no date).

Arctic

Defining the extent of the Arctic is challenging given the many and varied considerations of what the Arctic represents. Classically, the Arctic can be considered as that area within the Arctic circle, the latitude of 66° 33' 44" North, above which the sun can remain above or below the horizon continuously for 24 hours. The Arctic circle definition is restrictive however in that it does not describe many of the environmental and geographical conditions normally associated with the Arctic, such as temperature, the presence of permafrost or fauna and flora prevalence. Ignoring such factors in the consideration of development of Arctic built infrastructure is needless to say unsustainable. Although not all encompassing, the definition of the Arctic Council's Arctic Monitoring and Assessment Programme (Murray *et al.*, 1998; AMAP, 2020) considers these aspects, and as presented in the below Figure 2-1, largely also envelopes other common Arctic definitions. It is this AMAP definition of the Arctic, more clearly shown in Figure 2-2, that is considered within this assessment.
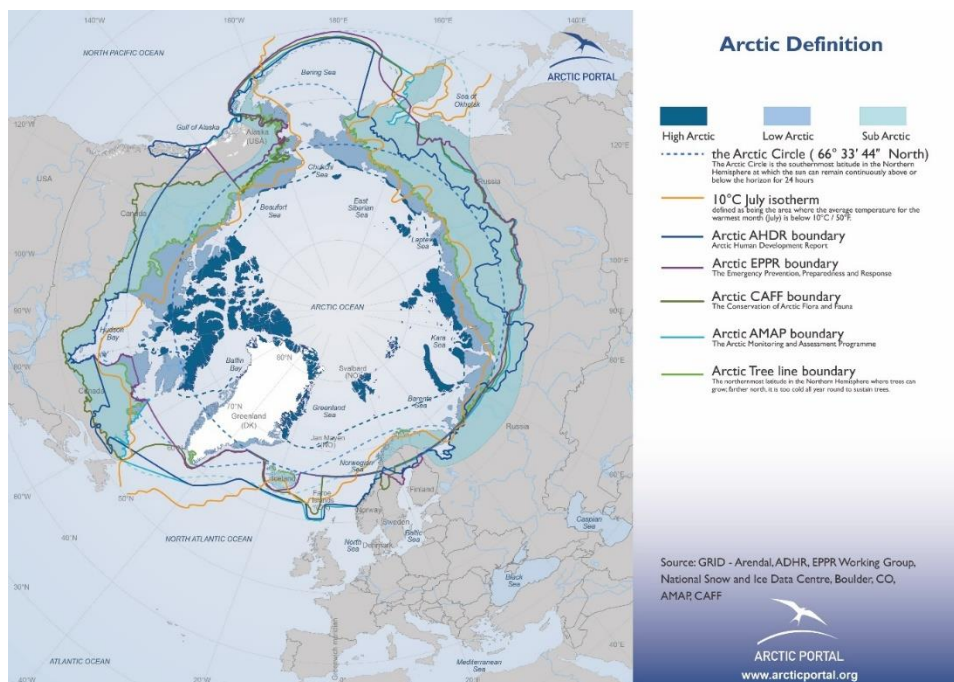
Figure 2-1: Arctic Definition (Source: GRID – Arendal, ADHR, EPPR Working Group, National Snow and Ice Data Centre, Boulder, CO, AMAP, CAFF via Arctic Portal (Arctic Portal, 2016). Graphic: © Arctic Portal 2006-2016)

Figure 2-2: AMAP Region (Source: Arctic Monitoring & Assessment Programme (AMAP, 2020). Graphic: © AMAP)

Holistic

A common definition of holistic is the 'dealing with or treating the whole of something or someone and not just part' (Cambridge University Press, 2020). With regards to built infrastructure, this can be considered at multiple levels. At the lowest level, a holistic construction is one that follows a cradle to grave sustainability mindset whereby the sustainability of a piece of infrastructure is considered from concept and design, through construction and operation to removal and remediation. At a higher level, one, or interconnected pieces of infrastructures act as one system within a network of systems (Imam, no date). I.e. infrastructure sits within a network of environmental, social, and geopolitical systems, the interaction of which must be considered. At the highest level, a piece of infrastructure should be holistically considered within the wider national and international offerings and requirements.

Holistic consideration of built infrastructure is twofold:

1. Consideration of sustainable development of a piece or system of infrastructure.
2. Consideration of the role of built infrastructure in sustainable development.

Built Infrastructure

Infrastructure in its broadest sense can be defined as the 'basic systems and services' 'that a country or organization uses in order to work effectively' (Cambridge University Press, 2020). It 'is the term used to describe the interconnected organisational structures that underpin society and enable it to function effectively' (Designing Buildings Wiki, 2020a).

Infrastructure can be considered in terms of being 'hard' or 'soft'. 'Hard' infrastructure describes physical assets 'necessary to facilitate the flow of supplies required by society' (Designing Buildings Wiki, 2020a), often in networks. This extends to sectors such as: Energy; Transport; Waste; Flood; Science; Water; and Telecommunications. 'Soft' infrastructure can describe both virtually networked 'built assets, such as hospitals and schools, that are central to the operation of society', and 'organisational mechanisms such as government, legislation the emergency services' (Designing Buildings Wiki, 2020a). Considering just physical assets, 'hard' and 'soft' infrastructure can together be described as built infrastructure.

Built Environment

The built environment is a holistic term describing the extent of the 'human-made environment'. The built environment encompasses 'all forms of building (housing, industrial, commercial, hospitals, schools, etc.), and civil engineering infrastructure, both above and below ground and includes the managed landscapes between and around buildings' (Designing Buildings Wiki, 2019). In essence it includes all buildings, built infrastructure and blue-green infrastructure.

Blue-Green Infrastructure

Blue-green infrastructure is interconnecting blue and green infrastructure. Where built infrastructure can be considered a network of built assets within the built environment, so to blue-green infrastructure be considered as a network of blue and green elements within the built environment. Green infrastructure describes incorporated 'natural landscapes into public spaces' (Louie, 2018). Blue infrastructure is that which relates to 'good water management'. Thus blue-green infrastructure is that which provides integrated water management systems within the green spaces forming part of the built environment.

Environment

The 'environment' has multiple meanings dependent on the context in which it is used. In relation to nature, the environment is 'the air, water, and land in or on which people, animals, and plants live' (Cambridge University Press, 2020). The environment can also relate to ones surroundings – 'the

conditions that you live or work in and the way that they influence how you feel or how effectively you can work' (Cambridge University Press, 2020).

In both cases, the environment is something in which humanity is involved and something over which humanity can exercise its control. The environment describes humanities interaction with nature both directly and indirectly. It does not describe nature itself.

Nature

Nature is the name given to 'all the animals, plants, rocks, etc. in the world and all the features, forces, and processes that happen or exist independently of people, such as the weather, the sea, mountains, the production of young animals or plants, and growth' (Cambridge University Press, 2020).

Natural Environment

The definition of natural is 'as found in nature and not involving anything made or done by people' (Cambridge University Press, 2020). Given that an environment is something that interacts with nature, the natural environment can be defined as nature interacting with itself. The natural environment thus encompasses all biotic (living) and abiotic (non-living) components existing on earth.

Ecosystem

Together, characteristic biotic and abiotic constituents interact and interdependently form an ecosystem (The Editors of Encyclopaedia Britannica, 2020). In other words, an ecosystem is the name given to 'all the living things in an area and the way they affect each other and the environment' (Cambridge University Press, 2020).

Ecological footprint

'The Ecological Footprint is a measure of consumption which is correctly understood as an amount of biological service consumed per unit time' (Global Footprint Network, 2009).

Social-ecological system

The Arctic Resilience Action Framework Review Committee, (2017) inform us that 'A social-ecological system is an integrated system that includes human societies and ecosystems. Its structure is characterized by reciprocal feedbacks'.

Climate Adaptation

The Arctic Resilience Action Framework Review Committee, (2017) consider that 'Climate Adaptation is an adjustment in natural or human systems, in response to climate change, which is intended to minimize disruption or take advantage of opportunities'.

Resilience

The Arctic Resilience Action Framework Review Committee, (2017) conclude that 'Resilience is the ability of a system to bounce back and thrive during and after disturbances and shocks'.

Sustainability

'The quality of being able to continue over a period of time' (Cambridge University Press, 2020).

Development

'The process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020).

Well-being

Well-being is a value which quantifies 'what ultimately is good for people'. This value 'concerns what benefits or harms you, or makes you better or worst off', and thus extends beyond happiness to include things 'such as achievement or friendship' (HAPPINESS & WELL-BEING, no date).

Happiness

Happiness is a 'state of mind'. It is a psychological understanding of 'being satisfied with your life or having a positive emotional condition' (HAPPINESS & WELL-BEING, no date).

Self-gratification

Where gratification is 'pleasure or satisfaction, or something which provides this' (Cambridge University Press, 2020), self-gratification is the act of providing oneself with pleasure or satisfaction.

Fulfilment

Fulfilment is 'the fact of doing something that is necessary or something that someone has wanted or promised to do' (Cambridge University Press, 2020).

Politics

Politics is the name given to 'the activities of the government, members of law-making organizations, or people who try to influence the way a country is governed' (Cambridge University Press, 2020).

Economics

Economics is the name given to 'the way in which trade, industry, or money is organized, or the study of this' (Cambridge University Press, 2020).

Sociology

Sociology is 'the study of the relationships between people living in groups, especially in industrial societies' (Cambridge University Press, 2020).

Society

Society can be described as 'a large group of people who live together in an organized way, making decisions about how to do things and sharing the work that needs to be done. All the people in a country, or in several similar countries, can be referred to as a society' (Cambridge University Press, 2020). People in a society partake in social interaction, and are 'often subject to the same political, economic, institutional and cultural environment, conditions and expectations' (Designing Buildings Wiki, 2020b).

Culture

Culture is understood to be 'the way of life, especially the general customs and beliefs, of a particular group of people at a particular time' (Cambridge University Press, 2020).

Section I : The literature defined direction of Arctic development

Section I of this dissertation undertakes identification and high-level characterisation of literature pertaining to development of Arctic built infrastructure. The identification of literature was undertaken in three ways. The first approach was that of undertaking a survey of experts / professionals involved to some degree with the development of the Arctic. This was primarily undertaken via direct contact, and secondarily through social media. The experts / professionals represented include national and municipal government ministers and employees; international council representatives; university academics; research body and institute representatives; standards agencies; security consultants; NGO's; engineering consultancies; and architects. Unfortunately, the survey response was very poor and of limited value, which could either mean that the selected contacts are ignorant of available literature, or that utilised literature is private and of restricted access.

The second approach to identification of literature was through direct interview and discussion with available contacts. This has proved of some value in the Longyearbyen locality. The final approach, providing the bulk of literature identified, was independent research. As such, the below literature is publicly available, which to some extent benefits the investigation in demonstrating that literature which is available for pan-Arctic application.

3 Literature problem hypothesis

Considering the Arctic development situation at hand, as briefly outlined within the introduction, a hypothesis on the availability and focus of literature is drawn.

1. The literature – policy, guidelines, and standards etc. that does exist for general and coastal zone specific arctic infrastructure development is primarily:
   a. Technically focussed.
   b. Nation based.
   c. Lacking focus on holistic sustainable principles.

Therefore:

2. There is limited planning policy for the assessment of pan-Arctic, national and local coastal infrastructure needs in the Arctic regions.
3. There is a void of available approach / guidance or instruction that seeks to ensure the development of the Arctic coastal zone in a holistic sustainable fashion. This is primarily the case at the high-level planning stage, both at national and international levels.

4. There is a lack of knowledge within Arctic nations for those people residing at the high decision-making level and at the low implementation (those physically designing structures) level.

   a. This for example can represent itself at the high level with governments / decision makers not knowing the questions that should be asked when considering the feasibility of infrastructure projects. Or it can represent itself at the low level with the designers of infrastructure failing to recognise the polar specific aspects that must be considered to ensure successful holistic sustainable development in the Arctic.

   b. This lack of knowledge is in part resultant of a lack of sharing of knowledge and lessons learnt.

      i. From the mid-level (in which academic research is assumed to sit) up to the high (decision making) level and down to the low (implementation) level through the development of frameworks and recommended practice etc.

      ii. From the lack of knowledge sharing between the high (decision making) and low (implementation) levels across national boundaries. I.e. decision making and engineering approaches to infrastructure development is largely national rather than pan-Arctic focussed.

   c. The above applies more acutely to the high (decision making) level than the low (implementation) level, where there has been a greater attempt to relate academic knowledge to practice.

5. Guidance is therefore required that serves both decision makers commissioning coastal infrastructure development and those engineers who have to design it.

   a. To ensure holistic sustainable Arctic development the approach / guidance or instruction must be common to all parties involved.

4 International, national, and local literature for Arctic built infrastructure development

To aid comparative assessment, identified literature has principally been collated by geographical area. This is either country or region based and considers first Arctic areas. Pan-Arctic literature is next considered, followed by Arctic focussed literature and strategy of non-Arctic states and collaborations. For each piece of literature or strategy identified an attempt at classifying it in accordance with the standard definitions and terminology, along with its level of focus (international, national, municipal (state, territory), local) has been made. For example (policy; national). Where possible, attention has been drawn to aspects relating to the development of the coastal zone, and prominent mention of sustainable development.

4.1 Arctic geographical collation

In this first geographical collation of literature, no particular order has been given to the countries considered, excepting that all eight Arctic nations are considered and have been done so in logical circumpolar fashion. For each country, in addition to the identification and 'tagging' of literature, the following has been considered:

- The primary focus of the identified literature, for example: Spatial planning; social aspects; technical design; sustainability.
- The extent to which sustainable development is considered in the identified literature.
- The extent to which the Arctic, or cold climates are considered if the literature is general.

4.1.1 United States of America – Alaska

The Arctic policy of the United States of America needlessly to say is concerned primarily with Alaska. The baseline policy is seen in U.S. Department of State's 2013 'National Strategy for the Arctic Region' (Government of the United States of America, 2013) *(Policy; National)*. The policy document itself is short and after considering a changing Arctic, promotes three main considerations, namely to 'Advance United States Security Interests', 'Pursue Responsible Arctic Region Stewardship' and 'Strengthen International Cooperation' (Government of the United States of America, 2013). Regarding built infrastructure, reference is made to security and control in relation to maritime activities and resource management.

Implementation of this policy is further detailed in the 2016 'Implementation Framework for the National Strategy for the Arctic Region' (Government of the United States of America, 2016) *(Procedure; National)*. A later released 2019 'Department of Defense Arctic Strategy' (US Department of Defence, 2019) *(Policy; National)*, moves away from constructive cooperation and Arctic

stewardship and towards 'strategic competition' (US Department of Defence, 2019) with a focus on 'building Arctic awareness', enhancing Arctic operations' and 'strengthening the rules-based order in the Arctic' (US Department of Defence, 2019).

4.1.2   Canada

At national (federal) level, Canada assesses the case for the development of built infrastructure through its 'Investing in Canada Plan' (Government of Canada, 2019b) *(Policy Framework; National)* which considers three key objectives, namely: 'Create long-term economic growth'; 'Support a low carbon, green economy'; and 'Build inclusive communities'.

The 'Investing in Canada Plan' translates to the built environment through the 'Investing in Canada: Canada's Long-Term Infrastructure Plan' (Infrastructure Canada, 2018) *(Policy; National)*, which focusses on five key areas, namely 'Public Transit'; 'Green Infrastructure'; 'Social Infrastructure'; 'Trade and Transport', and 'Rural and Northern Communities'. Within these five key areas, a number of forward thinking and sustainable themes are discussed including: 'Innovation in Infrastructure; Private Sector Investment and Alternative Financing Mechanisms; Infrastructure and Social Development; Green Infrastructure; Social Infrastructure; Rural and Northern Communities; Supporting Indigenous Communities and Smart Cities' (Infrastructure Canada, 2018).

The plan was developed in consultation with 'provincial, territorial, municipal and indigenous' (Infrastructure Canada, 2018) partners and as such reflects the needs and desires of Canadians at all levels, whilst providing a top down infrastructure cascade arrangement. I.e. an upward guidance supported downward policy. In this way, not only can the urgency and effectiveness of different infrastructure developments be assessed, but each 'provincial, territorial, municipal and indigenous' (Infrastructure Canada, 2018) partner is stimulated to consider integrated infrastructure development at each level.

Downward implementation of governmental built infrastructure policy is ultimately achieved through an 'Integrated Bilateral Agreement (for the Investing in Canada Infrastructure Program)' (Government of Canada, 2019b) *(Procedure; Municipal)* between the Government of Canada and the province or territory. This is indeed the case for Canada's three 'Arctic' Territories of Yukon (Government of Canada and Government of Yukon, 2018), Northwest Territories (Government of Canada and Government of the Northwest Territories, 2018) and Nunavut (Government of Canada and Government of Nunavut, 2018). As required by the integrated bilateral agreement each territory, through its devolved power is required to develop its own infrastructure plan.

Most recently, these infrastructure plans in part are developed with and form a significant component of Canada's recently launched 'Arctic and Northern Policy' Framework (Government of Canada, no date b) *(Policy Framework; National)* which replaces the previous Northern strategy (Government of Canada, 2019a) and 'Interim Report on the Shared Arctic Leadership Model' (Government of Canada,

no date c). 'Canada's Arctic and Northern Policy' Framework (Government of Canada, no date b), like the 'Investing in Canada: Canada's Long-Term Infrastructure Plan' (Infrastructure Canada, 2018), has been co-developed with Yukon, Northwest Territories and Nunavut territorial governments and over 25 indigenous organisations. Similarly to the 'Investing in Canada Plan' (Government of Canada, 2019b) but with further focus, the 'Arctic and Northern Policy' Framework (Government of Canada, no date b) features eight primary goals, namely:

- 'Strong, sustainable, diversified and inclusive local and regional economies'.
- 'Canadian Arctic and northern Indigenous peoples are resilient and healthy'.
- 'The Canadian Arctic and North and its people are safe, secure and well-defended'.
- 'Strengthened infrastructure that closes gaps with other regions of Canada'.
- 'The rules-based international order in the Arctic responds effectively to new challenges and opportunities'.
- 'Knowledge and understanding guides decision-making'.
- 'Canadian Arctic and northern ecosystems are healthy and resilient'.
- 'Reconciliation supports self-determination and nurtures mutually respectful relationships between Indigenous and non-Indigenous peoples'.

The 'Arctic and Northern Policy' Framework (Government of Canada, no date b) is holistic in that its construction is not centred in federal government, but at territorial, pan-territorial, indigenous organisation and pan-Arctic level, with each partner contributing a chapter to the framework.

The pan-territorial chapter (Government of Yukon, Government of the Northwest Territories and Government of Nunavut, 2019) *(Policy; Pan-Territorial (pan-municipal))* of the 'Arctic and Northern Policy' Framework (Government of Canada, no date b) considers shared opportunities and challenges of Yukon, Northwest Territories and Nunavut and is grown from the 'Pan-Territorial Vision for Sustainable Development'. The chapter identifies that 'Strengthened and diversified economies are central to sustainable community wellness and to Indigenous self-determination', which is to be implemented thorough resource development, economic diversification, infrastructure and innovation (Government of Yukon, Government of the Northwest Territories and Government of Nunavut, 2019).

4.1.2.1   *Northwest Territories*

The government of Northwest Territories also contributed a chapter to the 'Arctic and Northern Policy' Framework (Government of Canada, no date b). Through collaboration of the Inuvialuit, Dean, Métis and non-indigenous peoples, the Northwest Territories chapter (Government of the Northwest Territories, 2019) *(Policy; Municipal)* considers the economy, infrastructure, people, environment and governance and reconciliation.

At territorial (municipal) level Northwest Territories has publicly available written legislation and is responsible for administrating on a range of subjects including airports and highways. There does not

appear to be any available legislative literature relating to the coastal zone. The Northwest Territories department of infrastructure in addition is responsible for implementation of the 'Northwest Territories Infrastructure Establishment Policy' (Government of the Northwest Territories, 2017) *(Policy; Municipal)*.

4.1.2.2   Nunavut

The government of Nunavut has also contributed a chapter to the 'Arctic and Northern Policy' Framework (Government of Canada, no date b). Again, the Inuit and non-indigenous peoples have collaborated to produce a joint Nunavut chapter (Government of Nunavut, 2019) *(Policy; Municipal)* which addresses well-being, economic development, infrastructure, employability, education and training, and territory definition.

Within Nunavut, all communities are separate settlements unconnected by road and little connected by boat. Each settlement is then assessed individually. This is done though 'Integrated Community Sustainability Plans' (ICSP) (Government of Nunavut, no date) *(Procedure; Local)*. Each community participates in identifying the actions required, thus each infrastructure plan is tailored to the specific needs of community. These ICSP's target 'cultural, social, economic and environmental values associated with each community infrastructure priority'(Government of Nunavut, no date).

4.1.2.3   Yukon

Yukon, unlike Northwest Territories and Nunavut has chosen to submit separate chapters from the government and native peoples. In reflection of this, these chapters are still works in progress and currently do not form part of the 'Arctic and Northern Policy' Framework (Government of Canada, no date b).

There does exist a previous 2015 – 2020 'Yukon Infrastructure Plan' (Government of Yukon, 2015) *(Procedure; Municipal).* In addition to such a plan Yukon does have individual acts and regulations on various aspects that fall under the umbrella of built infrastructure such as building standards, economic development, environment, highways, housing development, lands, mining, noise, oil and gas, public airports and public utilities. There appears to be no legislation in relation to the coastal zone.

4.1.2.4   Additional high level literature

In a more general sense Canada also boasts an Arctic Foreign Policy (Government of Canada, 2010) *(Procedure; National)* that focusses on sovereignty, economic and social development, environmental protection and governance devolution in the Arctic region. In relation to the coastal zone, mention is made of activities relating to the coast guard, continental shelf claims and resource development and

coastal traffic. In regards to shipping and marine activity in the Canadian Arctic, there are a number of pieces of legislation including 'the Arctic Waters Pollution Prevention Act and its regulations, the Canada Shipping Act 2001, the Marine Liability Act, the Marine Transportation Security Act, the Coasting Trade Act, and the Canada Labour Code. All of these focus on 'safety', 'protection of life, health, prosperity and the marine environment' (Government of Canada, no date a).

One respondent of the survey undertaken indicated that there was work currently being undertaken by the National Research Council of Canada (NRC) into the development of a Coastal Flood Risk Assessment Guideline, some of which is Arctic focussed (Anonymous, 2019). At a national level, scientific knowledge pertaining to climate change and its impact on the coastal Canadian Arctic is pooled through ArcticNet, a Canadian 'network of centres of excellence' (ArcticNet, 2019).

4.1.2.5   *Practitioner level literature*

Thus far a lot of high-level literature has been identified for development of built infrastructure in the Canadian Arctic. Unfortunately, little of this defines actionable practices for the implementation of infrastructure and there is next to nothing relating to the holistic sustainable development of coastal infrastructure. In general, construction in Canada is undertaken in accordance with the 'National Building Code of Canada' (NRCC, 2015), and the 'Canadian Foundation Engineering Manual' (CGS, 2006). These are however 'ill-suited to the Arctic climate and physical site properties (e.g., permafrost)' (Ingeman-Nielsen and Lemay, 2018).

There is however an expanding suite of standards and guidelines for Arctic infrastructure development in general. Much of this has been developed under the Standards Council of Canada's Northern Infrastructure Standardisation Initiative (NISI) which aims to develop 'mechanisms to help adapt and reduce the vulnerability of its infrastructure to the impacts of climate change' (Standards Council of Canada, no date) in northern infrastructure. Currently available standards *(standards; National)* are technically focussed and include:

Developed under phase I of the NISI

- CAN/CSA-S500: Thermosyphon foundations for buildings in permafrost regions.
- CAN/CSA-S501: Moderating the effects of permafrost degradation on existing building foundations.
- CAN/CSA-S502: Managing changing snow load risks for buildings in Canada's North.
- CAN/CSA-S503: Community drainage system planning, design, and maintenance in northern communities.
- CAN/BNQ 2501-500: Geotechnical site investigations for building foundations in permafrost.

Developed under phase II of the NISI or in addition too, are the following standards and technical guidelines:

- CSA W203: Planning, design, operation, and maintenance of wastewater treatment in northern communities using lagoon and wetland systems.
- CSA Plus 4011.1: Technical Guide: Design and Construction Considerations for Foundations in Permafrost Regions.
- CAN/CSA S504: Fire resilient planning for northern communities.
- CSA Plus 4011: Technical Guide: Infrastructure in Permafrost: A Guideline for Climate Change Adaptation.
- CAN/CSA W205: Erosion and sedimentation management for northern community infrastructure.

Future literature includes:

- CAN/CSA S505: Techniques for dealing with high winds and snow drifting as it pertains to northern infrastructure (available 2020).
- CAN/BNQ 9701-500: Risk-based approach to community planning in northern regions (available 2021).

As one survey respondent put it, all of the above "have been developed to support addressing climate change impacts to northern infrastructure design, planning and management. Each standard helps building owners and operators as well as those responsible for public and community infrastructure build and maintain infrastructure in a changing climate" (Anonymous, 2019). However, none of the standards focus on sustainable development. As is evident by the title, the standard CAN/CSA W205: Erosion and sedimentation management for northern community infrastructure focusses on the coastal zone and permafrost erosion.

Lastly, both the Government of Northwest Territories and the Government of Nunavut have developed technical guidelines on "good building practice", namely 'Good Building Practice for Northern Facilities' (Government of the Northwest Territories, 2011) *(Guidance; Municipal)*; 'A Homeowner's Guide to Permafrost in the Northwest Territories: Keep Your House on Solid Ground' (Government of the Northwest Territories, 2015) *(Guidance; Municipal)*; 'Good Building Practices Guideline' (Government of Nunavut, 2005) *(Guidance; Municipal)*; and 'A Homeowner's Guide to Permafrost in Nunavut: Keep your House on Solid Ground' (Government of Nunavut, 2013) *(Guidance; Municipal)*. "They are aimed at providing all groups involved with buildings - building developers, building designers, building constructors, suppliers, and administrators and operators - with a comprehensive set of practice" (Anonymous, 2019).

4.1.3 Kingdom of Denmark

The kingdom of Denmark includes Denmark, Greenland and the Faroe Islands, of which Greenland is certainly an Arctic nation. Given the difficulties in defining the extent of the Arctic, the Faroe Islands could or could not be considered as within the Arctic.

The Kingdom of Denmark's primary Arctic policy is currently contained within their 'Kingdom of Denmark Strategy for the Arctic 2011-2020' (Kingdom of Denmark, 2011) *(Policy; international)*. The primary aim of the strategy is to present a consistent and common approach of all Denmark, Greenland and the Faroe Islands on Arctic development. This includes the pursuit of peace and security, sustained economic growth and development, respectful consideration of the environment and nature and international cooperation (Government of Denmark, no date). Although there is fairly extensive discussion of the coastal environments, little of it is in relation to built infrastructure. Rather, there is a strong focus on law and order, such as in relation to continental shelf claims, marine activity, search and rescue, the Law of the sea, and the Ilulissat declaration, which focusses on coastal state cooperation.

That being said, where mention is made to infrastructure, it is often in relation to activities occurring in the coastal zone, and fairly exclusively in relation to Greenland. This is of course not surprising, as Greenland is the Kingdom of Denmark's primary Arctic territory and all of its built infrastructure is naturally along the coast. Infrastructure is considered in relation to marine traffic, tourism and air transportation and mention is made of its place within a socio-economic setting and in the consideration of private financing.

In extension to the 'Kingdom of Denmark Strategy for the Arctic 2011-2020' (Kingdom of Denmark, 2011), Denmark has strengthened its focus on research and education in the Arctic regions with reference to sustainable development, through the subsequent release of their 'Strategy for research and education concerning the Arctic' (Government of Denmark, 2016) *(Procedure; international)*. This strategy seeks to develop 'high-quality research and education in and about the Arctic that is relevant to society', place 'Denmark as a strong Arctic actor and international partner' and to ensure 'responsible and sustainable societal development of the Arctic region' (Government of Denmark, 2016). With regards to the first point, mention is made of increasing access to Arctic data. Access to information within Greenland is a persistent challenge to Arctic professionals and its increased availability would make the work of both engineers and planners easier. A good example is that of infrastructure development guidance held by Asiaq – Greenland Survey. Although in existence, this historic design guidance that could be used by engineers in the design of built infrastructure is all in paper format and centrally stored, thus access is made very difficult.

4.1.3.1   The Faroe Islands

The Government of the Faroe Islands seemingly do believe that they are an Arctic nation, and indeed as a High North Nordic nation do share many challenges and similarities with other High North nations,

such as Iceland and Norway between which the Faroe Islands reside. In reflection of this the Government of the Faroe Islands has developed its own Arctic focussed strategy entitled 'The Faroe Islands – a Nation in the Arctic' (The Government of the Faroe Islands, 2013) *(Policy; National)*, the purpose of which is to assess necessary adaptation and capitalisation of new opportunities resultant of change in the Arctic. This plays to the strengths of the Faroe Islands by focussing on shipping, fisheries, research and education and the environment. The policy, unsurprisingly, given the Faroe Islands location has a large focus on the coast and maritime activities throughout. The mention of infrastructure is limited however to the Faroe Islands search and rescue (SAR) capability.

4.1.3.2   Greenland

Greenland is of course the substantial Arctic entity within the Kingdom of Denmark and as such deals with development of the Arctic built environment as standard – All policy is effectively Arctic policy. Unfortunately, as clarified in one response to the survey, 'most of the national and local policy, frameworks and guidance etc. is made by looking at what they do in Denmark and in the Danish municipalities' (Anonymous, 2019). None the less these policies are constructed by the Government of Greenland themselves for Greenland.

At a national level this is publicly available policy (byginfo.gl, no date) and includes but is not limited to:

- 'Inatsisartutlov nr. 17 af 17. november 2010 om planlægning og arealanvendelse' (planning and use of areas).
- 'Inatsisartutlov nr. 9 af 22. november 2011 om beskyttelse af miljøet' (protection of the environment)
- 'Inatsisartutlov nr. 16 af 17. november 2010 om byggemodning, offentlige kloakledninger og offentlige veje' (land development, public sewer lines and public roads)
- 'Bygningsreglement 2006 (BR06)' (The Building Regulations 2006).

In relation to technical literature regarding cold climate specific aspects of infrastructure, there is little information, with what there is being largely contained to early publications by the Greenlandic Technical Organisation (GTO). For an account of technical literature availability, refer to section 10.9.2 of Ingeman-Nielsen and Lemay, (2018).

At municipal level in Greenland, the structure is largely similar to that of Denmark. Overarching schemes for towns and settlements are implemented though an overall municipal plan, renewed every 4 years. Within the primary municipal plan, local plans are created or renewed for local areas as and when required. These are primarily for the purpose of allowing the establishment of built infrastructure. In addition to the creation of local plans by the municipality, local regulation is created to govern aspects such as land rent for boats and containers etc. This regulation is again modelled on regulation developed by other municipalities in Greenland and Denmark.

4.1.4   Iceland

Iceland, although largely not within the Arctic circle itself, like the Faroe Islands is considered to be in the Arctic under the definition used herein. The primary 2009 policy of Iceland 'Ísland á norðurslóðum' (Iceland in the High North) (Utanríkisráðuneytið, 2009) *(Policy; National)*, looks to place Iceland as a recognised player in the development of the Arctic, with a focus given to cooperation with other Arctic nations. Islandic policy considers climate change, the environmental, natural resources, cooperation, and social development.

The above policy was strengthened in 2011 with the release of 'A Parliamentary Resolution on Iceland's Arctic Policy' (Althingi, 2011) *(Policy; National)*. This considers 12 principles. In short these are:

- 'Promoting and strengthening the Arctic Council'.
- 'Securing Iceland's position as a coastal State within the Arctic region as regards influencing its development'.
- 'Promoting understanding of the fact that the Arctic region extends both to the North Pole area proper and the part of the North Atlantic Ocean which is closely connected to it'.
- 'Resolving differences that relate to the Arctic on the basis of the United Nations Convention on the Law of the Sea'.
- 'Strengthening and increasing cooperation with the Faroe Islands and Greenland'.
- 'Supporting the rights of indigenous peoples in the Arctic'.
- 'Building on agreements and promoting cooperation with other States and stakeholders on issues relating to Icelandic interests in the Arctic region'.
- 'To use all available means to prevent human-induced climate change'.
- 'Safeguarding broadly defined security interests in the Arctic region through civilian means and working against any kind of militarisation of the Arctic'.
- 'Developing further trade relations between States in the Arctic region'.
- 'Advancing Icelanders' knowledge of Arctic issues and promoting Iceland abroad'.
- 'Increasing consultations and cooperation at the domestic level on Arctic issues'.

Regarding local policy, the survey undertaken (Anonymous, 2019) revealed that a coastal planning act is currently in preparation for Icelandic fjords and coastal areas.

4.1.5   Kingdom of Norway

The Kingdom of Norway, excluding dependent territories and land claims, includes mainland Norway, Jan Mayen, Bjørnøya and the Svalbard archipelago. Of mainland Norway, three municipalities extend into the Arctic, namely Nordland, Troms and Finnmark.

Norway's current approach and attitude towards their Arctic territory and the wider Arctic as a whole is presented in 'Norway's Arctic strategy – between geopolitics and social development' (Government

of Norway, 2017) *(Policy; National)* released in 2017. This policy addresses both foreign and domestic issues and particularly focusses on international cooperation, sustainable business development, leadership of knowledge expansion, environmentally sound infrastructure development, and maritime safety and security. The 2017 Arctic strategy is a replacement of 'Norway's arctic policy' (Government of Norway, 2014) of 2014, and earlier 'High North Strategy' (Government of Norway, 2006). A new government white paper currently under development is set to present the governments 'ambitions for a strong and innovative Arctic region', and will confirm their 'commitment to international cooperation' (Government of Norway, 2020)

With 80% of Norway's waters within the Arctic, and with 80% of Arctic maritime traffic passing though those waters (Government of Norway, 2014), it is unsurprising that a large amount of focus is given to Arctic maritime security and international cooperation. In regards to the subject of infrastructure therefore, focus is given to development of transport systems, power supply and digital infrastructure, all whilst 'limiting negative environmental impacts' (Government of Norway, 2017). There is no specific focus given to infrastructure in the coastal zone. Regarding the coast, particular attention is paid to maritime operations and security.

It is highlighted within 'Norway's Arctic strategy – between geopolitics and social development' (Government of Norway, 2017) that county councils have been given responsibility over regional development of infrastructure, albeit coordinated though a regional perspective. Infrastructure is also a priority at a Nordic cooperative level. Infrastructure planning at the county level within Nordland, Troms and Finnmark, primarily focusses on transport and energy. See 'Regional planstrategi for Nordland 2016 – 2020' (Nordland Fylkeskommune, 2016) *(Policy; Municipal)*, 'Troms regional-planstrategi-2016-2019' (Troms fylkeskommune, 2016) *(Policy; Municipal)*, and 'Regional planstrategi for finnmark 2016 – 2019' (Finnmark Fylkeskommune, 2016) *(Policy; Municipal)*. Within these, more detailed plans are in existence.

At a more detailed standards level, a large proportion of Norway's Arctic interest is in Oil and Gas for which many standards have been developed across various nations. The primary Arctic standards within this industry are international standards and are thus not considered here. Building constructions within Norway are subject to 'Building Technical Regulations (TEK17)' (DIREKTORATET FOR BYGGKVALITET, 2017) *(Standard; National)*, where TEK17 is the current version. TEK20 is currently under development.

4.1.5.1   Svalbard

Of primary consideration in Svalbard, is the 'Svalbard Treaty' (Sysselmannen, 1920). Originally constructed in 1920, the Svalbard Treaty, as of 2005 had 39 signatories (Finstad, no date). Although the treaty grants Norway sovereignty over the archipelago with the authority to impose laws on development and environmental practices etc, it does so with restrictions. These restrictions extend to

non-discrimination against all of the signatories, thus allowing infrastructure development and resource extraction by all signatory nations, of which Norway and Russia are currently the primary participants.

As such, there are two different focusses on built infrastructure development in Svalbard, that of the Norwegians and that of the Russians. It is seen that the Russians develop their infrastructure in a fashion to ensure longevity. Development is undertaken to ensure permanence, and as such, infrastructure is planned thoroughly from the off and developed for the long term. This approach is not necessarily economically sustainable. Norwegian development on the other hand is more economically focussed as a result of historic step by step development.

Longyearbyen is the principle Norwegian settlement in Svalbard and as such represents the Norwegian approach to development of built infrastructure in the High Arctic. In planning, Longyearbyen is subject to an area plan (Longyearbyen Lokalstyre, no date) *(Regulation; Local)*, with sub partial plans within this as produced by the municipality. The extent of sustainability (environmental, social etc.) that is considered depends on the individual Engineers and Architects that then develop within these plans, with the ultimate focus on how green and/or sustainable a building is, at the discretion of the client (Wickström, 2019).

Resultant of geopolitical priorities, it is not desired that Longyearbyen should grow in size (Wickström, 2019), which is in difference to a normal development consideration. Planning therefore focusses on other aspects such as reorganisation and replacement to better adapt the settlement to its current function. The outcome of planning exercises by Longyearbyen Lokalstyre however, and thus the approach / direction that development of the town takes, is very dependent on who is currently in charge. Given a high turnaround of local government staff there are lots of changes in approach (Wickström, 2019), and it was felt that the municipality focussed more on the type and form of infrastructure itself rather than the social impact that that piece of infrastructure may have.

Construction in Svalbard is largely undertaken as per the mainland, with not too many special considerations. In Longyearbyen each construction is undertaken on a case by case basis using local knowledge and always with first consideration of svalbardmiljøloven (The Svalbard Environmental Act) (LOVDATA, 2002) *(Regulation; Municipal)*. Although the current TEK17 building regulations are used in mainland Norway, on Svalbard, construction is undertaken in line with the previous TEK10, excepting some modifications to requirements for storage and disabled access. TEK10 appears to be weak on the reuse of materials and has little context for the Arctic (Wickström, 2019). There is a need for technical standards developed for the Arctic.

Regarding the interplay between knowledge and literature, it was identified during consultation with Wickström, (2019) that the first port of call is usually personal experience, or that of colleagues, followed by specific literature and then academic research. It was identified that there is a general lack of experience in the Arctic surrounding construction of the built environment. These conclusions are fundamentally the same as those expressed by Kjetil Bråten, (2020) – director of the port of Longyearbyen. Bråten, (2020) also expressed the view that there are not many people who know about

the problems faced in the Arctic, and confirmed that in development of the port there was a strong reliance on local academics for guidance. Additionally, there is use of external consultancies, consultancies whom it must be pointed out are technically focussed, but not polar specific.

The same goes for literature used by Bråten, (2020). In development of the port, the only literature that was identified as being of any use is the Port Designer's Handbook (Thoresen, 2014), which is not tailored to the Arctic. There is no other useful literature available to stipulate what must be considered (Bråten, 2020). Indeed, there is no collaborative coastal guidance known about (Wickström, 2019). Regarding literature created by the port, there is a developed strategic port plan for Longyearbyen (Multiconsult, 2014).

4.1.6   Sweden

Unlike Norway, Sweden does not boast an Arctic coastline. Rather its Arctic interests are limited to its northernmost Norrbotten county located above the Arctic circle. At a national level, 'Sweden's strategy for the Arctic region' (Government of Sweden, 2011) *(Policy; National)* published in 2011 has a strong focus on international collaboration. The strategy considers Sweden's ties to the Arctic and then its priorities. These are 'climate and the environment' dealing with protection, biodiversity, and research, 'Economic development' dealing with trade, industry, and education, and 'the human dimension' dealing with environmental aspects, languages and knowledge transfer.

Within 'Sweden's strategy for the Arctic region' the need for infrastructure is correlated to the emergence of 'shipping, hunting, fishing, trade and energy extraction' (Government of Sweden, 2011) opportunities. Focus is given to infrastructure adaptation resultant of changing climate and land and maritime transport infrastructure provision. In relation to Sweden's coastal considerations, expertise are offered in 'Maritime security and the environmental impact of shipping' and 'sea and air' search and rescue capabilities (Government of Sweden, 2011).

Further to their 2011 policy, in 2016 Sweden released a 'New Swedish environmental policy for the Arctic' (Ministry of the Environment and Energy, 2016) *(Policy; National)* that furthers security and protection for the Arctic environments. It highlights a need for 'stronger climate efforts', 'better protection of biodiversity and ecosystems', and 'Sustainable use of resources'.

4.1.7   Finland

Finland's approach to its Arctic territory is much the same as that of Sweden, unsurprising given their geographical similarities. Finland's Arctic territory is that of Finnish Lapland, and like Sweden has no Arctic coastline.

At a national level, the Government of Finland's vision for the Arctic is set out in its 2013 'Strategy for the Arctic Region' (Government of Finland, 2013) *(Policy; Procedure; National)* and subsequent 2016

'Government Policy Regarding the Priorities in the Updated Arctic Strategy' (Prime Minister's Office Finland, 2016) *(Policy; National)* and 2017 'Action Plan for the Update of the Arctic Strategy' (Prime Minister's Office Finland, 2017) *(Procedure; National)*. Finland's 2013 vision extends to promoting Finland as an Arctic country and as an Artic expert and to enshrining the principles of sustainable development whilst participating in international cooperation. Particular focus is given to the role of the EU along with ongoing partnership with neighbouring Arctic states. Within this their strategy extends to consider Arctic residents, education and research, Arctic business and the economy, infrastructure, the environment, stability and international cooperation in the Arctic (Government of Finland, 2013).

The offerings of Finland of particular relevance to the built environment, construction and operation include energy infrastructure, the offshore industry, maritime industry, shipping, cold climate expertise, social sustainability and Arctic environmental expertise. Particular focus is given to the energy industry, renewable natural resources, mining, clean technologies, tourism, transport and the digital environment.

Although, like Sweden, Finland has no Arctic coastline, it does have significant maritime experience and indeed of managing a coastal zone subject to cold climate conditions. In regards to expertise associated with the coastal zone, 'Finland's Strategy for the Arctic Region 2013' (Government of Finland, 2013) identifies design of oil and gas offshore and coastal infrastructure based on their expertise in material technologies.

The 2016 'Government Policy Regarding the Priorities in the Updated Arctic Strategy' (Prime Minister's Office Finland, 2016) builds upon the 2013 policy by clearly defining Finland's priorities within 'Arctic foreign and EU policy', 'Sustainable Tourism', 'Arctic Expertise' and 'Infrastructure'. The procedure for achieving Finland's infrastructure aims is set out in their 2017 'Action Plan for the Update of the Arctic Strategy' (Prime Minister's Office Finland, 2017), and includes, telecommunications, rail, internet, space and roads infrastructure.

In response to the survey (Anonymous, 2019) it became clear that Finland operates a regional / municipal planning strategy with spatial planning the responsibility of the municipalities.

4.1.8 Russian Federation

Arctic policy in the Russian Federation is largely a national affair, with 'basic objectives, primary goals and strategic priorities of the state policy of the Russian Federation in the Arctic' determined by 'national interests'. 'The realization of national interests of the Russian Federation in the Arctic is provided by institutions of the state power together with institutions of the civil society in strict conformity with the legislation of the Russian Federation and its international treaties' (Government of the Russian Federation, 2008).

The Russian Federation's current Arctic policy, adopted 2020, is established in the President's Executive Order: 'Basic Principles of Russian Federation State Policy in the Arctic to 2035.'

(Government of the Russian Federation, 2020) *(Policy; Procedure; National)*. The basic national interests of the Russian Federation in the Arctic are:

1. 'To ensure Russia's sovereignty and territorial integrity'.
2. 'To preserve the Arctic as a territory of peace and stable mutually beneficial partnership'.
3. 'To guarantee high living standards and prosperity for the population of the Russian Arctic'.
4. 'To develop the Russian Arctic as a strategic resource base and use it rationally to speed up national economic growth'.
5. 'To develop the Northern Sea Route as a globally competitive national transport corridor'.
6. 'to protect the Arctic environment, the primordial homeland and the traditional way of life of the indigenous minorities in the Russian Arctic'.

Additionally, the document sets out both the broad implementation pathway for the state policy in the Arctic, and identifies the primary national security challenges in the Arctic (Presidential Executive Office, 2020b). The importance of Arctic security is highlighted in the national interests of 'sovereignty and territorial integrity', and 'living standards and prosperity', new in the 2035 Arctic strategy. The remaining interests of peace and cooperation, use of the 'Arctic as a strategic resource base', utilisation of the Northern Sea Route, and protection of Arctic ecosystems are consistent with the previous 2020 strategy (Government of the Russian Federation, 2008).

The broad implementation pathway to fulfilment of the basic principles is seen to include the development of 'better infrastructure and technology to help "settle the Arctic"', privatised energy investments, incentives for population relocation into the Arctic, enhanced communications infrastructure, and strengthened borders, partially for increased neighbourly cooperation (AFP, 2020).

Consideration of the Arctic however is not limited to the basic principles, but is bolstered by additional implementation procedure (Security Council of the Russian Federation, 2020), such as the 'Strategy of Development of the Arctic Zone of the Russian Federation and the Provision of National Security for the Period to 2035' *(Procedure; National)* currently under development (Buchanan, 2020). Additionally, to support implementation of the strategy, there will be revision of the 'Social and Economic Development of the Arctic Zone of the Russian Federation' *(Policy; National)* programme (Security Council of the Russian Federation, 2020).

Further measures to aid Arctic development include recent amendments to the Tax Code of the Russian Federation in order to incentivise the production of hydrocarbons in the Arctic regions, particularly Arctic offshore (Presidential Executive Office, 2020a). Although the vision for the Arctic is coordinated at a federal level, as AMAP, (2017a) identifies, since 1991 there has been steady decentralization of 'functions and competences' away from federal government to the Chukotka Autonomous Okrug and local governments in relation to 'environmental, climate change, and natural resource policies', thus enlarging capacity for action in these areas.

For the fact that it stretches around nearly one half of the Arctic circle, the coastal regions are an important aspect of the Russian Arctic, and attention must be given to its development. This is done so in the 'Development Strategy of the Sea Port Infrastructure of Russia until 2030' (Maritime College, 2015) *(Procedure; National)*, whose priorities (Rosmorport, 2020) are:

- 'To provide accelerated growth of terminals of primary importance (container and coal terminals)'.
- 'To ensure the development of harbours in the main sea basins of the country'.
- 'To eliminate disproportions in the development of approaching railways and motorways to seaports.

Russian standards for construction in the Arctic come from both the federal and state level and from industry. Information relating to cold climate specifics, such as permafrost, and its relation to linear infrastructure can be found across standards for various industries. Such standards are contained in the SNIP (building regulations) database (SNIP, 2020) *(Standards; National)*.

4.2   Pan-Arctic and international collaborations

Further to the various literature and cooperatives at national level, there is a large array of international collaborations that offer governance, policy, and guidelines. Some of these collaborations are pan-Arctic, and some are regionalised within the Arctic.

The idea for cross-collaboration between the Arctic nations arose in 1987, with the proposal of Mikhail Gorbachev, Secretary-General of the Soviet Communist Party, to create an Arctic 'zone of peace' (Gorbachev, 1987). Speaking in Murmansk, at a time of geopolitical Cold War strife Gorbachev 'launched a series of policy initiatives that tied together a wide array of security, economic and environmental issues in a unified package' (Åtland, 2008). To the ends of achieving a 'zone of peace', the policy initiatives focussed on the de-securitization of non-military Arctic issues between the eastern and western hemispheres (Åtland, 2008). Cooperation between Arctic states was suggested in the areas of resource extraction, scientific exploration, indigenous peoples, environmental protection, and marine transportation (Gorbachev, 1987). Such civilian initiatives 'ultimately came to mark the beginning of the end of the Cold War era in the Arctic' (Åtland, 2008)

Despite the delayed or yet unachieved realisation of collaborative policy in these areas, Gorbachev, (1987) identified some key ideas still of great relevance today and of pertinence to the built environment and infrastructure development. In recognising the need for 'peaceful cooperation in developing the resources of the North' Gorbachev, (1987) identified the **extreme importance of experience and knowledge exchange to the 'rational development of northern areas'**. Two ideas put forth were the creation of a collaborative 'energy programme for the north of Europe', and the creation of pan-Arctic 'firms and enterprises' for mineral extraction. Separately, it was identified that **'the scientific exploration of the Arctic is of immense importance for the whole of mankind'** and an increase of

scientific exchange was proposed, notably the holding of a conference of sub-Arctic states. Likewise, the '**interests of the indigenous population of the North' were recognised as important**, and '**the study of its ethnic distinctions and the development of cultural ties between northern peoples' highlighted as requiring 'special attention'**. An urgent need for **cooperation 'of the northern countries in environmental protection**' was also recognised, with the suggestion made of extending marine protection measures of the Baltic to the entirety of Arctic waters. It was highlighted that 'the **North European countries could set an example to others by reaching an agreement on establishing a system to monitor the state of the natural environment'**. Lastly, in relation to marine transportation, Gorbachev raised the idea of the Northern Sea Route being opened up to foreign vessels (Gorbachev, 1987).

The above ideas, of relevance to Arctic built infrastructure, can be distilled into the following: **knowledge sharing; collaborative scientific monitoring; protection of the natural environment; social inclusion; and shared differences**. In extension to those prominent areas of collaboration identified, the idea of collaborative infrastructure and companies is seen. Rather than being limited to northern Europe, **collaborative infrastructure and companies could extend across the Arctic**. One such application may be to the shipping industry. Similarly, as North European countries could set an example to others on monitoring the state of the environment, so too could **the Arctic as a whole demonstrate to the world, true holistic sustainable development.** The way that **the built environment is of dominant relevance to all peoples and its presence, or thereby lack of presence throughout the Arctic, makes infrastructure an ideal and necessary element for consideration in the pursuit of a sustainable Arctic.** Just as collaborative civilian policy initiatives proposed by Gorbachev in 1987 commenced the easing of geopolitical tensions in the Arctic then, so to can **a pan-Arctic focus on non-militarised holistic collaborative sustainable development of Arctic built infrastructure aid today in limiting geopolitical tensions at the Arctic frontiers of the European, Asian and American continents.**

Of Gorbachev's proposals for areas of cooperation, only some gained traction. Given the security tensions of the time, the idea of cooperative resource extraction floundered for a lack of commitment to technological knowledge transfer. Pan-Arctic cooperation on scientific exploration on the other hand proved to be a resounding success. With international support having been given for a body to coordinate international Arctic research, the International Arctic Science Committee (IASC) was established in 1990 (IASC, no date). Regarding indigenous peoples, 1987 marked a soviet policy change, from restriction of indigenous peoples interacting with their non-Soviet counterparts, to more open contact. Little progress was initially made on cooperation over environmental protection, excepting that which could be achieved without discussion of arms control issues. Lastly, the issue of passage along the Northern Sea Route. Although perceived by the Soviet Union at the time as a 'military utility', Gorbachev seemingly recognised the commercial value to international shipping and resource extraction, and the Northern Sea Route was opened to foreign vessels in 1991 (Åtland, 2008).

The idea of convening all of the Arctic states was realised in 1989 in Rovaniemi, Finland (Barry, 2020a). Here, discussions commenced on arranging a meeting of 'circumpolar Ministers responsible for Arctic environmental issues' (AEPS, 1991), along with the development of an Arctic Environmental Protection Strategy (AEPS). The developed strategy was resultant of cooperation between the eight Arctic states, indigenous peoples groups, non-Arctic nations, and the International Arctic Science Committee (IASC) (AEPS, 1991). These discussions resulted in the subsequent 1991 signing of the 'declaration on the protection of the Arctic environment', proving to be the first steps in the creation of the Arctic Council.

Today, international governance in the Arctic can be seen in the form of both soft law, and hard law. Soft law is soft for the fact that it is not actually law, i.e. it is not legally binding (Sandvick, 2019). Rather it describes declarations and agreements encompassing policy, procedures, and guidelines. Hard law on the other hand is legally binding, with obligations placed on parties enforceable within court (Sandvick, 2019). International law is constructed around maintained sovereignty of independent nations, and thus the degree to which a multinational agreement is hard or soft is flexible (Sandvick, 2019).

The majority of international agreements in the Arctic are considered soft law. This means that although the signatory countries should agree with the enclosed broad principles, they may disagree with particulars and they retain their sovereign rights and independence. This is arguably a challenge to agreement on controversial issues, such as military security. In general however, international agreements work for the fact that they are constructed to advance the interests of the signatory nations. For rather more controversial issues requiring regulation, hard law becomes the tool of choice. At an international level, treaties are a common form of governance. A Treaty is 'a binding formal agreement, contract, or other written instrument that establishes obligations between two or more subjects of international law (primarily states and international organisations)' (Shaw, 2019). A prime example of such a treaty is the 1945 Charter of the United Nations (United Nations, 2020a). In many cases, international treaties have themselves instigated the development of new international regulations and directives. One such example of this is the 1982 United Nations 'Convention on the Law of the Sea' (UNCLOS) (United Nations, 1982), which took 12 years to ratify (Shaw, 2019). Other examples which took a respectively much shorter time to ratify include the 1992 'Convention on Biological Diversity', and the 1992 'United Nations Framework Convention on Climate Change' (UNFCC) (Shaw, 2019). Some of the most widely applicable Arctic fora and collaborative instruments are summarised herein and have a focus ranging from international to sub-regional. Particular attention is given to the Arctic Council as it is the premier fora for Arctic governance.

Soft Law cooperation:

- Intergovernmental forums (e.g. Arctic Council).
- Arctic cooperative bodies (e.g. IASC).
- Interparliamentary & Intergovernmental bodies (e.g. Nordic Council).

- Sub-regional cooperative bodies (e.g. Northern Forum).

Hard law cooperation:

- Global multilateral agreements (e.g. United Nations).
- Regional multilateral agreements.
- Executive meetings of Arctic coastal states (e.g. Ilulissat Declaration).
- Arctic specific agreements (e.g. Polar Code).

4.2.1   Arctic Council

Prior to the formation of the Arctic Council (AC), pan-Arctic collaboration at a political level was restricted to a series of ad hoc meetings of 'circumpolar Ministers responsible for Arctic environmental issues' (AEPS, 1991), as described, which in 1991 led to a joint 'Declaration on the Protection of the Arctic Environment'. This declaration committed to a transboundary action plan in support of the 'Arctic Environment Protection Strategy' (AEPS, 1991), which included 'cooperation in scientific research', 'assessment of potential environmental impacts of development activities', and measures for the control of pollutants (AEPS, 1991).The underlying motives of the strategy included the safeguarding of the Arctic environment for people and nature under development for 'our common future' (AEPS, 1991). This includes protection of indigenous cultures, and prevention of environmental degradation. The principle areas of strategy focus included 'persistent organic contaminants, oil, heavy metals, noise, radioactivity, and acidification' (AEPS, 1991).

The strategy was to be implemented through national legislation and in accordance with international law. The strategy recognised that cooperation through multilateral agreements 'among both circumpolar and non-circumpolar nations' (AEPS, 1991) is required. Practically, implementation of the strategy was to be achieved through four principle measures, namely: Arctic Monitoring and Assessment Programme (AMAP); Protection of the Marine Environment in the Arctic (PAME); Emergency Prevention, Preparedness and Response in the Arctic (EPPR); and Conservation of Arctic Flora and Fauna (CAFF). The meetings of the circumpolar officials and indigenous peoples officially became the Arctic Council in 1996 with the signing of the 'Declaration on the Establishment of the Arctic Council' – the Ottawa declaration (Arctic Council, 1996) *(Policy; International)*.

The Ottawa declaration affirmed the commitment of the eight Arctic countries to 'the well-being of the inhabitants of the Arctic', 'to sustainable development', and 'to the protection of the Arctic environment' (Arctic Council, 1996). The Arctic Council recognised 'the contributions of the Arctic Environmental Protection Strategy', the importance of both 'traditional knowledge' and 'of Arctic science and research', and the contribution of indigenous peoples groups in the development of the Arctic Council (Arctic Council, 1996). Lastly, the declaration demonstrated a desire to promote 'circumpolar cooperation' with 'full involvement of indigenous people and their communities and other

inhabitants of the Arctic' through 'regular intergovernmental consideration of and consultation on Arctic issues' (Arctic Council, 1996).

Ultimately, the Arctic Council was established as a top-level pan-Arctic intergovernmental forum providing for pan-Arctic consensus based political discussion on shared interests. The work of the Arctic Council is focussed on a sustainability motion and in particular sustainable development and environmental protection. The topic of discussion within the Arctic Council is everything except military action, thus providing a key platform for cooperation between the eight arctic nations, indigenous peoples and other Arctic inhabitants in accordance with international law. The Arctic Council in 1996 subsumed the AEPS, and thus retained a primary environmental focus though its four working groups – AMAP; CAFF; PAME; and EPPR. The scope of the Arctic council was later expanded with the addition of two further working groups: the Sustainable Development Working Group (SDWG) – Established 1998; and the Arctic Contaminants Action Program (ACAP); – established 2006 (Arctic Council, 2020).

Further to six working groups, the Arctic Council is made up of eight Arctic states, and six permanent participants (Arctic Council, 2020). The member states include Canada, The Kingdom of Denmark, Finland, Iceland, Norway, The Russian Federation, Sweden, and the United States of America. The permanent participants include: the Aleut International Association (AIA); Arctic Athabaskan Council (AAC); Gwich'in Council International (GCI); Inuit Circumpolar Council (ICC); Russian Association of Indigenous Peoples of the North (RAIPON); and the Saami Council (SC). The permanent participants hold full consultation rights, but no voting rights, and their number is always less than the number of Arctic states (Barry, 2020a).

4.2.1.1   *Arctic Council operation*

As to how the Arctic Council operates, it is a consensus body in which decisions are made through acceptance by all parties. Topics of friction are largely put aside. Decisions made by the council are not legally binding, and recommendations do not have to be followed (Barry, 2020a). At the highest level, every two years, there is a ministerial meeting of foreign ministers of the Arctic countries, at which a declaration is signed. This declaration supports the work of the previous two years and identifies priorities for the next two. Additionally, work plans presented by the working groups are agreed upon (Barry, 2020a). Below the foreign ministers and on a more regular basis, the top level of the Arctic Council are the Senior Arctic Officials (SAO's) – representatives from the eight Arctic countries responsible for interpreting the outcomes of the working groups and translating them into agreeable policy proposals. The underpinning documents of the Arctic Council are therefore the Ottawa declaration, the biannual SAO report to ministers, and the biannual minister's declaration. The focus of the Arctic Council shifts every two years with its chairmanship, and as such the Arctic Council does not have an overarching strategy. The Arctic Council is currently under an Icelandic chairmanship which has an overall theme of sustainable development. Iceland's four priorities include: 'The Arctic

Marine Environment, Climate and Green Energy Solutions, People and Communities of the Arctic, and a Stronger Arctic Council' (Arctic Council, 2020).

Considering the SAO reports to ministers from the previous three chairmanships (Canada - 2015, US - 2017, Finland - 2019) (Arctic Council, 2015, 2017b, 2019), a number of trends of focus for the Arctic Council can be seen. In connection to the consideration of **infrastructure**, across the three chairmanships focus is consistently given to digital infrastructure for Arctic Spatial Data and telecommunications. In the different chairmanships, further general focus is given to port, marine and research infrastructure, improved preparedness, safety and assessment of community, industrial and environmental infrastructure, reduced waste and pollution with increased sustainability, and citizen engagement for construction and connectivity.

In consideration of **coastal** activities, consistent focus across the three chairmanships is given to biodiversity and ecosystem-based management. In the different chairmanships, further general focus is given to environmental change, cultural and resource use of coastal areas, conservation, sustainable use and economic opportunities, tourism, and waste management.

With regard to **sustainable development**, specific focus across the chairmanships is given to the human dimension – development for people based on the classic three pillars of sustainability understanding, encompassing social, economic and environmental aspects. Prominent focus areas include environmental protection and traditional knowledge and food practices. Other focus areas within the various chairmanships include WASH (water, sanitation, and hygiene) and energy infrastructure, education, business and economic development, pollution and climate, culture and health, and improved connectivity.

The primary work of the Arctic Council, as previously mentioned is largely carried out through the six working groups, with each working group maintaining its own strategy. In addition a task force or expert group can be appointed at ministerial meetings to investigate a specific issue (Arctic Council, 2020). These include:

- Task Force on Arctic Marine Cooperation (TFAMC).
- Task Force on Improved Connectivity in the Arctic (TFICA).
- Task Force on Telecommunications Infrastructure in the Arctic (TFTIA).
- Task Force for Enhancing Scientific Cooperation in the Arctic (SCTF).
- Task Force on Arctic Marine Oil Pollution Prevention (TFOPP).
- Task Force on Black Carbon and Methane (TFBCM).
- Task Force to Facilitate the Creation of a Circumpolar Business Forum (TFCBF).
- Task Force for Institutional Issues (TFII).
- Task Force on Search and Rescue (TFSR).
- Task Force on Arctic Marine Oil Pollution Preparedness and Response.
- Task Force on Short-Lived Climate Forcers (SLCF).

- Black Carbon and Methane Expert Group (2015 – Present).
- Ecosystem-based Management Expert Group (2011 – 2013).

Further to its work coordinating soft law pan-Arctic agreements, and although the Arctic Council holds no legal power, it has helped facilitate three legally binding agreements (Barry, 2020a), namely:

- Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic (Arctic Council, 2011) *(Regulation, International)*.
- Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic (Arctic Council, 2013) *(Regulation, International)*.
- Agreement on Enhancing International Arctic Scientific Cooperation (Arctic Council, 2017a) *(Regulation, International)*.

4.2.1.2   *Arctic Council task forces*

Two of the task forces of particular relevance to pan-Arctic cooperation and infrastructure are TFAMC and TFICA. In recognition that 'marine ecosystems do not necessarily correspond to the boundaries' delimited by national jurisdiction (Arctic Council Task Force on Arctic Marine Cooperation (TFAMC), 2017), the 'Report to Ministers' of the TFAMC *(Guidance, International)* 'identified the following functional needs for fulfilling' their 'role as the principal stewards of the Arctic marine environment into the future'.

- 'Extending cooperation throughout marine stewardship cycle'
- 'Integration across sectors and jurisdictional boundaries'.
- 'Integration of knowledge'.
- 'Strengthening the science-policy interface'.
- 'Regional cooperation in the development and regular assessment of ecological quality indicators and objective'.
- 'Regional cooperation on area-based stewardship'.
- 'Regional assessment, monitoring and accountability'.
- 'Communication and advocacy of Arctic marine stewardship'.
- 'Coordination of marine-related work within the Arctic Council and by the Arctic Council with other relevant bodies'.

Common themes of the identified needs include the necessity of **holistic cradle to grave considerations; pan-Arctic application; horizontal and vertical knowledge transfer; spatially scaled nature and society inclusion.**

The TFICA is the only current Arctic Council task force (Barry, 2020a), and has a focus on telecommunications infrastructure. The TFICA report 'Improving Connectivity in the Arctic' (Arctic

Council Task Force on Improved Connectivity in the Arctic, 2019) *(Guidance, International)* was commissioned to fulfil the given mandate of the TFICA to 'compare the needs of those who live, operate, and work in the Arctic with available infrastructure, and to work with the telecommunications industry and the Arctic Economic Council (AEC) to encourage the creation of the required infrastructure with an eye toward pan-Arctic solutions' (Arctic Council Task Force on Improved Connectivity in the Arctic, 2019). Currently, as the 2015 Senior Arctic Officials' Report to Ministers identifies, 'the existing telecommunications infrastructure in the Arctic is not sufficient to meet current demands for modern community needs, regional connectivity, human services, scientific observations, navigation, and support for potential emergency [search and rescue] or oil spill response' (Arctic Council, 2015). The authors of the 'Improving Connectivity in the Arctic' (Arctic Council Task Force on Improved Connectivity in the Arctic, 2019) report believe that 'modern connectivity will underpin economic growth, and allow for the delivery of better services to Arctic peoples', for example broadband internet. The report identifies that 'This work builds upon member states' commitments under the United Nations Sustainable Development Goals (UN SDGs) to strive towards providing "universal and affordable access," in order to help achieve sustainable development and to empower communities' (Arctic Council Task Force on Improved Connectivity in the Arctic, 2019). The key findings of the 'Improving Connectivity in the Arctic' report (Arctic Council Task Force on Improved Connectivity in the Arctic, 2019) are as follows:

- 'Close the digital connectivity gap'.
- 'Opportunities for improved connectivity in the Arctic are on the horizon'.
- 'The digital economy is taking shape in the Arctic'.
- 'Multiple solutions for connectivity'.
- 'Importance of redundancy'.
- 'Enable industry innovation through regulatory flexibility'.
- 'Need for regulatory clarity'.
- 'Windows of opportunities for infrastructure installation are short'.
- 'Gaps remain in Positioning, Navigation and Timing (PNT) services available across the Arctic'.
- 'Information gaps concerning Arctic connectivity remain'.
- 'The AEC seeks to be a resource body for the Arctic Council's future work on connectivity'.

Key themes across the findings include the benefits of infrastructure **provision to reduce inequalities, collaboration for optimisation, opportunities for innovation, infrastructure robustness, scale appropriate regulation, and patchy infrastructure.**

4.2.1.3   Arctic Council expert groups

As identified, one area of consistent focus of the Arctic Council is ecosystem-based management (EBM), and the need for its implementation. The Arctic Council understanding of EBM has been developed through the Ecosystem-based Management Expert Group, established in 2011. The final proposed definition of EBM was set out in the expert groups 2013 report (Expert Group on Ecosystem-Based Management, 2013) as follows:

'Ecosystem-based management is the comprehensive, integrated management of human activities based on best available scientific and traditional knowledge about the ecosystem and its dynamics, in order to identify and take action on influences that are critical to the health of ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity'

An important point set out within the report is that although 'EBM strives to integrate commercial, social, cultural, and ecological values', '**the ecosystem aspect is "first among equals" because ecosystem failure would compromise all other values or goals**; hence the term "ecosystem-based". The bottom-line of EBM is ecosystem sustainability, without which there is no means to assure sustainable economic or social systems'(Expert Group on Ecosystem-Based Management, 2013).

In proposing activities to be undertaken by the Arctic Council, the Ecosystem-based Management Expert Group identify that 'advancing Arctic EBM will require the **identification of important coastal, marine, and terrestrial areas, improved data comparability and compatibility, enhanced information exchange and monitoring, and improvements in the development and use of integrated assessments'** (Expert Group on Ecosystem-Based Management, 2013). It is further suggested that the marine and terrestrial Arctic should be divided into assessment units 'based upon ecological criteria or existing ecoregions' (Expert Group on Ecosystem-Based Management, 2013), that is to say complete **ecosystems should be considered at different scales – local, regional and transboundary. To that extent human activities, including the building of infrastructure, must be assessed and undertaken within the ecosystem scales, and as such thought must be given to infrastructure at a pan-Arctic level.**

4.2.1.4   Arctic Council Sustainable Development Program

The Arctic Council Sustainable Development Program was founded in 1998 alongside the Sustainable Development Working Group (SDWG) in order to 'propose and adopt steps to be taken by the Arctic States to advance sustainable development in the Arctic, including opportunities to protect and enhance the environment, and the economies, cultures and health of indigenous communities and of other inhabitants of the Arctic, as well as to improve the environmental, economic and social conditions of Arctic communities as a whole' (Arctic Council, 1998).

This was followed in year 2000 with the adoption by the Arctic Council of the 'Sustainable Development Framework Document' (Arctic Council, 2000) *(Policy Framework; International)*, a

document which sets out the considerations of the Arctic Council and their priorities in regard to sustainable development. Of note, the document identifies that:

'Sustainable Development must meet the needs of the present without compromising the ability of future generations to meet their own needs. Economic, social and cultural development are, along with environmental protection, interdependent and mutually reinforcing aspects of Sustainable Development and are all part of the Council s focus in this regard'.

The work of the Arctic council, is thus seen to be based on the common 1987 definition of sustainable development proposed within the World Commission on Environment and Development (WCED) report, 'Our Common Future' (World Commission on Environment and Development, 1987; United Nations, 2020e). Likewise, the Arctic Council's understanding of sustainable development appears to be based on the social, environmental and economic aspects traditionally considered together as the triple bottom line (Alhaddi, 2015). The six priorities of the Arctic Council, (2000) within sustainable development are identified as follows:

- 'Health issues and the well-being of people living in the Arctic',
- 'Sustainable economic activities and increasing community prosperity',
- 'Education and cultural heritage',
- 'Children and youth',
- 'Management of natural, including living resources',
- 'Infrastructure development'.

4.2.1.5 Sustainable Development Working Group (SDWG)

Although the Arctic Council has a sustainable development focus in general, the environmental, economic, and social aspects are largely considered separately. For the most part the environmental component is well considered, across ACAP, AMAP, CAFF, EPPR and PAME. The wider consideration of sustainable development, particularly the human dimension is given to the SDWG. As outlined in 'SDWG 2019 – 2021 work plan' (SDWG, 2019c), the SDWG generally work within 12 thematic areas as follows:

1. Educational Opportunities,
2. Heritage and Culture of Arctic Communities,
3. Reduction/Elimination of Inequalities,
4. Human Health,
5. Community Vitality,
6. Water and Sanitation Services,
7. Infrastructure,
8. Sustainable Energy,
9. Transport Links,

10. Science and Research for Sustainable Development,
11. Economic Assessments,
12. Sustainable Business Involvement and Development.

What can be observed from studying the range of current and past SDWG projects is that focus is given to tackling the perceived problems of humankind. A strong focus is given to investigating and making recommendations on how to improve the living, economic, social, and cultural situation of Arctic inhabitants.

4.2.1.6   Significant Arctic Council and working group literature

Within the various working groups, a number of reports have been produced which are particularly pertinent to sustainable development of infrastructure in the coastal zone. These reports take the form of science assessments, and summaries thereof, reports for policy makers, and action plans (Barry, 2020a). Significant reports include:

1. **'Arctic Marine Shipping Assessment' (AMSA)** (Arctic Council, 2009) (Guidance; International)

The 2009 AMSA recognised that **'Currently, vast areas of the Arctic have insufficient infrastructure to support safe marine shipping and respond to marine incidents in the Arctic'**. Regarding bult infrastructure this extends to 'supporting shoreside infrastructure to respond appropriately to marine incidents; port reception facilities for ship-generated waste; and availability of deep water ports, places of refuge and salvage resources for vessels in distress' (Arctic Council, 2009).

2. Adaptation Actions for a Changing Climate (AACA)

The AACA is a long standing project of the Arctic Council, establishing an integrated assessment of the drivers of change in the Arctic, with the objective of enabling 'more informed, timely and responsive policy and decision making in a rapidly changing Arctic' (Arctic Council, 2014). The third part of AACA, commenced by AMAP in 2013 was to 'produce information to assist local decision makers and stakeholders in three pilot regions in developing adaptation tools and strategies to better deal with climate change and other pertinent environmental stressors' (AMAP, 2017d). These three areas include the Bering, Chuckchi, Beaufort region; Baffin Bay / Davis Strait Region; and Barents Area. Assessment was carried out and presented in a set of three overview reports and three supporting scientific reports. Lessons learnt regarding infrastructure across the three areas include:

'Bering, Chuckchi, Beaufort region Overview Report' (AMAP, 2017d) (Guidance; International)

- 'Significant investment in infrastructure, hydrographic research, and safety (search and rescue) would be required' for increased transportation and tourism through the Northwest Passage.

- Considering the sustainability of commercial fishing, 'the ability of communities to economically benefit from fisheries' in part 'depends on investment in infrastructure'.
- 'The extractives sector also faces risks from climate change, such as the effects of permafrost thaw on infrastructure, transport routes, waste containment and hydrology'.

'**Baffin Bay / Davis Strait Region Overview Report**' (AMAP, 2017b) (Guidance; International)

- Climate change is identified as negatively affecting human health and non-living resource development through its impact on 'existing and planned infrastructure'.
- 'Permafrost thaw, changing patterns of precipitation, and increased incidence of extreme weather' are identified as being the main drivers of impact on 'housing, municipal and industrial building, and transport infrastructure in the region'.
- 'Coastal erosion and changes in sea level also are likely to impact infrastructure in the region, and falling relative sea levels caused by reduced icecap mass could potentially leave ports stranded'.
- 'Focused climate-related predictions of, for example, permafrost thaw, have considerable practical value for designing infrastructure'.
- 'Decision makers responsible for designing, building, maintaining, and decommissioning industrial infrastructure have limited understanding of the likely impacts of future climate changes, as well as limited guidance on how to adjust to the likely changes'.

'**Barents Area Overview Report**' (AMAP, 2017c) (Guidance; International)

- Infrastructure will have a key role in local extractive industries of large influence to future prospects of the area.
- Infrastructure development, 'will have particular implications for Indigenous Peoples in the area, in that it could lead to fragmentation of land used for reindeer herding'.
- 'A constant upgrading of infrastructure' has in part, historically allowed 'the small, open Nordic economies' be 'quick to adapt to new economic and technological conditions'.

Section 10.9.2 – Policy and regulation of AMAP, (2018) describes well the major challenge facing the Arctic construction sector at a practical level, particularly in the Baffin Bay / Davis Strait Region:

'Several infrastructure issues related to permafrost thawing result from using designs that are poorly adapted to site-specific ground and environmental conditions in Arctic regions. The use of inappropriate designs clearly reveals limited knowledge at most coordination levels and among various actors involved in construction projects. This current situation results partly from the limited regulatory framework and appropriate governance structures available for construction in the BBDS region.'

3. Arctic Resilience Action Framework (ARAF)

The Arctic Resilience Action Framework (ARAF) is a cross-cutting 'regional resilience framework' of the Arctic Council 'to address the urgent need to collaboratively build arctic resilience'. It is 'to improve coordination and shared learning around the resilience approach and demonstrate the suitability of Arctic resilience efforts for additional public and private investment (SDWG, 2019a). The ARAF has four overarching priorities with subordinate action areas. These are summarised in Figure 4-1 extracted from The Arctic Resilience Action Framework Review Committee, (2017).

As part of the ARAF a series of Arctic case studies which build resilience were reviewed. Five commonalities were identified as follows:

- 'Capacity for self-organization'.
- 'Diversity of response options'.
- 'Integration of different knowledge types and systems'.
- 'Sustainability of livelihoods'.
- 'An orientation to change as the norm'.

Outcome			
A measurable increase in the capacity of Arctic States and Arctic communities to understand and respond to risks and changes in ways that support social-ecological development and healthy, functioning ecosystems and ecosystem services.			
Goal			
To mobilize and use the broad competence and expertise of all Arctic Council Member States, Permanent Participants, Working Group secretariats and Observers, along with other Arctic stakeholders, to provide the information, tools, analysis, and capacity necessary to address immediate and future resilience and adaptation needs in the circumpolar Arctic.			
Priority Areas and Action Areas			
Priority Area 1: Analyzing and Understanding Risk and Resilience in the Arctic	Priority Area 2: Building Resilience and Adaptation Capacity	Priority Area 3: Implementing Measures that Build Resilience with Policy, Planning and Cooperation	Priority Area 4: Encouraging Investment to Reduce Risk and Build Resilience
Increase the effectiveness of existing monitoring systems and include social-ecological indicators and their interactions Substantially enhance our understanding of ecologically vulnerable areas and areas in which Arctic-adapted biodiversity can persist under a changing climate Improve short and long-term projections for the Arctic under different future greenhouse gas emission and development scenarios, using natural and social sciences and indigenous/Traditional Knowledge and local knowledge Expand the documentation of adaptation responses to changing threats in the Arctic	Increase the co-production of knowledge using science, Indigenous/Traditional Knowledge and local knowledge Expand the ability of community-based observation networks to collect critical data for monitoring change and integrate with Earth observations Improve tools for assessing management strategies in changing Arctic ecosystems Ensure data and tools are equitably distributed and easily accessible for local communities, decision makers, and policy makers at all levels Substantially increase the number of communities, youth and emerging leaders that understand Arctic change using a variety of knowledge approaches Increase administrative and planning support to communities, governments and decision-makers at all levels, including support for applying resilience knowledge to decision-making	Increase the inclusion of local perspectives in local and sub-regional decision-making Enhance the development and deployment of resilient infrastructure, telecommunications, and technologies to deal with emerging challenges that are unique to the Arctic (e.g., waste, water security, energy, food security, health, etc.) Expand the use of ecosystem-based management in the Arctic Substantially expand the use of transdisciplinary approaches for understanding change and implementing strategies to enhance resilience Encourage consistent practices and for ensuring public participation and the integration of Indigenous/Traditional Knowledge and local knowledge in environmental impact assessments and other decision-making processes	Improve our understanding of best practices for resilient or "climate proof" investments in the Arctic Substantially increase private sector investments that support resilient communities Expand the use of innovative financial mechanisms for improving resilience Encourage the identification of specific funding gaps and resilience priorities, as a way to provide guidance to potential donors and catalyze new investments
Guiding Principles			

- Build on the strengths of the Arctic Council as a regional mechanism for cooperation
- Value and draw on Indigenous/Traditional Knowledge and local knowledge
- Build upon existing global, regional and national strategies for sustainable development, climate change adaptation and mitigation, and disaster risk reduction
- Support multi-stakeholder engagement

- Empower local communities
- Address multiple risks together and look for co-benefits
- Consider risk and resilience across temporal and spatial scale
- Encourage innovative investments that prevent and proactively mitigate risk
- Monitor progress and adjust strategies as needed

Figure 4-1: Arctic Resilience Action Framework at a Glance. Source: The Arctic Resilience Action Framework Review Committee, (2017)

4. Arctic Maritime & Aviation Transportation Infrastructure Initiative (AMATII) (Institute of the North, 2020)

AMATII seeks to consider 'Arctic air and maritime transportation policy, education, and research from various vantage points' increasing pan-Arctic communication, collaboration and coordination of research and technology. As part of AMATII a workshop was held, considering Arctic Transportation Infrastructure: Response Capacity and Sustainable Development (Institute of the North, 2012). Regarding infrastructure and sustainable development, it was recognized that:

- 'Arctic nations should work to better understand the impact of transportation infrastructure on sustainable development, leveraging growth, change and increased activity in this pursuit'.
- Transport infrastructure impacts on 'social and economic development; cross-border collaborative opportunities'; environment and culture; and risk.
- Transportation and response infrastructure are closely tied to' 'the six priorities of sustainable development identified by the Arctic Council'.
- 'Careful planning inherent to a strategic approach in the Arctic' is required to deal with the negative impacts of climate change on the sustainability of infrastructure. E.g. deteriorating runway infrastructure.
- 'External (outside the Arctic) financing' of infrastructure could be either negative, or positive.
- Local workforce development brings community benefit.
- The development of infrastructure can 'facilitate community-building', e.g. the building of strengthened family groups'.
- The use of technology can limit environmental impact.
- 'Right-sizing infrastructure is also a key factor in sustainable development – for example, Arctic nations could improve sewage and water treatment facilities relative to runway lengths'.
- 'In the future, response capacity and sustainable development will be more clearly linked'. E.g. through improved utilization of and communication with local communities.
- Funding should be linked to development in cooperation with local communities.
- Infrastructure should be developed as much for the benefit of rural residents as for urban residents.
- A balance must be struck between increased tourism and the health of the resource that drives tourism, e.g. nature.

5. Zero Arctic: Concepts for carbon neutral Arctic construction based on tradition

As outlined in the 'SDWG Work Plan 2019 – 2021' (SDWG, 2019c), the objective of this project, under the theme of infrastructure, is to:

- 'Develop regional concepts for Arctic building construction that are carbon neutral over their full life-cycle'.
- 'Utilize both scientific life-cycle assessment and energy simulation methods'.

- 'Learn from and apply traditional knowledge of sustainable construction'.
- 'Explore the potential for compensating anthropogenic greenhouse gas emissions through natural and man-made carbon sinks in the context of Arctic construction'.
- 'Enable the capacity for continuous development of Arctic carbon neutral construction'.

6. **'Good Practices for Environmental Impact Assessment and Meaningful Engagement in the Arctic'** (SDWG, 2019b)

A common requirement for built infrastructure projects is the undertaking of an Environmental Impact Assessment (EIA). The Good Practices for Environmental Impact Assessment and Meaningful Engagement in the Arctic document considers good practice and makes subsequent recommendations as follows:

- 'Seek true dialogue to meaningfully engage'.
- 'Utilize Indigenous knowledge and local knowledge'.
- 'Build internal capacity and provide resources to meaningfully engage in EIA'.
- 'Allow EIA to influence project design and decision-making process'.
- 'Strengthen circumpolar cooperation on transboundary EIA'.

4.2.2   Arctic Economic Council

Created by the Arctic Council, the Arctic Economic Council, (no date) (AEC) is arranged to facilitate 'Arctic business-to-business activities and responsible economic development through the sharing of best practices, technological solutions, standards, and other information' The AEC represents and works for five overarching themes, namely:

- 'Fostering strong market connections within the Arctic as a vital part of international value chains'.
- 'Encouraging public-private partnerships for infrastructure Investments'.
- 'Promoting stable and predictable regulatory frameworks'.
- 'Facilitating knowledge and data exchange between industry and academia'.
- 'Embracing traditional indigenous knowledge, stewardship and small business'.

4.2.3   International Arctic Science Committee (IASC)

In their own words, 'the International Arctic Science Committee (IASC) is a non-governmental, international scientific organization', with 'a mission of encouraging and facilitating cooperation in all aspects of Arctic research, in all countries engaged in Arctic research and in all areas of the Arctic region' (IASC, no date). Thus, in difference to the Arctic council, IASC focusses first on Arctic research and its communication, with pan-Arctic cooperation and policy formation second. None the less,

cooperation is of great importance as recognised at the 2018 Arctic Circle Assembly session: 'The Cooperation of Arctic Science with Business and Industry', in which it was identified that **cooperation needs to be extended to 'academic, industry, and government' for the fact that 'all three need the capacities and insights of the other two'** (IASC, 2018).

IASC science bridges 'human and environmental boundaries' through all of 'Traditional Knowledge, Indigenous Knowledge, and "Western" scientific knowledge' (IASC, no date). This is done through IASC's five working groups: Atmosphere; Cryosphere; Marine; Social & Human; and Terrestrial.

4.2.3.1   *Arctic Science Summit Week (ASSW)*

The mixed use of different science streams was a notable theme at the Arctic Science Summit Week (ASSW) 2020 Science for a Sustainable Arctic international assembly. Within the meeting session: 'Changes to Arctic Coastal Social-Ecological Systems' (Lantuit *et al.*, 2020), the topic of science and knowledge in relation to **coastal environments being social-ecological systems** was discussed.

It was identified that the biggest problem for coastal environments is the **lack of communication, both between indigenous peoples and 'western' science practitioners, and between both of these and policy makers.** Many indigenous peoples are themselves scientists in combination with being traditional knowledge holders, and have been leading research for decades, for example the Inuit in Hudson Bay. Indeed, part of training of Inuit hunters is how to communicate with researchers. Also, of note is that indigenous knowledge extends beyond the local environment to ecosystems a long way away.

Unfortunately, **traditional knowledge is being lost as a result of green colonialism – the imposing of external environmental views through scientific based policy**. One example would be a ban on hunting of Beluga whales. Another could be space taken for the mining of raw materials for the creation of batteries for renewable sustainable technologies, all at expense of the local environment. Less thought is given to traditional knowledge being of use in the promotion of sustainability. For example, traditional knowledge for recycling and making the full use of a hunted animal.

A main conclusion of the session was that **knowledge co-production is required, yet without integration of scientific and traditional knowledge.** The two are different and must both be given space. Traditional knowledge cannot be squeezed through a process designed for scientific knowledge. Additionally, traditional knowledge belongs to the community, and thus **the community decides if, when, and how its knowledge is shared.** The session recognised that **the Saami do not support a collective pooling of knowledge to be picked and chosen from.** There is however ongoing development of indigenous knowledge networks in Canada.

Regarding the focus of science and policy, it was recognised that **more focus needs to be given to the coast itself, rather than just to marine or terrestrial areas.** Coastal communities need to be considered as part of marine and terrestrial ecosystems. Additionally, consideration needs to be given

to the High North, e.g. including northern Norway, rather than just to the high Arctic. It was recognised that there is substantially **more funding to scientists, and those working on the 'ice edge' than to indigenous knowledge in the coastal regions** for example. **This is increasing the gap between traditional knowledge holders and scientists.** Support is required to develop traditional knowledge centres etc.

4.2.4   The Nordic Council

Part of the Nordic Co-operation, the Nordic Council (Nordic Co-operation, no date b) was established in 1952 and is the official parliamentary cooperative body of the Nordic nations including Norway, Sweden, Finland, Denmark, Iceland, the Åland Islands, the Faroe Islands and Greenland, representing 87 parliamentary members. The topics of consideration for the Nordic Council is extensive and includes issues that would typically be found within both foreign and domestic policy.

Areas of consideration include: Legislation and Justice; Working life; Digitalisation; Disability; The environment and climate; Sustainable development; Children and young people; Energy; Culture; Education and research; Gender equality; Language; Health and social affairs policies; Freedom of movement; Integration; and Nordic bioeconomy.

4.2.5   Nordic Council of Ministers

Part of the Nordic Co-operation, the Nordic Council of Ministers is the council of representative government ministers from each participant country, limited to Norway, Sweden, Finland, Denmark, Iceland, the Åland Islands, the Faroe Islands and Greenland. Each country gets a vote on cooperative issues with the intension of making the Nordic region the 'most sustainable integrated region in the world by 2030' (Nordic Co-operation, no date a).

A principle result of the Nordic Co-operation is the publication of the 'Arctic Human Development Report' (Nordic Council of Ministers, 2015). Its purpose is 'to highlight the major trends and changes unfolding related to the various issues and thematic areas of human development in the Arctic over the past decade; and, based on this assessment, to identify policy relevant conclusions and key gaps in knowledge, new and emerging Arctic success stories'. Although of great insight, as of yet there have not been a set of recommendations for follow up action, to aid in the generation of social impact.

4.2.6   Barents Euro-Arctic Council

The Barents Euro-Arctic Council (Barents Euro-Arctic Cooperation, no date a) is an intergovernmental forum that oversees cooperation in the Barents region of Northern Norway, Sweden and Finland, and

north western Russia. Its focus is security, stability and sustainable development and is led by the various countries Foreign Ministers.

4.2.7   Parliamentary and regional cooperation

Below the upper ministerial level, there is extensive cooperation between the Arctic nations at a parliamentary and regional level. This cooperation includes the Conference of parliamentarians of the Arctic Region (Conference of Parlimantarians of the Arctic Region, no date) , the Barents Regional Council (Barents Euro-Arctic Cooperation, no date b), Northern Dimension (Northen Dimension, no date) and The Northern Forum (The Northern Forum, no date).

4.2.8   Ilulissat Declaration

Resultant of increasing political pressures and sources of conflict in the Arctic, the five Arctic coastal nations were convened in 2008 so as to form an agreement over management of the development of the Arctic. Known as the 'Ilulissat Declaration' (Government of Denmark *et al.*, 2008) *(Policy; International)*, the five nations vowed to cooperate in line with international law on subjects such as search and rescue, environmental management and continental shelf claims.

4.2.9   United Nations entities

The United Nations (UN) is worth consideration in its own right given the number of treaties arranged under it of application within the Arctic. The main 'organs' of the UN are the General Assembly, Security Council, Economic and Social Council, Trusteeship Council, International Court of Justice, and the Secretariat (United Nations, no date b).

Below these top 'organs' of the UN is the United Nations Sustainable Development Group, (2020) (UNSDG) – A coalition of UN entities working 'to support countries to achieve the 2030 Agenda'. Some UNSDG entities of particular relevance to infrastructure, the coastal zone and sustainable development are:

- United Nations Department of Economic and Social Affairs (UN DESA).
- United Nations Development Programme (UNDP).
- United Nations Environment Programme (UNEP).
- United Nations Educational, Scientific and Cultural Organization (UNESCO).
- United Nations Human Settlements Programme (UN-Habitat).
- United Nations Industrial Development Organization (UNIDO).
- International Maritime Organization (IMO).
- United Nations Office for Project Services (UNOPS).

Of further relevance to the Arctic, but not part of the UNSDG:

- United Nations Framework Convention on Climate Change (UNFCC) *(Policy; International)*.
- Convention on Biological Diversity (CBD) *(Regulation; International)*.
- United Nations Convention on the Law of the Sea (UNCLOS) *(Regulation; International)*.

Of note is that United Nations member states derive from all over the world, including most of the Arctic nations, yet as shown in Figure 4-2 **most of the UN's work is restricted to the southern hemisphere, largely in those countries traditionally associated as developing**.
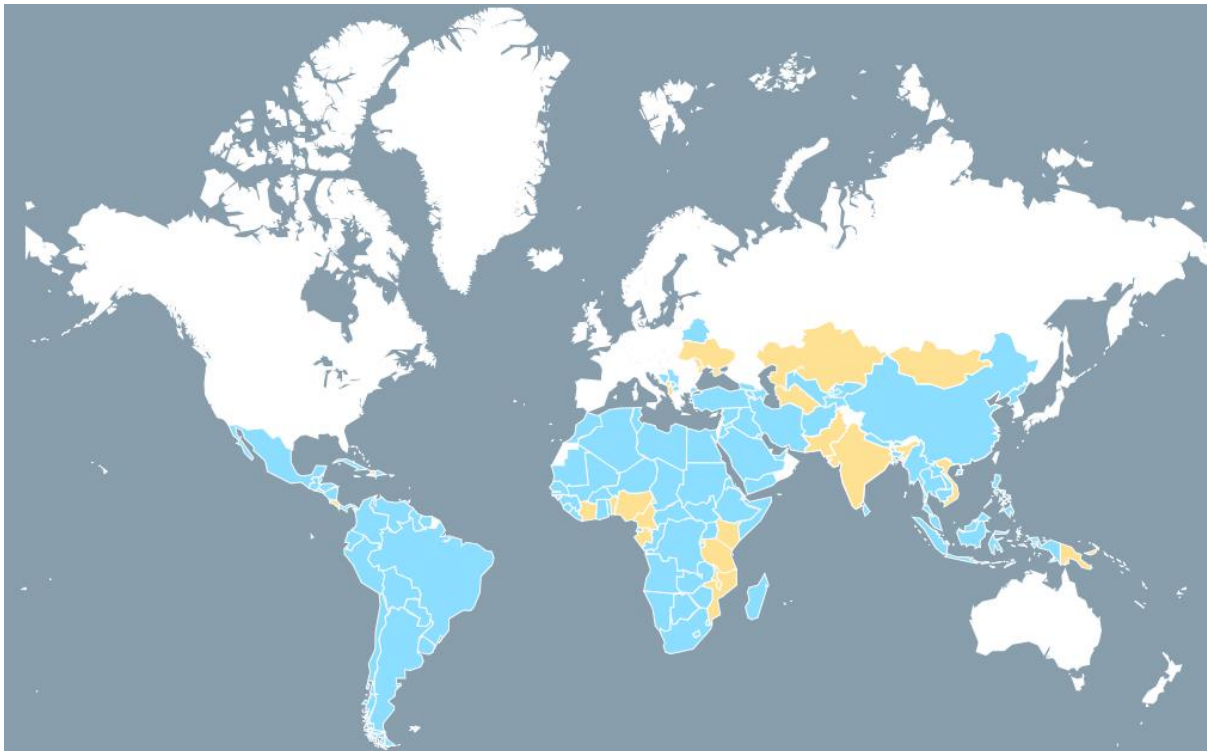
Figure 4-2: 'Where We Work'. Source: UNSDG citing UN INFO. © United Nations Sustainable Development Group, (2020)

4.2.9.1   Law of the Sea

The 'United Nations Convention on the Law of the Sea' (UNCLOS) (United Nations, 1982) *(Regulation; International)* is an international agreement that sets out the rights and responsibility of signatory nations with regards to use of the world's oceans. It is of specific use in the Arctic given that the Arctic is constructed from maritime nations and many of the challenges resultant of changing Arctic conditions manifest themselves in the oceanic and coastal environments. Examples include navigational and mineral extraction rights.

The International Maritime Organisation, (no date) (IMO) is a 'specialized agency of the United Nations'. It is the 'global standard-setting authority for the safety, security and environmental performance of international shipping. Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented' (International Maritime Organisation, no date). The IMO publishes a range of guidelines relating to the coastal zone. Of particular relevance to the Arctic is the 'International Code for Ships Operating in Polar Waters' (Polar Code) (IMO, 2015) *(Regulation, International)* – a code developed to 'provide for safe ship operation and the protection of the polar environment by addressing risks present in polar waters and not adequately mitigated by other instruments of the Organization'.

4.2.10 Antarctic Treaty

Although not developed for the Arctic, the Antarctic Treaty is a prime example of a successful longstanding collaborative international agreement on polar affairs. In particular, the Antarctic treaty has a strong focus on environmental protection, collaborative science and operations and the peaceful use of Antarctica (Secretariat of the Antarctic Treaty, no date). All of these aspects are of equal importance within the Arctic.

4.2.11 European Union

There are a number of European Union (EU) projects of relevance to the Arctic including:

4.2.11.1 Nunataryuk

Nunataryuk is an EU funded project looking at Arctic coastal environments and their adaptation. The purpose of the project as stated (NUNATARYUK, no date) is to:

- 'Develop quantitative understanding of the fluxes and fates of organic matter released from thawing coastal and subsea permafrost'.
- 'Assess what risks are posed by thawing coastal permafrost, to infrastructure, indigenous and local communities and people's health, and from pollution'.
- 'Use this understanding to estimate the long-term impacts of permafrost thaw on global climate and the economy'.

4.2.11.2 CAPARDUS

CAPARDUS is a EU Horizon 2020 project focussing 'on capacity-building to develop guidelines, standards and best practices related to exploitation of new technologies and utilization of data to support sustainable development in the Arctic' (Horizon 2020 Environment and resources data hub, no date).

4.2.11.3   Trans-European Network for Transport (TEN-T)

TEN-T policy and programme financially supports 'Priority Projects, representing high European added value, as well as projects of common interest and traffic management systems that will play a key role in facilitating the mobility of goods and passengers within the EU' (European Commission, 2020). The TEN-T 'finances work and studies to enhance rail capacity in northern Finland, Sweden and Norway, focussing on cross-border networks and links between maritime and land transport' (EEAS, 2017).

4.2.12   Non-Arctic states

Further to Arctic strategies from the eight Arctic nations, there exists Arctic strategies from both non-Arctic nations and indigenous bodies, including: The European Union, France, Germany, Italy, Japan, South Korea, the United Kingdom, China, and the Inuit Circumpolar Council (The State Council Information Office of the People's Republic of China, 2018; Arctic Portal, no date a).

4.2.13   International standards

- ISO 19906:2019 Petroleum and natural gas industrial – Arctic offshore structures

The ISO 19900 series of international standards consider the design requirements of offshore structures used within the petroleum and natural gas industries. ISO 19906, Petroleum and natural gas industrial – Arctic offshore structures (ISO, 2010) *(Standard; International)*, as the name suggests specifically considers offshore and coastal structures within the Arctic, or in extension other cold climates.

Much of the international standardisation within the Arctic maritime environment revolves around the oil and gas industries. Some further identified standards of relevance to built infrastructure in the Arctic include:

- ISO/TS 35105:2018 Petroleum and natural gas industries – Arctic operations – Material requirements for arctic operations.
- ISO 35101:2017 Petroleum and natural gas industries — Arctic operations — Working environment.
- ISO 35103:2017 Petroleum and natural gas industries — Arctic operations — Environmental monitoring.
- ISO 35106:2017 Petroleum and natural gas industries — Arctic operations — Metocean, ice, and seabed data.
- ISO 35104:2018 Petroleum and natural gas industries — Arctic operations — Ice management.

Additionally, two standards under development:

- ISO 35102 Petroleum and natural gas industries — Arctic operations — Escape, evacuation and rescue from offshore installations.
- ISO/WD 24247 Ships and marine technology — Marine environment protection — Arrangement and management of port reception facilities in the arctic.

4.3   Other literature and initiatives

Further to the primary sources of literature identified above that have been written by and for local, national, or international bodies, there are further sources of information available to the polar practitioner in particular. These vary in the topics covered and the level of interest required to make use of them.

4.3.1   Barents 2020

The Barents 2020 project is a collaborative project between Norwegian and Russian partners assessing the standards available to the oil and gas industry operating in the Barents Sea. 130 offshore standards are promoted – 'Barents 2020 Final Report Phase 3' (Barents 2020, 2010) *(Guidance; International)* – and recommendations of pan-Arctic applicability are made for the safe exploration, production and transportation of oil and gas – 'Barents 2020 Final Report Phase 4' (Brown, 2012) *(Guidance; International)*. These topics covered include improvement of 'ISO 19906 as an Arctic design standard; best practice for ice management; recommendations on evacuation, escape and rescue; recommendations on working environment' (DNV GL, no date).

4.3.2   Published texts

There is an adequate supply of both general and specific published literature (textbooks, papers, proceedings etc.) on the engineering execution of infrastructure development and adaptation in the Arctic. However, in many instances this literature is theoretically heavy and requires prior appreciation of the subject by the practitioner.

Regarding the design of cold climate built infrastructure, there are several textbooks addressing technical design aspects (Johnston, 1981; Smith, 1996; Andersland and Ladanyi, 2004; Palmer and Croasdale, 2013), including multiple focussed on ice mechanics and structural ice loading (Michel, 1978; Cammaert and Muggeridge, 1988; Sanderson, 1988; Schulson and Duval, 2009). In extension, there are also multiple design handbooks and guides (Tabler, 1991; Fransson, 2009; Fransson and Bergdahl, 2009; Sinitsyn *et al.*, 2019). Other than technical design, there are textbooks exemplifying spatial planning practices in polar territories (Shepard and White, 2017), and textbooks on polar law (TemaNord, 2013; Coates and Holroyd, 2020).

4.3.3   Arctic information sources

In addition to literature published in journals and through publishing houses etc. there are a plethora of web-based databases and portals containing access to Arctic data sources and institutional literature. Such databases and portals include, but are not limited to the: Arctic Portal (Arctic Portal, no date b); ARCTIS Database (CHNL, no date); Arctic Ship Traffic Data – ASTD (PAME, 2020); Polar Data Catalogue (CCIN, 2018); Barents info (Arctic Centre, no date); National Oceanic and Atmospheric Administration (NOAA, no date); EU Arctic Information Centre (EUAIC, no date); Arctic Council Archive (Arctic Council, no date); UArctic (University of the Arctic, 2020); Arctic Spatial Data Infrastructure (STI) (Arctic STI, no date); MEMA Database (PAME, 2018); Arctic Adaptation Exchange Portal (SDWG, no date); and Nordic Co-Operation DiVA Portal (Nordic Co-Operation, no date).

5 The arrangement of literature for Arctic built infrastructure development

5.1 National literature trends

5.1.1 National literature trends – Types of literature

The type of literature identified as of relevance to development of the Arctic nations is here identified. The literature considered is that associated with an individual Arctic nation and is assessed in terms of applicability, both in its type (overarching focus) and spatial scale (level of focus). Although the extent of literature accessed is not exhaustive, it is a reasonably full representation of that literature which is accessible.

- United States literature is limited and constrained to nationally focussed policy *(Policy; National – x3)*.

- Canada is certainly the most populous in terms of relevant Arctic literature, from policy, through procedure, guidance, and standards, reducing in quantity in that order – excepting standards. Ten current standards dedicated to cold climate development have been identified, with two more in development. The level of focus is largely national and municipal, with local focus constrained to procedure. Literature: *(Policy Framework; National – x2); (Policy; National)*; *(Policy; Municipal – x3); (Policy; pan-municipal)*; *(Procedure; National)*; *(Procedure; Municipal – x2); (Procedure; Local)*; *(Guidance; Municipal)*; *(standards; National – Multiple).*

- The kingdom of Denmark has limited applicable literature in general. This is largely for the fact that the literature of Greenland is poorly developed. It does however exhibit dedicated local policy and regulation, which could be considered as partially Arctic. Generally, the identified literature is at a very high political level. Literature: *(Policy; international); (Policy; National – x2); (Policy; Municipal – multiple); (Policy; Local – multiple); (Regulation; Local – multiple).*

- Iceland's identified literature is national policy *(Policy; National – x2).*

- Although limited, Norway's literature has a wide spread of focus. Given the situation of Svalbard, the literature extends from international policy through to local regulation. There is seen to be insufficient Arctic focus to standards. Literature: *(Policy; International)*; *(Policy; National); (Policy; Municipal – x3); (Regulation; Municipal); (Regulation; Local); (Standard; National).*

- Sweden's identified literature is national policy *(Policy; National – x2).*

- Finland's identified literature extends in applicability from national policy *(Policy; National – x2)* to national procedure *(Procedure; National – x2).*

- Russia's literature at the high level is a mixture of policy and procedure. At the lower level there is a fairly good supply of standards. They do however span a long time period in their

development, and thus some are likely less applicable to infrastructure adaptation in the current changing Arctic. Literature: *(Policy; National – x2)*; *(Procedure; National – x3)*; *(Standards; National -- Multiple)*.

Considering the Arctic countries collectively, a number of trends can be drawn. Of the literature, there is a focus on the high level and low level, i.e. policy and standards. There is little observed literature in the middle realm – guidelines and regulation etc. Although the lack of observation may correlate to ease of access of this literature – which may exist, this is still a major problem, for it is this literature that is used by practitioners in combination with standards. If it is inaccessible, then it is arguably pointless. The need for this communicative literature (guidelines; regulation) between the high political level and low practitioner level is of heightened importance in the Arctic due to lacking or poor standards. Regarding policy and procedure literature – that to aid implementation of policy, its quantity is limited yet largely sufficient.

Regarding standards, the picture varies around the Arctic. Canada has limited standards of applicability but is actively developing its capacity. These standards are up to date and highly relevant. Greenland has a wider array of standards, however they either show a lessor tailoring to the Arctic and are based on non-Arctic standards, or they are out of date, difficult to access and of limited value to the current Arctic. The Nordic countries have very little, if any truly applicable Arctic specific standards. Russia has a fairly large suite of standards of applicability to the Arctic (given the domination of permafrost), however they range in age from modern to soviet era standards, thus may not be sufficient for changing Arctic environmental conditions.

5.1.2   National literature trends – Focus of literature

Disregarding standards, which cover subjects of pertinence to physical construction, the focus of different levels of literature can be considered together. As the literature considered below policy is for the purpose of implementation of that policy, focus within this literature is by extension the focus of the policy of the country in question. The points of Arctic focus – in no particular order – of each country are as follows.

The focus of the United States is reduced to:

- Responsible Arctic Region Stewardship.
- Strengthened International Cooperation.
- strategic competition.
- Building Arctic awareness.
- Enhancing Arctic operations.
- Strengthening the rules-based order in the Arctic.

The focus of Canada is reduced to:

- Economy – Growth; Green; Strong; Sustainable; Diversified; Inclusive.
- Transport.
- Infrastructure – Strengthened; Green; Social.
- Trade.
- Resource Development.
- Governance – Territory definition; Devolution.
- Safety and Security – Humanitarian; Sovereignty; Effective international order.
- Rural and Northern communities – Inclusiveness; Community wellness; well-being.
- Indigenous peoples – Reconciliation; Self-determination.
- Social – Development; Employability.
- Education and training.
- Knowledge and understanding.
- Innovation.
- Ecosystems – Environment; Protection.

The focus of the Kingdom of Denmark is reduced to:

- Peace and security.
- Economic growth and development.
- Environment and nature.
- International cooperation.
- Shipping.
- Fisheries.
- Research and education.
- Construction.

The focus of Iceland is reduced to:

- Strengthened international cooperation – Dispute resolution; Security.
- Icelandic Arctic identity.
- Indigenous peoples.
- Social development.
- Knowledge.
- Climate change – Environment.
- Natural resources.
- Trade.

The focus of Norway is reduced to:

- International cooperation.
- Business.
- Knowledge.
- Infrastructure – Environmentally sound development; Reorganisation and replacement.
- Transport.
- Energy.
- Safety and security – Maritime.
- Innovation.

The focus of Sweden is reduced to:

- International collaboration.
- Climate and ecosystems – Environmental security and protection; biodiversity; research, sustainable use.
- Economic development.
- Trade.
- Industry.
- Education.
- Languages.
- Knowledge transfer.

The focus of Finland is reduced to:

- Cooperation – International; Neighbouring Arctic states; EU.
- Finnish Arctic expertise.
- Sustainable development – Enshrinement of principles.
- Environment.
- Sustainable Tourism.
- Arctic residents.
- education and research.
- Business.
- Economy.
- Infrastructure.

The focus of Russia is reduced to:

- Sovereignty and territorial integrity.
- Peace and stability.
- Cooperation – Mutually benefiting.
- Resource development.

- Economy – National growth.

- Transport – National utilisation.

- Environment.

- Arctic peoples – Indigenous tradition; Living standards; Prosperity.

Considering the multiple foci within each country, a general underlying theme for each country is seen. These are as follows: **USA – knowledge, utilisation and control; Canada – Holistic development; Kingdom of Denmark – Utilisation and stability; Iceland – Social security; Norway – Built environment progression; Sweden – People and nature; Finland – Sustainable offerings; Russia – People, utilisation and control**. These themes of current literature are interesting for the fact that they describe the historic relation between each country and its Arctic territory equally as well.

First to note are the similarities between the USA and Russia. In both cases the Arctic territories are considered remote and somewhat removed from the majority workings of the country. To this extent the Arctic territories are seen as a resource and a region for control. The difference in the strategies is that in the USA focus is on knowledge and in Russia, focus is on people.

The strategies of both Canada and Sweden are rather more focused on sustainable balance. Canada's holistic strategy is reflective of its ongoing drive to attain reconciliation, and thus has considered a wide range of topics necessary to achieve well-being. Sweden's approach is rather simpler, yet it is effective in the recognition that a sustainable world is characterised as harmony between people and the rest of nature.

The Kingdom of Denmark's strategy of utilisation and stability reflects that of a kingdom of nations, ultimately a strategy in place since the colonial era for cohesion of nations through optimisation of their specific offerings. The strategies of Iceland and Finland is that of smaller countries trying to preserve their identity whilst promoting the resources that they can offer. Lastly, Norway's strategy reflects the position of Norway in its ability for self-improvement.

Across the strategies there are an additional number of themes. In order of their prevalence these are: Economy (inc. business and trade etc.) (8); Stewardship (Ecosystems) (7); International cooperation (7); Awareness (knowledge and understanding) (7); Social well-being (5); Built Environment (4); Increased governance (3); Safety and security (3); Strategic competition (2); Innovation (2). This order of prevalence is interesting in that it strongly correlates with the priorities of the Arctic Council – international environmental cooperation based on understanding. Although it is indeed good that these crosscutting themes are prominent in national policy, it is unfortunate that they do not carry through as the dominant themes earlier identified. Additionally, given the powerful position of the built environment to connect humanity with nature, it is a shame that the built environment is not more of a priority.

5.1.3   National literature trends – Infrastructure

Within the various pieces of national literature there is some specific consideration of infrastructure as follows.

The United States consideration of infrastructure extends to:

- Security and control in relation to maritime activities and resource management.

The Canadian consideration of infrastructure extends to:

- Innovation in Infrastructure.
- Green Infrastructure.
- Infrastructure for social development.
- Infrastructure for Inequality reduction.
- Infrastructure standardisation for adaptation and vulnerability reduction.
- Municipal control of infrastructure.
    - Through written legislation (acts and regulations) for building standards, economic development, environment, highways, housing development, lands, mining, noise, oil and gas, public airports, and public utilities.
    - Through planning of cultural, social, economic, and environmental community needs.

The Kingdom of Denmark's consideration of infrastructure extends to:

- Marine traffic.
- Tourism.
- Air transportation.
- Arctic data.
- Search and rescue (SAR) capability.
- Socio-economic benefits.
- Private financing.

The Norwegian consideration of infrastructure extends to:

- Transport systems.
- Power supply.
- Digital infrastructure.

The Swedish consideration of infrastructure extends to:

- Land and maritime transport
- Hunting.
- Fishing.
- Trade.

- Energy extraction
- Infrastructure adaptation

The Finnish consideration of infrastructure extends to:

- Construction and operation capability.
- Cold climate expertise.
- Energy, renewable and clean technologies.
- Maritime – shipping and offshore.
- Mining.
- Tourism.
- Transport – roads and rail
- The Digital environment – internet and telecommunications.
- Space infrastructure.

The Russian consideration of infrastructure extends to:

- Settling the Arctic.
- Privatised energy.
- Communications.
- Transport.

In summary of the consideration of infrastructure within national literature there are number of common themes across the nations as follows: Transportation (5); Data & communications (4); Power / Energy (4); Marine activities (3); social development (3); Natural resources (3); Adaptation (2); Tourism (2). Although themes of only one count were discounted it is worth mentioning those which were mentioned in relation to infrastructure and are particularly pertinent to sustainable development. These are: Inequality reduction (1); Innovation (1); Green Infrastructure (1). All were the Canadian consideration. **Further to note is the wide range of themes considered (including for example space), demonstrating the commonality of infrastructure across all forms of development.**

5.1.4   National literature trends – Coastal zone

Within the various pieces of national literature there is some specific consideration of the coast and coastal zone as follows.

The United States consideration of the coast and the coastal zone extends to:

- security and control in relation to maritime activities.

The Canadian consideration of the coast and the coastal zone extends to:

- Coast guard.

- Continental shelf claims.

- Continental shelf resource development.

- Coastal traffic.

- Safety, protection of life, health, prosperity, and the marine environment in relation to shipping and marine activity.

- Erosion and sedimentation management.

The Kingdom of Denmark's consideration of the coast and the coastal zone extends to:

- Continental shelf claims.

- Marine activity.

- Search and rescue.

- The Law of the sea.

- The Ilulissat declaration – cooperation.

The Icelandic consideration of the coast and the coastal zone extends to:

- Development.

- Law of the Sea.

The Norwegian consideration of the coast and the coastal zone extends to:

- Maritime operations and security.

The Swedish consideration of the coast and the coastal zone extends to:

- Maritime security.

- Shipping and the environment.

- Search and rescue capabilities.

The Finland consideration of the coast and the coastal zone extends to:

- Maritime expertise.

- Coastal zone management subject to cold climate conditions.

- Offshore oil and gas infrastructure.

- Coastal infrastructure.

The Russian consideration of the coast and the coastal zone extends to:

- Port expansion.

- Harbour development.

- Road and Rail to support port capacity.

In summary of the topic of consideration in relation to the coast or coastal zone, with the exception of safety and security, there is little clarity. Consideration extends to: **Safety and security (inc. search &**

recuse etc.) (5); Marine activities (3); Continental shelf claims (2); Resource development (2); The Law of the sea (2); and Coastal infrastructure (2). The language used is vague, and there is little definite certainty on policy for the coastal zone. This is perhaps for the reason that there is little policy itself on the topics of consideration. For the fact that many of the topics of consideration in some way relate to infrastructure, the limited specific mention of coastal infrastructure is surprising.

5.1.5   National literature trends – Sustainable development

Within the various pieces of national literature there is some specific consideration of sustainable development as follows.

The United States consideration of sustainable development elements extends to:

- Pursuit of responsible Arctic Region Stewardship.

The Canadian consideration of sustainable development elements extends to:

- Innovation.
- Private Sector Investment and Alternative Financing Mechanisms.
- Infrastructure and Social Development.
- Green Infrastructure.
- Rural and Northern Communities.
- Supporting Indigenous Communities.
- Smart Cities.

The Danish consideration of sustainable development elements extends to

- Responsible and sustainable societal development.

The Finish consideration of sustainable development elements extends to

- Enshrining the principles of sustainable development.

In consideration of sustainable development, there was little mention within national literature. Where there was, it was in relation to **social development (2), or general sustainability (2)**. The only country with more specific reference was that of Canada. There is no mention of sustainable development in relation to the coastal zone.

5.1.6   National literature trends – Knowledge presence, sharing & transfer

In general, across the literature of the various Arctic countries, there is little mention of where knowledge is stored, or how it is shared and transferred (utilised). However, once again, it is Canada who best identifies the value of knowledge in policy formation. Canada recognises that 'knowledge and

understanding guides decision-making' (Government of Canada, no date b), and based on this shares and utilises knowledge both vertically through the political, scientist and practitioner levels, and horizontally between entities.

- Policy is based on knowledge transferred from pan-Arctic, federal, territorial, pan-territorial, and indigenous levels.
- Knowledge is shared between municipalities (pan-territorial) for optimum consideration of shared opportunities and challenges.
- Scientific knowledge is pooled through national networks.

Iceland's consideration of knowledge extends to advancing Arctic residents knowledge of the Arctic, whilst it was identified that in Norway the extent of sustainable development in the Arctic is reliant on the individual practitioner, and the knowledge that they must and do seek from others, such as Academics (Wickström, 2019; Bråten, 2020).

5.1.7   National literature trends – Approaches to development

There are a number of approaches to the development of Arctic Infrastructure Policy. Two prominent examples are that of Canada and Russia.

5.1.7.1   Canada

Both Canada's 'Investing in Canada: Canada's Long-Term Infrastructure Plan' (Infrastructure Canada, 2018), and 'Arctic and Northern Policy' Framework (Government of Canada, no date b) have been developed cooperatively between Federal government, municipal government, and many indigenous organisations, and as such reflects the needs and desires of Canadians at all levels.

This policy demonstrates a circular approach to its creation. I.e. it reflects cascaded downward policy, based on upwards guidance. This upwards guidance was extracted from engagement with municipal and indigenous partners in the form of regional roundtables, internet-based roundtables, and public submissions (Government of Canada, no date b). Such engagement is useful in that information on the effectiveness of current policy and further infrastructure needs is provided from the implementation (practitioner) and scientific levels. Such engagement also encourages the municipal and indigenous partners to actively consider their needs, and how they could integrate into larger infrastructure developments.

In return for the upward guidance, the 'Arctic and Northern policy' framework is used as a base for the development of 'governance mechanisms' and 'implementation plans' detailing how partners (territorial governments etc.) will share knowledge, implement and reflect on the framework. The Infrastructure plan is implemented through bilateral agreements. **The form of holistic political engagement demonstrated in Canada is reflected in their holistic policy. Thus, it can be deduced that holism is based on knowledge sharing and transfer.**

5.1.7.2   Russia

The same conclusion regrading holism being based on engagement can also be seen in Russia, albeit in a completely different form. Rather than Arctic peoples-based policy, Russian policy is national goals based, i.e. Arctic policy is developed at a national level based on national goals to serve national priorities. For example, current Russian Arctic policy focusses on utilisation of Arctic transport and energy reserves for the need to develop Russia as a whole.

Whereas Canadian policy is based on the circular exchange of information, Russian policy is prescriptive and one directional from the political level downwards. Although effective in the areas of consideration, the Russian policy is rather less holistic. The larger federal control of Arctic policy in Russia is most likely related to the lesser devolution of powers in Russia than in Canada.

5.1.7.3   Comparison

Comparatively considering the Arctic policy of Canada and Russia, it is seen that the forms of policy creation are reflective of the goals of the country, with these goals themselves being based on the development position of the country. As will later be demonstrated Canada is, on an international scale, considered to be more developed than Russia. Where Canada is considered developed, Russia is developing. Given this, whilst Russia is utilising Arctic resources for national development, Canada exhibits a greater balance between national development and Arctic peoples. **Holism therefore, in addition to reflecting knowledge sharing and transfer, also appears to be positively correlated to the level of development.** An apparent link between knowledge sharing and development is the degree of devolution of power – the distribution of power and control from central government to lower levels. I.e. Canada, who is more developed with more devolution of power exhibits a more holistic Arctic policy, than Russia, who is less developed, with less devolution of power and who exhibits a less holistic Arctic policy.

The challenge to achieving a holistic development strategy is of course the interdependence of holism with the level of general development, and the degree of devolution. It is therefore difficult to ensure a holistic consideration of infrastructure development when a country or municipality is less developed generally and has less devolution of power. An example of this is the ongoing Greenlandic Airport developments, where a centralised political decision was made under municipal protest for the development of multiple extensive new international airports, all within a country that exhibits a sporadic profile of moderate development. This case exemplifies limited holistic consultation and raises the **need for a structure to guide less developed countries in particular on the questions that should be asked when considering infrastructure construction and adaptation.**

5.2   International literature trends

5.2.1   International literature trends – Types of literature

There are various pieces of applicable governance and infrastructure literature at an international level ranging from broad policy through to specific standards. Of that identified, the vast majority has been orchestrated by the Arctic Council and its subsidiaries. Some however stem from other international fora.

- Policy; International – x3 -- 2(AC); 1(other).
- Policy Framework; International – x1(AC).
- Regulation, International – x6 – 3(AC); 3(other).
- Guidance, International – x8 – 6(AC); 2(other).
- Standard; International – x1(other).

As can be seen, the scope of the Arctic Council largely extends to non-legally binding literature, i.e. policy and guidance. The applicable legally binding international regulation and applicable standards come from bodies other than the Arctic Council, albeit, the Arctic Council has aided in some of its formation.

Considering the Arctic Council, it is seen that their literature contribution is reflective of the scope of the Arctic Council. **All of the guidance identified was guidance from the scientific level upwards to the political level.** This guidance takes the form of scientific assessments, summaries for policy makers and action plans. Unfortunately, the development of action plans is less common, and thus, **downwards guidance is largely limited to pure policy**, rather than equivalent guidelines which would aid in its implementation. Although the ability to produce guidelines is diminished because of the non-binding nature of the Arctic Council, increased action plans would still be to the benefit of both more refined policy, and the independent countries looking to implement it.

The applicable regulation stems from the international political level external to the Arctic Council. The applicable standards stem from the international practitioner level.

Further to applicable regulation and standards being derived from other international bodies, **there is published information in the form of textbooks, research papers, and conference proceedings etc. In addition, there is an array of web-based databases and portals. The vast majority of these resources come from the scientific level, for the benefit of the scientific and practitioner levels.**

5.2.2   International literature trends – Focus of literature

Across the International literature reviewed, there are a number of both specific focusses and more general cross cutting themes identified. Specific focuses include cooperation, natural resources, knowledge, nature, climate, people, coastal and marine, infrastructure, and business. Cross cutting

themes include sustainable development, pan-Arctic consideration, decision makers, and Resilience and Adaptation.

5.2.2.1 Cooperation

Cooperation in the Arctic has been in strong focus ever since Mikhail Gorbachev's Murmansk speech in 1987. Although this did spur pan-Arctic cooperation on scientific research and monitoring, environmental protection, and marine activities – continuing to this day, there remains a need for further cooperation. Regarding people and science in the Arctic, there remains a lack of communication, both between indigenous peoples and 'western' science practitioners, and between both of these and policy makers. In extension, it is recognised that cooperation needs to be extended to 'academic, industry, and government' given that 'all three need the capacities and insights of the other two' (IASC, 2018).

Although further cooperation within the sciences would be useful, the real need for increased cooperation is between the political, scientific, and practitioner levels.

5.2.2.2 Resources

Given that the resource extractive industries will have a large impact on the prospects of the Arctic, then increased cooperation is found to be required. This is particularly the case given the Arctic climate change specific risks to the extractive industry, such as permafrost thaw, and transport changes. Minimal attention is given specifically to resource extraction within international literature.

5.2.2.3 Nature

The underlying focus of international literature, within nature, is the environment, most notably environmental protection. The environment is considered in relation to sustainable development and ecosystem-based management. **The protection of the natural environment is considered in its interaction with society through infrastructure**, and the need for consideration at different spatial scales (pan-Arctic, regional etc.). Further to protection of the environment, consideration is given to the prevention of environmental degradation, through mechanisms such as Environmental Impact Assessments. **Mitigating environmental degradation is recognised as being linked to meaningful dialogue and utilisation of indigenous and local knowledge.**

5.2.2.4 Climate

Within international literature there is a strong focus on climate for the sake of science itself – for monitoring and prediction. Within this, there is a focus on black carbon and methane. Further, **attention**

is paid to the interplay between climate and its impacts, application, and practical value to built infrastructure.

5.2.2.5   People

The consideration of people within international Arctic literature most extensively extends to indigenous peoples. However, other Arctic peoples and communities are also given thought. There is a **particular focus on cooperation with and between Arctic peoples, their well-being, and the protection of indigenous cultures.**

In relation to infrastructure, it is recognised that its development could lead to negative impacts for indigenous peoples in particular. There is additionally a strong focus on differences in peoples from different areas of the Arctic, and the need for consideration of different inequalities experienced. These considerations promote the **need for flexibility in policy and development strategies.**

5.2.2.6   Business

There is little direct mention of business within the international literature reviewed, excepting identification of multiple fora to facilitate international dialogue. It was however recognised that **ongoing development of infrastructure keeps it current and reliable, and allows effective adaptation to economic and technological changes.**

5.2.2.7   Pan-Arctic consideration

A pan-Arctic approach is appreciated as necessary across various pieces of international literature. This extends to pursuing stronger Arctic governance, pan-Arctic application and solutions for infrastructure, and holistic cradle to grave considerations. **Cradle to grave considerations extend to vertical consideration through the political, scientific and practice levels, and horizontal consideration between humanity and nature. Such considerations include politics and economics etc.**

5.2.2.8   Decision makers

Within international literature there is an ongoing attempt from the science sphere to 'produce information to assist local decision makers and stakeholders'. It is recognised that 'Decision makers responsible for designing, building, maintaining and decommissioning industrial infrastructure have limited understanding of the likely impacts of future climate changes, as well as limited guidance on how to adjust to the likely changes' (AMAP, 2017d). **In general however, what is produced is general**

information, rather than action orientated information, and/or information targeted specifically towards built infrastructure.

Regardless, the 2018 'Arctic Resilience Forum' (Halonen et al., 2018) identified that 'there is a wealth of information, expertise, and experiences in building resilience across the Arctic that should be actively shared'. Additionally, it was recognised that 'building resilience in a way that meets the urgency of climate change requires partnerships across the Arctic region and other regions of the world. Effectively building resilience requires engagement of multiple stakeholders, including scientists, policy makers, indigenous peoples, the private sector and civil society'. It was also highlighted that 'climate change resilience should be dealt with in the context of sustainable and inclusive development at all levels (i.e., local, national, regional)'.

There is thus an identified need at the pan-Arctic level for increased knowledge sharing, partnerships, and engagement of political, scientific, and practice stakeholders across local, municipal, and national boundaries.

5.2.2.9   Resilience and adaptation

A key document for understanding resilience and adaptation is the 'Arctic Resilience Action Framework' (The Arctic Resilience Action Framework Review Committee, 2017) which identifies an urgent need to collaboratively build arctic resilience. This can in part be achieved through increased 'cooperation and shared learning'. It is concluded that demonstration of 'Arctic resilience efforts' is required. A review of case studies revealed that projects building resilience shared a 'capacity for self-organization'; 'diversity of response options'; 'integration of different knowledge types and systems'; 'sustainability of livelihoods'; and 'an orientation to change as the norm'. **What this demonstrates is the need, not only for a shared understanding of the questions that should be asked for holistic sustainable built infrastructure construction, but also examples of practical application.**

5.2.3   International literature trends – Infrastructure

Throughout the international literature reviewed it is seen that built infrastructure is connected to people and nature, indicating that it is useful for the pursuit of sustainable development. Within the literature six broad topics can be identified as: **Connective infrastructure – including digital infrastructure; Preparedness and safety; Physical conditions; Policy and regulation; Financing; and Society. Additionally, more specific mention is made to port, marine and research infrastructure**.

5.2.3.1   Connective infrastructure

Connective infrastructure is a broad topic. The literature gives consideration to connective infrastructure stimulating economic growth – which supports improved infrastructure for Arctic peoples, optimisation, empowered communities, and **opportunities for innovation**.

5.2.3.2   Preparedness and safety

It is identified that there is currently insufficient shoreside infrastructure in the Arctic to 'support safe marine shipping and respond to marine incidents in the Arctic' (Arctic Council, 2009). Shoreside infrastructure includes deep water ports, sheltered harbours, port waste reception facilities, and salvage systems etc. Increased response capacity relies on improved knowledge transfer and cooperation, especially with local communities. **Thus, increased infrastructure robustness can also facilitate more sustainable development.**

5.2.3.3   Physical conditions

The greatest connection between a changing Arctic and infrastructure is physical conditions. These changing Arctic physical conditions include permafrost thaw, changing frequency of extreme weather and changing frequency of rockfalls and avalanches etc. **Adaptation of infrastructure for resilience therefore must be a key driver of development**. It is understood that the use of technology can limit environmental impact (Institute of the North, 2012).

5.2.3.4   Policy and regulation

Within international literature it is recognised that there are gaps both in infrastructure provision, and in the knowledge pertaining to its development. AMAP, (2018) tells us that there is 'limited knowledge at most coordination levels and among various actors involved in construction projects. This current situation results partly from the **limited regulatory framework and appropriate governance structures available for construction**'. Literature tells us that careful planning with consideration of future infrastructure needs is required, indicating the **need for regulatory flexibility and clarity, e.g. in consideration of spatial and temporal scale.**

5.2.3.5   Financing

We are told that external funding of Arctic infrastructure could either bring benefits or drawbacks, and that funding should support infrastructure in cooperating with local communities.

Infrastructure can help build family and community benefits. This demands citizen engagement. Literature suggests that **the Arctic can also realise carbon neutral construction based on traditional knowledge**. This would likely include consideration of local and traditional building materials, cradle-to-grave / life cycle thinking, and compensation of emissions.

5.2.4 International literature trends – Coastal zone

In general, there is fairly little direct consideration of the coastal zone within international literature. What there is, is high level and in relation to: Biodiversity and ecosystem-based management; Environmental change; Cultural use; Resource use; Conservation; Sustainable use; Economic opportunities; Tourism; Waste management; Coastal erosion; and Changes in sea level. Thus, there is consideration of environmental, social, and economic elements.

Rather than the coastal zone, there is a greater focus on the marine environment, extending to: Cooperation; Oil pollution prevention; Search and rescue; Infrastructure investment; Hydrographic research; and Commercial fishing. Here are demonstrated themes of safety and security, and economic benefit.

5.2.5 International literature trends – Sustainable development

Consideration of topics related to sustainable development within international literature are moderately holistic, i.e. the range of consideration is moderately wide. That being said, the topics considered all relate to problems of humankind, and thus in general **the understanding of sustainable development is humancentric**. Topics of consideration include: Environmental protection; Traditional knowledge and food practices; WASH (water, sanitation and hygiene) infrastructure; Energy infrastructure; Education; Business; Economic development; Pollution; Climate; Culture; Health and well-being; Improved connectivity; and Natural resource management

5.2.6 International literature trends – Knowledge presence, sharing & transfer

Key lessons learnt from international literature with regards to knowledge include:

- There is a necessity for horizontal (between local, municipal, national, and pan-Arctic), and vertical (between politics, science, and practice) knowledge transfer.
- Knowledge extends from a local to international scale, thus its application is also required at these scales. Implementation however must be subject to national legislation and international law; thus, cross boundary cooperation is required.

- Experience and knowledge exchange are extremely important for reasonable development of the high north.
- Recognition of ethnically distinct interests of indigenous Arctic peoples is important.
- Green colonialism is causing a loss of traditional knowledge
- Scientific and traditional unintegrated knowledge co-production is required, where un-integration is based on:
  - Traditional knowledge being shared if and when deemed appropriate by the community.
  - Indigenous non-support of collective knowledge pooling to be picked and chosen from.
- Balanced attention and funding to the preservation and development of traditional and scientific knowledge in the coastal zone.

5.3   Literature summary and conclusions

5.3.1   Governance – Knowledge and literature

5.3.1.1   *Focus of literature*

Within the Arctic, the focus of literature, and focus in general, is at some levels similar, and some levels dissimilar between individual countries and between national and pan-Arctic levels. The majority of literature features general information, rather than built infrastructure action orientated information.

General national focus the Arctic countries was identified as follows: USA – knowledge, utilisation and control; Canada – Holistic development; Kingdom of Denmark – Utilisation and stability; Iceland – Social security; Norway – Built environment progression; Sweden – People and nature; Finland – Sustainable offerings; Russia – People, utilisation and control. **At a national level then, there is a general focus of stability, development, and control. This is in difference to the international level, which has a general focus on scientific and indigenous knowledge, human well-being, sustainable development, and environmental protection.**

At increased depth within literature, where it becomes more specific, national and international priorities start to align. National and *international* considered themes can be correlated as follows: Economy – *Business*; Stewardship (Ecosystems) – *Sustainable development; nature; climate*; International cooperation – *Cooperation*; Awareness (knowledge and understanding) – *Knowledge*; Social well-being – *People*; Built Environment – *Coastal and marine; infrastructure*; Increased governance – *Pan-Arctic consideration*; Innovation – *Resilience and Adaptation*;

In addition to the above, there are however also themes that do not align. Additional national themes include safety and security, and strategic competition. Additional *international* themes include n*atural resources*, and d*ecision makers.* Interestingly the two national themes underline the national general

focus. It is also interesting to note that, at the increased depth, the most prevalent national themes correlate with the priorities of the Arctic Council.

What is seen here is the delicate balance between pan-Arctic governance and national sovereignty. International cooperation, primarily through the Arctic Council is successfully influencing national policy within its remit – i.e. scientific and indigenous knowledge, human well-being, sustainable development, and environmental protection etc. Likewise, there is a lack of collaborative international influence on policy outside of remit – e.g. geopolitical dispute, military action etc.

Although international collaboration / literature is having a positive effect, with the exception of perhaps Sweden, Finland and Canada, the more holistic thinking that it provides is not being fully transferred to National policy. This is an issue for the fact that it is largely national policy that shapes the future of the Arctic.

Further lessons learnt regarding the focus include:

- There is a need for increased cooperation between the political, scientific, and practitioner levels.
- Likewise, there is a need to focus on cooperation with and between Arctic peoples, their well-being, and the protection of indigenous cultures.
- There is an increased need for pan-Arctic knowledge sharing, partnerships, and engagement of political, scientific, and practice stakeholders across local, municipal, and national boundaries.
- There is a need for the development of a shared understanding of the questions that should be asked for holistic sustainable built infrastructure construction. In addition, there is a need for exemplified practical application.
- There is a need for flexibility in policy and development strategies.
- Cradle to grave / system thinking spans humanity and nature through politics, economics, sociology, and environment.
- Infrastructure connects protection of the natural environment with society.
- Meaningful dialogue and utilisation of indigenous and local knowledge is key for mitigating environmental degradation.
- Built infrastructure must be considered in relation to climate and its impacts.
- Robustness must be inherent in built infrastructure to allow effective adaptation to economic and technological changes.
- There is a need for more built infrastructure action orientated literature.
-

5.3.1.2 *Types of literature*

In addition to the type of national and international literature and knowledge seen across the Arctic, there is also variation in its focused level of application. Literature is here considered to be a principle mechanism of knowledge transfer. The various literature and other knowledge transfer mechanisms

have been sorted in accordance with where it originates from, and subsequently considered in terms of where the literature targets. For example, national policy is generated at the national political level, and both vertically targets the scientific and practitioner levels, and laterally targets municipal and local levels. The key literature types are set out below under their originating position and shown pictorially in Figure 5-1. Additionally, considering the quantity and / or effectiveness of the literature and other knowledge sharing mechanisms, each position on the municipal / local : national : pan-Arctic vs political : scientific : practitioner knowledge transfer mesh is considered and assigned a general strength.

Municipal / local : Political

- Moderate lateral guidance (e.g. to national government).
- Moderate downward guidance and regulation (e.g. to practitioners).

Municipal / local : Scientific

- Moderate downwards guidance (e.g. practical advice to practitioners).
- Moderate lateral guidance (e.g. knowledge networks).

Municipal / local : Practitioner

- Weak lateral guidance (e.g. community engagement).
- Weak upward guidance (e.g. community engagement).

National : Political

- Strong downward policy (e.g. to scientific and practitioner level).
- Weak downward guidelines and regulation (e.g. to scientific and practitioner level).
- Strong lateral policy (e.g. to municipal / local level).

National : Scientific

- Strong lateral literature (e.g. articles, data, conference proceedings etc.).
- Moderate upward guidance (e.g. knowledge networks).
- Weak downward guidelines (e.g. design guides etc.).

National : Practitioner

- Weak lateral standards.

International : Political

- Moderate lateral regulation (e.g. pan-Arctic applicable treaties).
- Moderate downward policy (e.g. Arctic Council).

International : Scientific

- Moderate lateral literature (e.g. databases and portals, coordinated assessments etc.).
- Moderate upward guidance (e.g. pan-Arctic science assessments).
- Weak downward guidance (e.g. environmental guidance).

International : Practitioner

- Moderate lateral literature (e.g. standards and textbooks etc.).
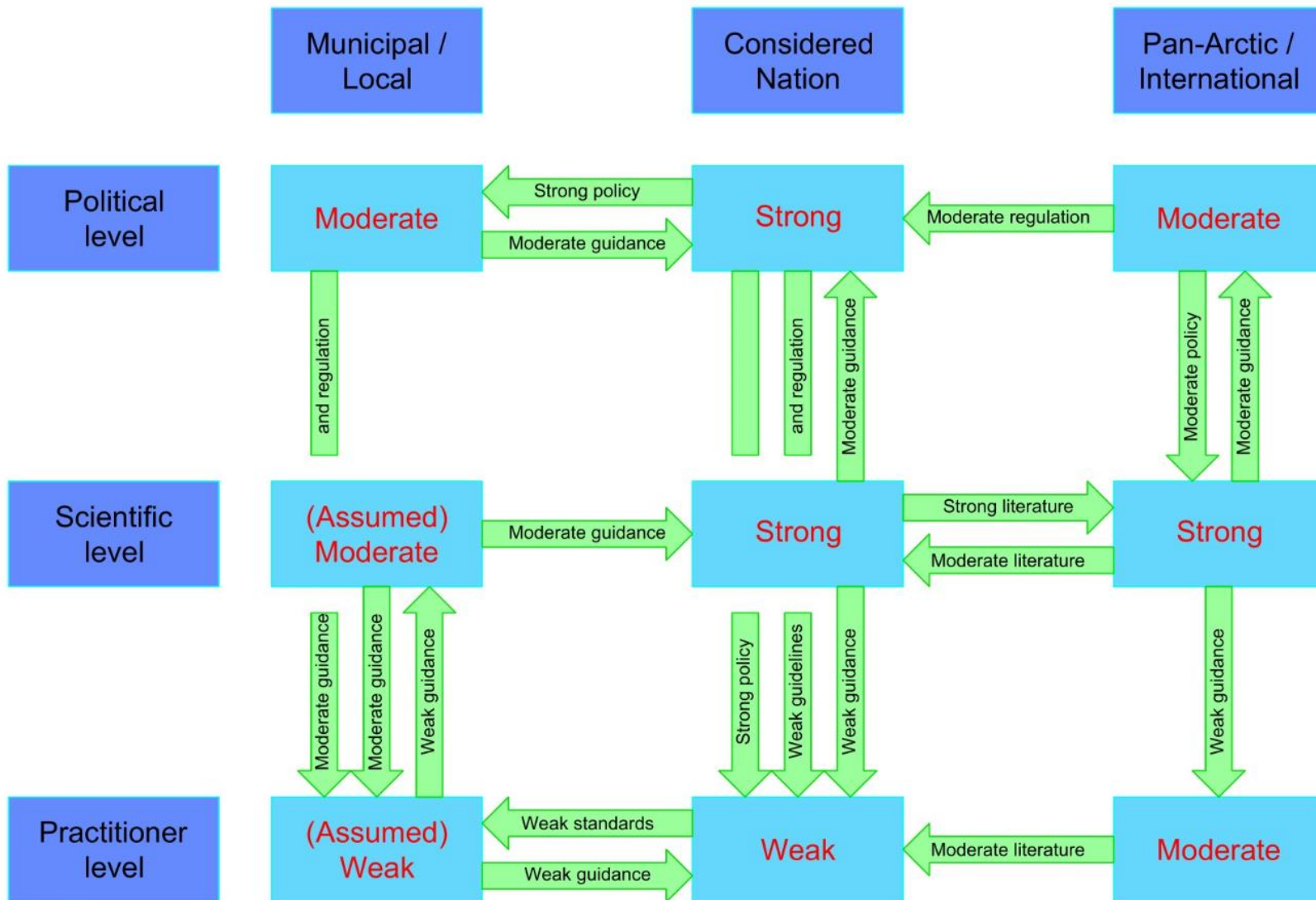
Figure 5-1: Arctic Literature Knowledge Transfer Mesh

In conclusion of the above, the majority of Arctic literature and other knowledge transfer activities, such as engagement sessions is realised in the form of policy and guidance. This is in relation to a lack of regulation, guidelines, and standards. Although guidelines and recommended practice can be detrimental for their lack of command, they are useful in the Arctic – where there are complex environmental and social interconnections – to move issues forward, which would otherwise struggle to gain definitive traction. The strength of the various knowledge transfer mechanisms varies across the levels, as is summarised below. The practitioner level is assumed to include, not only practitioners of Arctic development, but also Arctic residents.

- At the political level there is moderate guidance being received from the scientific level. Gaps are seen in the lack of knowledge transfer from the practitioner level.
- At the scientific level there is little knowledge transfer into the scientific level from the political and practitioner levels. The scientific level however is seen to provide moderate guidance upwards to the political level, and weak guidance downwards to the practitioner level.
- At the practitioner level, there is strong policy, but weak to moderate guidance and regulation from the political level. There is also in general weak guidance from the scientific level.
- At the municipal / local level there is experienced strong policy but weak standards from the political level.
- At the national level, there is weak to moderate guidance from the municipal / local level, and moderate regulation and other knowledge sharing from the pan-Arctic / international level.
- At the pan-Arctic / international level, there is an inflow of strong scientific literature knowledge.

In summary, with regards to the presence of quantity and / or quality of useful applicable knowledge, the various levels vary. The political level is moderate, the scientific level is strong, albeit with little reliance on the political and practitioner levels, and the practitioner level is weak to moderate. The municipal / local level is weak to moderate, the national level is moderate to strong, and the pan-Arctic / international level is moderate.

Gaps can therefore be identified. **With the exception of lateral scientific knowledge transfer, there is a need for improved knowledge transfer in all directions**. **Increased knowledge transfer is particularly required from the practitioner and local / municipal levels upwards**. Local / municipal practitioners are seen to be in a particularly weak position.

Considering development in general, if the voice of the people for whom the development is being undertaken, and who possess local knowledge is not being heard, then the development will undoubtedly be unsatisfactory and unsustainable – both socially and environmentally.

For practitioners such as engineers who reside at the practitioner local / municipal level, without appropriate incoming knowledge, such as vertical regulation, and lateral standards and design guidance, appropriate built infrastructure solutions will be hard fought and inadequate.

In addition, without increased appropriate knowledge transfer from the practitioner and scientific levels up to the political level, the political level decision makers will not have an understanding of the correct questions to ask when considering development, and thus inappropriate development will be dictated. There is currently insufficient planning policy for the assessment of pan-Arctic, national and local infrastructure needs, particularly coastal. The insufficiency of planning policy guidance, and practical knowledge for practitioners in the Arctic, is in part likely due to the largely independent national approach to infrastructure development.

Considering vertical knowledge transfer vs lateral knowledge transfer, it is seen that vertical knowledge transfer is substantially weaker. None the less, weakness is seen in both vertical and lateral knowledge transfer, a conclusion which supports the initial motivation for this study.

Thus:

Guidance is required that serves both decision makers commissioning Arctic built infrastructure development and those engineers who have to design it. – especially coastal infrastructure. An underlying principle of sustainable design is interconnectivity and thus **the guidance must be common to all parties involved, spanning across both the vertical political, scientific and practitioner levels, and the lateral pan-Arctic, national and municipal / local levels.**

The guidance should be in the form of a common set of considerations (themes) of applicability to all of the political (decision making), scientific (academic) and practitioner (engineering) spheres at pan-Arctic, national, and municipal / local level. This is for **the purpose of developing a common understanding of the questions that should be asked for development of holistic sustainable built infrastructure.**

In addition, **a built infrastructure development decision making framework is required to give shape to the common set of considerations (themes) and deduced questions.**

Such an arrangement of a common set of considerations (themes) with subsequent development decision making framework will help to address the above lessons learnt by:

- Introducing a holistic sustainable consideration of Arctic coastal built infrastructure development across geopolitical boundaries.
- Increasing cooperation and knowledge sharing between the political, scientific, and practitioner levels.
- Increasing cooperation and knowledge sharing at a pan-Arctic level, and across local, municipal, and national boundaries.
- Increasing focus on, cooperation with, and protection of indigenous and other Arctic peoples, and their well-being.

- Allowing flexibility in development of policy and development strategies in light of scale specific requirements.
- Introducing a cradle to grave / system thinking that spans humanity and nature through politics, economics, sociology, and environment.

Additionally through:

- Stimulating an understanding that infrastructure forms a key connection between society and protection of the natural environment.
- Providing a stimulus to engage in meaningful dialogue and utilisation of indigenous and local knowledge.
- Ensuring a holistic and sustainable approach is taken to built infrastructure development such that its due consideration is given to the impacts of changing Arctic environmental and social conditions.
- Encouraging inherent built infrastructure robustness, such that it can effectively adapt to economic and technological changes.
- Targeting development considerations on built infrastructure, and its central role in achieving human harmony with nature.

On the knowledge transfer mesh, the common set of considerations (themes) with subsequent development decision making framework originate, much like the Arctic Council, from the pan-Arctic / international scientific level. Unlike the Arctic Council though, who's work largely only extends to the pan-Arctic and national political levels, the reach of the themes and framework is across the entirety of the knowledge transfer mesh.

The two big disadvantages of the Arctic Council (Barry, 2020a) include:

- Complex paths to agreement on what is required in the Arctic, and on the actions required to achieve it.
- A danger of the least controversial choice being made.

The simplicity of having a common set of considerations (themes) with subsequent development decision making framework for built infrastructure is that individual nations and municipalities etc. retain flexibility whilst working from a pan-Arctic applicable common understanding.

5.3.1.3   Knowledge presence, sharing & transfer

Key lessons learnt from national literature with regards to knowledge include:

- 'Knowledge and understanding guides decision-making' (Government of Canada, no date b).
- A holistic circular approach to policy creation results in holistic policy.
- Holism is based on knowledge sharing and transfer.

- Holism positively correlates with the level of general development and the degree of power devolution.
- Knowledge of the Arctic can be generated through educating the people of the Arctic.
- Shared opportunities and challenges can be optimised through knowledge sharing (e.g. pan-local and pan-municipal).
- The need for this communicative literature (guidelines; regulation) between the political level and practitioner level is of heightened importance in the Arctic due to lacking or poor standards.

Key lessons learnt from international literature with regards to knowledge include:

- There is a necessity for horizontal (between local, municipal, national, and pan-Arctic), and vertical (between politics, science, and practice) knowledge transfer.
- Knowledge extends from a local to international scale, thus its application is also required at these scales. Implementation however must be subject to national legislation and international law; thus, cross boundary cooperation is required.
- Experience and knowledge exchange are extremely important for reasonable development of the high north.
- Recognition of ethnically distinct interests of indigenous Arctic peoples is important.
- Green colonialism is causing a loss of traditional knowledge.
- Scientific and traditional unintegrated knowledge co-production is required, where un-integration is based on:
  - Traditional knowledge being shared if and when deemed appropriate by the community.
  - Indigenous non-support of collective knowledge pooling to be picked and chosen from.
- Balanced attention and funding to the preservation and development of traditional and scientific knowledge in the coastal zone is required.

A principle conclusion drawn from consideration of knowledge presence, sharing and transfer is surrounding the difficulty of engaging indigenous and local knowledge. As is identified, traditional and indigenous knowledge cannot be considered as one with scientific knowledge. For this reason, although a common set of considerations across the knowledge transfer mesh will go some way in improving indigenous and local engagement, it will still be lacking. For example, a policy maker at the national political level, will, once promoted by considering the common themes, be able to find and retrieve scientific information from the local practitioner level. Given its ownership, the same policy maker will not be able to find traditional knowledge. As such, traditional knowledge is more likely to get ignored. Given that community and traditional knowledge does not necessarily fit into a scientific approach, then an additional mechanism of knowledge transfer is required.

To avoid unwelcomed pooling of community and traditional knowledge in knowledge networks, it is proposed that rather **an exemplified practical application approach is taken to learning from the local and indigenous levels.** Such an approach may still entail an accessible network, but a network of case studies rather than of knowledge that can simply be assumed to apply. Such case studies may detail how local and indigenous peoples can be effectively engaged and partnered with in relation to, for example, built infrastructure, and the wider built environment.

Separate to this, as evidenced by mistakes made in design of Arctic built infrastructure, and as per the above conclusions, **there is precedence for a network of practical design knowledge**. Once again, this would be most useful in a case study format highlighting key lessons learnt. Case studies could span from consideration of unique solutions to simple engineering problems through larger infrastructure systems.

5.3.2   Infrastructure

Within literature, infrastructure is seen to be mentioned in relation to a wide range of sectors demonstrating its wide importance. Unlike the overall focus of literature, reference to infrastructure is not particularly consistent across national and international literature. Where it is possible National and *international* literature considered themes can be correlated as follows: Transportation; Data & communications – *Connective infrastructure – including digital infrastructure;* Marine activities – *Port and marine infrastructure;* Social development – *Society;* Adaptation – *Physical conditions.*

Additional national themes include power / energy, natural resources, and tourism. Additional *international* themes include p*reparedness and safety, policy and regulation, financing*, and *research infrastructure.* **There is little to say regarding the focus of literature in reference to infrastructure other than the differences support the general national vs international literature focus.**

Further lessons learnt regarding the infrastructure include:

- Adaptation of infrastructure for resilience must be a key driver of development.
- There is need for a flexible and clear framework and regulatory governance structures for construction.
- Traditional knowledge should be utilised to help realise carbon neutral Arctic construction.

5.3.3   Coastal zone

Across both national and international literature there is a lack of clarity and a general sparce consideration of the coastal zone. It also appears that between national and international literature **there does not exist a common understanding of what the coastal zone it**. The only common reference to the coastal zone is in regard to resource use / development. It is noted that **there is little literature (policy, regulation, standards etc.) itself on the topics considered in relation to the coastal zone.**

National themes include safety and security (inc. search & recuse etc.), marine activities, continental shelf claims, resource development, The Law of the sea, and coastal infrastructure. *International* themes include *biodiversity and ecosystem-based management, environmental change, cultural use, resource use, conservation, sustainable use, economic opportunities, tourism, waste management, coastal erosion, and changes in sea level.*

The lack of similarity may be for the fact that the national literature barely considers the coastal zone in favour for the marine zone / environment. Thus, when considering national 'coastal zone' themes against international marine themes, there is a much closer similarity. National and *international* literature considered marine themes can be correlated as follows: Safety and security (inc. search & recuse etc.) – *Search and rescue;* Continental shelf claims – *Hydrographic research;* Resource development – *Commercial fishing;* The Law of the sea – *Oil pollution prevention;* Coastal infrastructure – *Infrastructure investment.*

5.3.4   Sustainable development

Where, national literature has a minimal consideration of sustainable development, international literature is fairly holistic in its consideration. Across both national and international literature **the understanding of sustainable development is humancentric.**

National consideration extends to social development, and general sustainability. International themes include environmental protection, traditional knowledge and food practices, WASH (water, sanitation, and hygiene) infrastructure, energy infrastructure, education, business, economic development, pollution, climate, culture, health and well-being, improved connectivity, and natural resource management. These could be summarised within ecosystem-based management and resilience adaptation, which are both strong general considerations within international literature.

5.4   Hypothesis confirmation

Prior to commencement of this study, a hypothesis was formed as to the state of literature and knowledge for the development of general and coastal zone specific arctic infrastructure development. That initial hypothesis, see chapter 3, is here confirmed.

1. The literature – policy, guidelines, and standards etc. that does exist for general and coastal zone specific arctic infrastructure development is primarily:

   a. Technically focussed; – *Partially. Considering directly applicable literature, then the bulk of it is either technically focussed literature at the practitioner level, or general literature at the political level. There is little in between.*

   b. Nation based; – *Yes. Considering directly applicable literature for infrastructure development, it is primarily nation based. Secondary literature stems from international sources rather than pan-Arctic collaboration. There are a few exceptions.*

   c. Lacking focus on holistic sustainable principles. – *Yes. With a few exceptions, policy of primary influence does not focus on holistic sustainable principles in relation to built infrastructure construction.*

2. There is limited planning policy for the assessment of pan-Arctic, national and local coastal infrastructure needs in the Arctic regions. – *Partially. In national policy, infrastructure is referenced in relation to facilitating national priorities. There is little consideration of infrastructure in general for its affect on people and nature. There is some pan-Arctic assessment.*

3. There is a void of available approach / guidance or instruction that seeks to ensure the development of the Arctic coastal zone in a holistic sustainable fashion. This is primarily the case at the high-level planning stage, both at national and international levels. – *Yes. In general, there is little guidance to high level decision makers as how to develop infrastructure. This is especially the case in the coastal zone. There is some guidance at the practitioner level.*

4. There is a lack of knowledge within Arctic nations for those people residing at the high decision-making level and at the low implementation (those physically designing structures) level. – *Yes.*

   a. This for example can represent itself at the high level with governments / decision makers not knowing the questions that should be asked when considering the feasibility of infrastructure projects. Or it can represent itself at the low level with the designers of infrastructure failing to recognise the polar specific aspects that must be considered to ensure successful holistic sustainable development in the Arctic. – Y*es. Both of these situations are experienced.*

    b. This lack of knowledge is in part resultant of a lack of sharing of knowledge and lessons learnt.

        i. From the mid-level (in which academic research is assumed to sit) up to the high (decision making) level and down to the low (implementation) level through the development of frameworks and recommended practice etc. *– Yes. Although there is wide sharing of assessment information, there is limited actional guidance or shared knowledge on the direction that development should take and the mechanisms to achieve this.*

        ii. From the lack of knowledge sharing between the high (decision making) and low (implementation) levels across national boundaries. I.e. decision making and engineering approaches to infrastructure development is largely national rather than pan-Arctic focussed. *– Yes. There is a void of actionable direction from the political decision making level down to the practitioner level. There is also a lack of actionable cooperation across national boundaries.*

    c. The above applies more acutely to the high (decision making) level than the low (implementation) level, where there has been a greater attempt to relate academic knowledge to practice. *– Yes. There is more actionable literature at the practitioner level than at the political level. i.e. there are more resources at the practitioner level to aid decision making on the direction of development than at the political level.*

5. Guidance is therefore required that serves both decision makers commissioning coastal infrastructure development and those engineers who have to design it.

    d. To ensure holistic sustainable Arctic development the approach / guidance or instruction must be common to all parties involved. *– Yes. A consistent understanding of what is holistic sustainable Arctic coastal infrastructure development is required.*

5.5   Port of Longyearbyen

This section of the study briefly further considers development within Longyearbyen and specifically the port of Longyearbyen. The first thing to note is that, should Longyearbyen be constructed again from scratch, it would not be built in its current location (Wickström, 2019). Perhaps in part for the consideration of sustainability, but primarily for the avoidance of construction in a location subject to natural constraints, such as topography.

5.5.1   Decisions for development

A major concern arising from review of available literature and knowledge is the lack of guidance on how to make decisions for development in the Arctic. Considering the port, Bråten, (2020) identified that decisions are made to facilitate local industry, such as coal export, cargo handling and tourism. Indeed, consideration of the industries and other requirements are contained in the strategic port plan for Longyearbyen (Multiconsult, 2014), and include: Tourism and cruise traffic; Fisheries, hunting and marine industries; Research and development activities and teaching; Shipping and logistics; Emergency preparedness, search and rescue; Border and resource control; Quay space for state vessels; Coal resources; Geothermal energy; Renewable energy sources; Other mineral resources; and Oil and gas.

Although the current plan is fairly holistic it its consideration of a wide range of sectors, Bråten, (2020) indicated that the process of developing port plans for Longyearbyen is very difficult given the fact that the direction of development in Svalbard is heavily politicised. With a change in both local and national government every few years, along with developing international politics, it is very difficult to develop a long-term strategic port plan. Unfortunately, there is little consultation between those planning the future of the port and those determining the wider future of Svalbard.

Although the service priorities of the port change in line with political focus, their remains an overarching drive to increase port capacity. This is for concern of the many vessels, that due to a lack of quayside, are forced to anchor in the harbour. Although ships are quite capable of this it can increase risk given the need for ship to shore transits. It also brings little if any benefit to Longyearbyen. In this way, vessels already visiting Adventfjorden are not be capitalised on. Bråten, (2020) tells us that tripling the current port capacity would serve the traffic needs of 2005, where port capacity has not majorly changed since then. Despite this, since 2005 the traffic has increased 400-500%.

A significant part of this traffic increase of unexpected rapidity is as a result of increased tourism activities as spurred by local government in reaction to the finishing of mining activities at Svea, a mining settlement to the south of Longyearbyen. The finishing of mining activities was itself a higher order political decision. A move from mining to tourism is indicative of the view of Longyearbyen permanence. Where an industry built on mining is inherently temporary, one built on tourism is theoretically more permanent.

Political decisions are thus seen to have a significant influence on the direction of Arctic development and subsequently the sustainability of that development. Constantly changing requirements for a port, especially in such an expensive and challenging location does not allow holistic long-term sustainable planning, or effective short-medium term reaction to opportunities. There is a lack of clarity as to the appropriate scope of development.

The necessity for clarity is an idea that becomes obvious when considering how development can be undertaken to focus on the offerings of a place such as Longyearbyen. Two ideas put forward by Wickström, (2019) include focussing on the natural offerings of the place, and a minimal development approach within the capacity of the offerings. In other words, development within ecosystem limits. Focussing on natural offerings such as nature, history, culture etc. both limits and focusses development (rather than trying to make something of nothing) and provides guidance as to the acceptable scale of development. A minimal development approach is important for the fact that once built it is almost impossible to remove infrastructure entirely and return a location to its original state.

One effective method employed by the Norwegian government to ensure minimal development is to create natural reserves under svalbardmiljøloven (The Svalbard Environmental Act) (LOVDATA, 2002). Although effective in natural settings, svalbardmiljøloven does not extend in consideration to areas already populated by humans (Wickström, 2019), and thus development within existing settlements is less strictly controlled. There is identified a need for new rules to force developers to consider existing site-specific development situations as a baseline on which to subsequently build. One such Svalbard example of this is the ongoing drive for a circular economy, the repurposing and reuse of materials in the local vicinity, such as was undertaken for a new floating sauna created in the port.

Despite the repurposing and reuse of materials being resource efficient, Bråten, (2020) identified that the sauna cost more than using new materials and is of a worse quality. Expense wise, the high cost of repurposing materials was likely due in part to their origin, which was, although on Svalbard, away from Longyearbyen. Repurposing of such materials involves deconstruction, transport, and subsequent reconstruction, all in the Arctic which is notorious for expensive and difficult operations. An interesting question is here thus raised. Is more rigorous planning regulation, for material reuse and environmental control etc. required in the remote Arctic than in more temperate well-connected locations? Undoubtedly, the answer is yes. For its remote and expensive nature, the Arctic environment has long been abused for the sake of ease and cost.

In answer to the lack of experience in the Arctic for development, it was identified by those interviewed that a solution would extend to more cross collaboration between for example Architects, Engineers and Anthropologists. As evidenced however, there is also need for increased vertical collaboration between such practitioners and higher political decision makers. In Longyearbyen there is already some knowledge transfer between academia and practitioners. Of particular use to Arctic practitioners would be a portfolio of tried and tested approaches to development from around the Arctic, detaining what practically worked and what did not, and what were the social impacts.

5.5.2   Considerations for sustainable development

Despite there existing poor environmental practices throughout the Arctic, there is concern for sustainable development already established to a certain extent in Svalbard. Although the premise for permanent settlements in Svalbard is questionable from an overall sustainability standpoint, there are smaller scale integrated practices of a nature contributary to sustainable development already in place.

Continuing to consider port Longyear, the understanding of sustainable development extends to green port strategies, such as those concerned with pollution, material usage, and development that does not negatively affect the local community or wider country. It was identified by Bråten, (2020) that such considerations in the port are made easier because Svalbard already exists as a 'green bubble'. Again, disregarding the very existence of Longyearbyen in Svalbard, this is somewhat true, what with extensive environmental protection strategies and an ongoing pursuit to improve settlement sustainability. The idea of a green port strategy extends to the current strategic port plan in not considering development for the support of the oil extractive industry so far North. This could of course also be understood as un-holistic.

Despite Longyearbyen power grid currently being reliant of coal, in the recognition that there is a need to start somewhere, plans are progressing to start implementing ship to shore power for smaller vessels docked in port Longyear. Further port improvement extends to early stage plans for a large floating cruise terminal. Changing political priorities once again however are significantly felt in the ongoing stop start nature of the project. Resultant of difficulties in political cooperation along with challenging environmental conditions, alternative solutions such as floating infrastructure is starting to become the norm in port Longyear.

Section II : Holism and sustainability in built infrastructure development.

The concept of sustainable development is ambiguous and lends itself to a variety of interpretations. These varying interpretations stem from the varied understanding of what the meaning is of the two components – sustainability and development. Resultant of the understanding of these components, a set of principles for sustainable development is formed. This section seeks to identify the historic, common, and developed understanding of sustainable development in time and place and its application to the Arctic.

6   The developing concept of sustainable development

In order to comprehend the concept of sustainable development, an understanding of the individual sustainability and development components must first be had. As a baseline, sustainability can be understood as 'the quality of being able to continue over a period of time' (Cambridge University Press, 2020). Likewise, development can be understood as 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020). It is therefore seen that Individually, the components of sustainability and development can take on different meanings dependent on the context in which they are used and the interpretation of the considering parties. As such, the concept of sustainable development as a whole is of a dynamic organism undergoing growth and change with time, where an organism can be defined by 2020 Dictionary.com LLC, (2020) as:

'any complex thing or system having properties and functions determined not only by the properties and relations of its individual parts, but by the character of the whole that they compose and by the relations of the parts to the whole'.

The natural instinct of humanity is of course to survive and flourish and thus the continuation of life and its betterment, which could be related to advancement, is an age-old driver. The concept of sustainable development then is not new, but rather humanities perception and understanding.

6.1   Utopian origins

According to Harlow, Golub and Allenby, (2013) the origins of the concept of sustainable development can be traced back hundreds of years to:

'18th and 19th century political economic thought, Rousseauian ideals, the modernism founded on Bacon and Descartes, early Christian utopianism, and classical utopias such as Republic and New Atlantis'.

Within these utopian ideals, Harlow, Golub and Allenby, (2013) identify common themes of 'social justice, environmental stewardship and economic growth'. It is highlighted repeatedly that these themes are born out of discourse. For example during the 18th and 19th centuries 'intellectual exchange around political economy raised questions about the morality of capitalist accumulation' leading to 'tensions between growth and social justice' (Harlow, Golub and Allenby, 2013).

Harlow, Golub and Allenby, (2013) communicate that 'small-scale, steady-state economics operating under an environmental ethic of humanity's harmony with nature' is explored in the work of Jean-Jacques Rousseau in the 18th century and that the theme of environmental stewardship can be traced back even further to Saint Francis of Assisi in the late 12th to early 13th century.

The understanding of development, according to Harlow, Golub and Allenby, (2013), can be traced back to the 13th century European Christian understanding of human progress. The concept of Human progress at this time, Du Pisani, (2006) identifies as being underpinned by 'two crucial strands', namely: 'awareness of the cumulative advancement of culture and a belief in a future golden age of morality on this earth'. The belief in a future golden age is arguably an early example of Christian utopianism. Later envisioned utopias reflect varied focus on the earlier identified themes of economic growth, social justice, and environmental stewardship.

6.2   The 1800's

One of the first direct recognitions of the relationship between humans and the environment was in 1798, when Thomas Robert Malthus, a 'demographer, political economist and country pastor in England' (Bac, 2008) predicted that 'food production could not keep pace with the growth of population' (Bac, 2008). With an approximate seven-fold increase in population from 1800 to 2019 (Roser, Ritchie and Ortiz-Ospina, 2020), this has proved to be largely untrue, with credit being given to technological advances and improved agricultural practices (Bac, 2008). Increasing trade and globalisation of course masks the true disparity between population requirements and food provision in any one region of the world.

6.3   1972 – The Limits to Growth

The next major actioned step in recognition of humanities connection and influence over the natural world is arguably 'The Limits to Growth' (Meadows *et al.*, 1972), the findings of The club of Rome's project on the predicament of mankind published nearly 200 years later in 1972. The project initiated in 1968 by the club of Rome – a group of likeminded individuals concerned with the general future of humanity (Club of Rome, 2020) – sought to consider the 'present and future predicament of man' (Meadows *et al.*, 1972) through consideration of a set of 'interdependent components – economic, political, natural, and social' (Meadows *et al.*, 1972). It was these four components that were recognised

as making up 'the global system in which we all live' (Meadows *et al.*, 1972), the components manifesting themselves to varying degrees in the plethora of problems faced by humankind around the world. Through the work undertaken, it was recognised that there are three aspects common to all areas of the world: The identified worldly growth problems – poverty; environmental degradation; institutional disenchantment; urbanisation; employment insecurity; youth alienation; traditional values rejection – occur in all societies to varying degrees; the problems faced contain 'technical, social, economic and political elements'; and all of the problems interact (Meadows *et al.*, 1972).

'The Limits to Growth' (Meadows *et al.*, 1972) is the culmination of computer simulations undertaken to assess the interaction and interconnectivity between the many components of the identified problems. Particular focus was given to five main factors that were considered to determine the limits of civilisation, the worldly limiting problems – The increase in 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources' (Meadows *et al.*, 1972). In each case an exponential growth is identified, with the predicted collapse of the interdependent system resultant of non-renewable resource depletion (Bac, 2008) within a century (Meadows *et al.*, 1972). The main conclusions of 'The Limits to Growth'(Meadows *et al.*, 1972) are as follows:

1. *'If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity'.*

2. *'It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his individual human potential'.*

3. *'If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success'.*

The start of growth of the present understanding of sustainable development occurred at the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden. The focus of the conference was entirely international environmental issues and was pivotal for the development of international environmental policy (United Nations, 2020e). A mixed representation of 113 countries and 19 international organisations convened to confirm the intrinsic link between the environment and development. It was here realised that development and environmental protection were seen as competing needs (Bac, 2008). The resulting United Nations Declaration of the Conference on the Human Environment (United Nations, 1972) recognised the disparity between the environmental problems of developing countries caused by under-development, and the environmental problems of industrialised countries 'related to industrialisation and technological development'. This can loosely be envisaged as a south-north divide of global countries.

6.4   1987 – Our Common Future

It was in 1987 that the most recently significant and most widely recognised definition of sustainable development emerged. Resultant of the World Commission on Environment and Development created in 1983 at the UN General Assembly, the report entitled 'Our Common Future' was published. Later known as the Brundtland Report, 'Our Common Future' submits 'sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). The provided definition is identified as including two key concepts:

1. *'The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given'.*

2. *'The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs'.*

As Bac, (2008) points out, the above definition is often criticised as being vague, and indeed 'Our Common Future' goes on to discuss in broad terms what sustainable development may include dependent on interpretation of the concept.

Although the description of sustainable development is broad in that is touches on a range of subjects there remains a strong focus throughout on economic development and its relation to human satisfaction. Technology progression is often depicted as the vehicle of change. The very first descriptions of sustainable development indeed draw focus directly and indirectly to economic development: 'Thus the goals of economic and social development must be defined in terms of sustainability in all countries'; 'Development involves a progressive transformation of economy and society'; 'A development path that is sustainable in a physical sense could theoretically be pursued even in a rigid social and political setting' (World Commission on Environment and Development, 1987).

It is interesting to note that attention is also drawn here to the possibility of development being sustainable in a physical sense regardless of the social and political situation. Considering our initial definition of development – 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020) – this seems unlikely. Process suggests decision, whilst advancement relates to one's perception, thus development is intrinsically linked with humanities entire being, be it personal belief, social security, political content etc. The concept of sustainable development within 'Our Common Future' is largely considered as a physical phenomenon, e.g. using only so much natural resource that there is sufficient for future generations, thus it is no surprise that there is a heavy focus on economic betterment and technological advancement.

An example of the above can be seen in the consideration of ecosystems. 'Our Common Future' (World Commission on Environment and Development, 1987) states: 'Development tends to simplify ecosystems and to reduce their diversity of species. And species, once extinct, are not renewable. The

loss of plant and animal species can greatly limit the options of future generations, so sustainable development requires the conservation of plant and animal species'. All of this is of course true. What is of concern however is the focus on conservation of the natural planet for the benefit of humanity as an exploitive resource for material satisfaction, rather than conservation to ensure balance between humanity and nature. It is this ideal, that development – achieved through economic growth and technological advancement – is the fulfilment of humanities requirements. Where economics and technology can play a positive role in the under-developed areas of the world – where the basic needs of people are not met, and where a lack of development can lead to environmental degradation – the portrayed ideal also gives credence to the developed areas of the world in their continued exploitation of natural resources for the purposes of self-gratification.

6.5   1992 – UN Conference on Environment and Development

The definition of sustainable development established in 1987 has, since its inception largely continued to form the basis of humanities understanding of the concept. The cementing of the concept came in 1992 as the result of the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil. As the name suggests the focus of the conference was on the elements of environment and development as if they are linked but separate. Arguably, the environment is one element within development, or vice versa. The principle products of the conference were 'Agenda 21', 'the Rio Declaration', and the formation of The Commission on Sustainable Development (CSD). The 1992 Rio conference was in fact a summit for 12 preceding international conferences tackling some of the biggest common world problems identified at the time, and seeking to determine the 'priorities for a new development agenda for the 1990s and beyond' (United Nations, 2020e). It is 'Agenda 21' that forms the 'comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment' (United Nations, 2020e). Although the focus still remains largely on environmentally impactive development, thought is now also given to a wider subject range as suggested by the breakdown structure of 'Agenda 21': Social and Economic Dimensions; Conservation and Management of Resources for Development; Strengthening the Role of Major Groups; and Means of Implementation (United Nations, 1992b). Thus starts a more holistic consideration of sustainable development.

6.6   1994 – Small Island Developing States – BPoA

During the 1990's there was a particular growth of interest in Small Island Developing States (SIDS), which in addition to general development challenges seen globally, are also susceptible to additional unique sustainable development challenges. The first conference of significance was the 1994 Barbados Programme of Action (BPoA) at which the 'Barbados Declaration' was adopted, a 'statement of political will' (United Nations, 2020e) in support of 14 identified priority areas for action as follows:

1. **Climate change and sea-level rise.**
2. **Natural and environmental disasters.**
3. Management of wastes.
4. **Coastal and marine resources.**
5. **Freshwater resources.**
6. Land Resources.
7. **Energy resources.**
8. **Tourism resources.**
9. Biodiversity resources.
10. National institutions and administrative capacity.
11. Regional institutions and technical cooperation.
12. Transport and communication.
13. Science and technology.
14. Human resource development.

6.7   1999 – Small Island Developing States – BPoA+5

A five-year review of the Barbados Programme of Action (BPoA+5) in 1999 drew increased focus to six of the originally identified areas – shown in bold – as needing urgent action. Additionally, reaffirmation and commitment was given by the 123 member states to the principles of 'sustainable development as embodied in Agenda 21, the Barbados Declaration and the BPoA' (United Nations, 2020e).

Further to the above identified priority areas, the two conferences identified the underlying need for effective implementation mechanisms stimulated by cross-sectorial cooperation. Attention areas include: sustainable development strategies; capacity building; institutional development at the national, regional and international levels; information management through strengthening the SIDS Network; cooperation in the transfer of environmentally sound technologies; trade and economic diversification; globalization and trade liberalization; resource mobilization and finance; and a vulnerability index (United Nations, 2020e).

6.8   2000 – The Millennium Summit

The decade following 1992 and the UN Conference on Environment and Development saw a series of significant United Nations conferences and summits some focussed on sustainable development as a whole and others towards environmental action specifically. Such an example is the 1997 Kyoto Climate Change Conference, which through the resulting Kyoto Protocol extended international commitment to the reduction of greenhouse gas emissions (United Nations, 2020f). These various

conferences culminated in the year 2000 with the Millennium Summit, the product of which was the United Nations Millennium Declaration, a declaration of committal to 'reduce extreme poverty' (United Nations, 2020c) through the setting of 8 measurable targets. These became known as the Millennium Development Goals (MDGs) and were implemented with a deadline of 2015. The MDGs were as follows:

1. Eradicate extreme poverty and hunger;
2. Achieve universal primary education;
3. Promote gender equality and empower women;
4. Reduce child mortality;
5. Improve maternal health;
6. Combat HIV/AIDS, malaria, and other diseases;
7. Ensure environmental sustainability;
8. Develop a global partnership for development.

6.9   2002 – The World Summit on Sustainable Development

Following on from the Millennium Summit was the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002. This summit brought the focus of the world to 'meeting difficult challenges, including improving people's lives and conserving our natural resources in a world that is growing in population, with ever-increasing demands for food, water, shelter, sanitation, energy, health services and economic security' (United Nations, 2020e). The result of the summit was ultimately the reaffirmation of the 1992 UN Conference on Environment and Development (UNCED) fundamental principles and the implementation of Agenda 21, along with the achievement of the Millennium Development Goals (MDGs) (United Nations, 2002).

6.10   2005 – Small Island Developing States – MSI

The next step in sustainable development again came from the consideration of SIDS at the 2005 Mauritius Strategy of Implementation (MSI) meeting, a 10-year review of BPoA. In extension to the BPoA, the MSI sets out 19 priority areas for sustainable development of SIDS. The original themes of National institutions and administrative capacity and Regional institutions and technical cooperation are combined into the theme of National and regional enabling environments. The original theme of Human resource development is broadened to the theme of Sustainable capacity development and education for sustainable development (United Nations, 2005). New additional priority areas in the MSI include:

1. Graduation from least developed country status.
2. Trade: globalisation and trade liberalization.

3. Sustainable production and consumption.
4. Health.
5. Knowledge management and information for decision making.
6. Culture.

6.11 2010 – Small Island Developing States – MSI+5

The MSI was followed 5 years later by a review (MSI+5) at which endorsement was given to its continuation. These conferences identified that in extension to the problems faced by developing countries in general, SIDS also experience additional unique vulnerabilities (United Nations, 2020e).

6.12 2012 – The Future we Want

It was in 2012 that the pursuit of the current understanding of sustainable development commenced. The United Nations Conference on Sustainable Development, Rio+20 was a milestone meeting both in political consensus and action. The resultant political outcome document – 'The Future we Want' focusses political consensus towards practical measures to be undertaken to further the implementation of sustainable development. Such measures as a start include the continued commitment to the major preceding summit actions, such as the 'Rio Declaration', and 'Agenda 21'. Encouragingly, the commitment also extends to and includes those areas of action identified as a priority for SIDS, such as through the commitment to the BPoA (United Nations General Assembly, 2012).

A significant result of the conference was the commitment of the member states to build upon the Millennium Development Goals, the culmination of which had a fulfilment date of 2015. This resulted in the commencement of a process to develop a set of Sustainable Development Goals (SDGs), eventually resulting in the development of the '2030 Agenda for Sustainable Development'. Rio+20 in addition saw the establishment of a high-level political forum (HLPF) on sustainable development, which grew to replace the Commission on Sustainable Development. The primary role of the HLPF is to oversee the implementation of the '2030 Agenda for Sustainable Development' (United Nations, 2020e).

A key outcome of the conference was the strong political alignment with the concept of a green economy. A concept identified as an important method to achieve sustainable development, it recognises any 'theory that views the economy as a component of the environment in which it is based' (Halton, 2019). A further result of the conference was the adoption of a 10-year framework of programmes on sustainable consumption and production patterns (United Nations, 2012). Covering the period 2012-2022 the framework seeks to shift the way in which society produces and consumes towards a sustainable model.

The scope of the conference, and by extension the resulting political outcome extended not only to the above but also focussed in on both established and cross-cutting sustainable development aspects. The established aspects of 'economic growth and diversification, social development and environmental protection' (United Nations General Assembly, 2012) form a central ideal. Thematic areas of conference concentration for action included:

1. Poverty eradication.
2. Food security and nutrition and sustainable agriculture.
3. Water and sanitation.
4. Energy.
5. Sustainable tourism.
6. Sustainable transport.
7. Sustainable cities and human settlements.
8. Health and population.
9. Promoting full and productive employment, decent work for all and social protection.
10. Oceans and seas.
11. Small island developing states.
12. Least developed countries.
13. Landlocked developing countries.
14. Africa.
15. Regional efforts.
16. Disaster risk reduction.
17. Climate change.
18. Forests.
19. Biodiversity.
20. Diversification, land degradation and drought.
21. Mountains.
22. Chemicals and waste.
23. Sustainable consumption and production.
24. Mining.
25. Education.
26. Gender equality and women's empowerment.

Further, 'the Future we Want' commands the facilitation of an 'enabling environment at the national and international levels as well as continued and strengthened international cooperation, particularly in the areas of finance, debt, trade and technology transfer, as mutually agreed, and innovation, entrepreneurship, capacity-building, transparency and accountability' (United Nations General Assembly, 2012). The conference recognises the need for country specific flexibility as well as the strengthening of international governance, specifically environmental, to ensure balance of economic, social, and environmental determinants.

Noting thematic area 11 – Small island developing states were re-recognised as being particularly vulnerable resultant of their 'small size, remoteness, narrow resource and export base, and exposure to global environmental challenges and external economic shocks, including to a large range of impacts from climate change and potentially more frequent and intense natural disasters' (United Nations General Assembly, 2012). To this extent, the Rio+20 conference committed to the further convening of a third international conference on SIDS.

6.13   2014 – Small Island Developing States – SAMOA Pathway

The third international conference on SIDS was held in Apia, Samoa in 2014 and was focussed on 'the sustainable development of small island developing states through genuine and durable partnerships' (United Nations, 2020e). The outcome of the conference was the adoption of the Small Island Developing States Accelerated Modalities of Action (SAMOA Pathway). Support and oversight of the SAMOA pathway is through the developed SIDS Action Platform (United Nations, 2020d) which includes the facilitation of partnership generation and maintenance and the sharing of lessons learnt.

6.14   Post 2015 Agenda

The culmination of the previous decades of conference led development of the concept of sustainable development was the UN Sustainable Development Summit 2015 and the adoption of the post 2015 development agenda. 'Transforming our world: the 2030 Agenda for Sustainable Development' (United Nations General Assembly, 2015) is the most comprehensive development agenda to date, with applicability to and acceptance by all countries. The agenda sets ambitious universal goals and targets for developing and developed countries alike whilst allowing for national application. The agenda looks to balance what is known as the triple bottom line (TBL), a sustainability construct of balanced economic, social and environmental dimensions (Alhaddi, 2015), and seeks execution though 17 Sustainable Development Goals (SDGs) and 169 targets.

Figure 6-1: United Nations 17 Sustainable Development Goals. Source – United Nations, (2020a)

The 17 SDGs are recognised to be integrated to the extent that action in one will cause an effect in others. They are developed to 'stimulate action' 'in areas of critical importance for humanity and the planet' (United Nations General Assembly, 2015). The identified areas are as follows:

1. People

'We are determined to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment'.

2. Planet

'We are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations'.

3. Prosperity

'We are determined to ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature'.

4. Peace

'We are determined to foster peaceful, just and inclusive societies which are free from fear and violence. There can be no sustainable development without peace and no peace without sustainable development.'

5. Partnership

'We are determined to mobilize the means required to implement this Agenda through a revitalized Global Partnership for Sustainable Development, based on a spirit of strengthened global solidarity, focused in particular on the needs of the poorest and most vulnerable and with the participation of all countries, all stakeholders and all people.

'The interlinkages and integrated nature of the Sustainable Development Goals are of crucial importance in ensuring that the purpose of the new Agenda is realized. If we realize our ambitions across the full extent of the Agenda, the lives of all will be profoundly improved and our world will be transformed for the better.'

The general success of the 'Millennium Declaration' through pursuit of the eight millennium development goals confirmed to the international community the usefulness of goal setting on an international scale (United Nations Development Programme, 2020b). There were however experienced limits to their success, limits which the new SDGs seek to avoid.

Where the millennium goals focussed on specific subjects, which undoubtedly contribute to sustainable development, they do not in themselves complete the scope of sustainable development as a whole. Their focus is on a number of humanitarian issues along with environmental sustainability and partnership for development, rather than on holistic sustainable development as a whole. In furthering the scope of actionable targets, as mentioned the SDGs look to balance economic, societal and the environmental demands through 169 targets, whilst remaining humancentric. Progression against these 169 targets and ultimately the 17 SDGs is monitored and directed through the Division for Sustainable Development Goals (DSDG) which forms part of the United Nations Department of Economic and Social Affairs (UN DESA) (United Nations, 2020e).

The UN sustainable Development Goals (SDGs) are first recognised by the Arctic Council under the U.S. 2015 – 2017 chairmanship. Within the 2017 Senior Arctic Officials' Report to Ministers (Arctic Council, 2017b), two Arctic Council working groups, the Arctic Monitoring and Assessment Programme (AMAP) and Sustainable Development Working Group (SDWG) aligned themselves with some of the SDGs.

Direction by Arctic Council Ministers and Senior Arctic Officials (SAOs) was given to AMAP to 'support Arctic Council Chairmanship priority work, as well as the development and implementation of relevant international processes and conventions relating to pollution and climate issues', along with 'work that contributes to the UN Sustainable Development Goals' (Arctic Council, 2017b). Support of Arctic Council Chairmanship priorities extends to the then commencing Finnish 2017 – 2019 chairmanship, whose priorities were environmental protection, connectivity, meteorological cooperation, and education. The SDG's noted by AMAP were #2 zero hunger, #3 good health and well-being, #6 clean water and sanitation, #12 responsible consumption and production and #13 climate action. #6 clean water and sanitation was also aligned with by SDWGs WASH (Water, Sanitation and

Health) programme – A project that seeks to 'ensure availability and sustainable management of water and sanitation for all' (Arctic Council, 2017b).

Commitment to SDGs #2, #3, #6 and #13 were affirmed within the 2019 Senior Arctic Officials' Report to Ministers (Arctic Council, 2019) under AMAPs 2019 – 2021 work plan activity of 'Addressing Contaminants and Human Health Issues'. In a general sense, the UN Sustainable Development Goals are promoted for 'Improving knowledge and public awareness' (Arctic Council, 2019) as part of the Conservation of the Arctic Flora and Fauna (CAFF) work plan 2019 – 2021. Recognition of the UN 2030 Agenda for Sustainable Development is limited to the 2019 Senior Arctic Officials' Report to Ministers, and is only in passing. Under the Indigenous Peoples' Secretariat (IPS) Work Plan 2020-2021, "support" is to be given to the permanent participances in their involvement in international fora, including Agenda 2030.

7   Indicators of sustainability and development - Lessons learnt from the developing concept

The individual understandings of sustainability and development were first identified, sustainability as 'the quality of being able to continue over a period of time' (Cambridge University Press, 2020), and development as 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020). As has been seen, the concept of sustainable development has itself developed – grown and changed – over the centuries and decades to become the current United Nations Sustainable Development Goals as part of the 2030 Agenda for Sustainable Development, an agenda which is considered by many the most comprehensive and inclusive agenda to date. The sustainable development organism has over time grown and is now recognised as an interrelated system of magnitude and depth. The question remains however, does Agenda 2030 effectively translate at scale to the Arctic? The following section considers the themes grown out of the developing concept of sustainable development and seeks to identify lessons that can be learnt, and which are applicable for holding Arctic sustainable development to account.

Utopian Origins

The earliest ideas surrounding sustainable development were not about the concept itself, as the concept did not yet exist, but around the three topics commonly associated with sustainable development. The triple bottom line, or the three pillars of sustainability – the environment, society, and economics. As is shown in the adjacent Figure 7-1, the first utopian idea of note is towards the environment, closely followed by human progress, or society. It is not until much later that an economic utopia is envisaged. Of note, human progress as considered in the 13th century tends to societal development, rather than technological for example. Joint consideration of the environment and society is seen in the concept of harmony with nature.
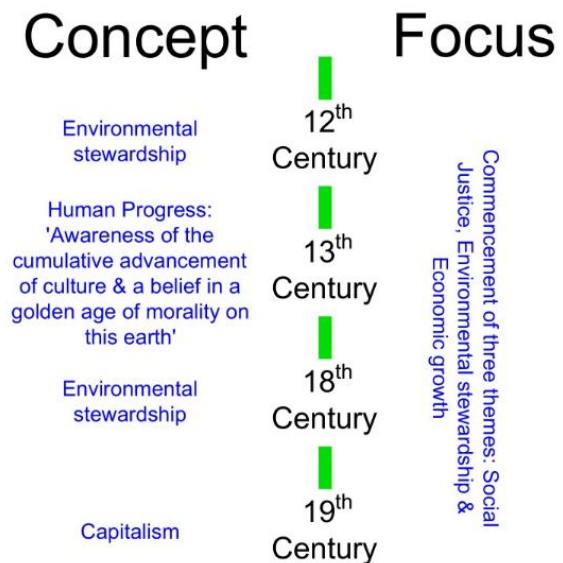
Figure 7-1: Sustainable development timeline

7.1   Harmony with nature

From its utopian origins, living in harmony with nature is now referenced as being necessary for prosperity within one of the United Nations Agenda 2030 'areas of critical importance for humanity and the planet' (United Nations General Assembly, 2015). The idea of living in harmony with nature within the modern context, and as a keystone to sustainable development can be traced to principle one of the Rio Declaration, the keynote result of the 1992 UN Conference on Environment and Development (UNCED). Principle one states that "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature".

Over the years there has been substantial debate on the direction in which this principle points. The bulk of the principle centres arounds an anthropogenic approach to sustainable development, with only a secondary consideration that this should be in harmony with nature. The principle considers that humans are 'entitled', alluding to 'a rights-based approach to development – that humans deserve a decent standard of living and may achieve this through development and resource exploitation, but equally the entitlement to a healthy and productive life must occur in harmony with nature' (United Nations, 2011). Of these two aspects, it is the former that appears to be hold sway in current Arctic built infrastructure developments.

As identified in Sherwin and Bishop, (2019) significant investment in large scale development projects is already underway in the Arctic and is set to continue. Although mixed, current Arctic development is dominated by the mining and fossil fuel energy sectors and associated facilitative infrastructure, such as ports, road and rail. Although such developments can bring benefits to local Arctic communities, such as improved access to education and healthcare, the detriment caused at both local, national and international levels can arguably outweigh the benefits. At a local level for example food stocks can be negatively affected by mining activities. One such case is that of the controversial copper mine in repparfjord in Finmark, northern Norway.

As of November 2019, the Norwegian government gave the go ahead to the mining company Nussir ASA to commence mineral exploration in what is mainland Europe's northernmost mine (Nilsen, 2019). Located in the Arctic coastal zone the mine has attracted much opposition from both local indigenous Saami people and environmental organisations alike. Opposition focuses primarily around disturbances to reindeer grazing pattens and the granted rights to dump mine tailings into the fjord, which as it happens is a protected national salmon fjord. Indeed, these oppositions are well founded with evidence that Nussir mine tailings have caused increased mortality of Atlantic cod larvae (Pedersen, 2019) and the circumstantial evidence of near decimation of the local fishing grounds in the 1970s when there was a much reduced level of mine waste dumping in Repparfjord (EARTHWORKS, 2019). The justification for the mining activities are three fold: To facilitate a transition to 'green' technologies such as electric vehicles and renewable energy sources, and for the creation of jobs and economic growth (Nilsen, 2019). Although both the Norwegian government and the mining company recognise that mining in

general has negative consequences for the environment, they maintain that the extraction will be undertaken 'in accordance with very high environmental standards' (Nilsen, 2019). 2017 – 2019 Saami president Aili Keskitalo maintains the project is a "violation of land and resource rights" and a counter to the United Nations Convention on Civil and Political Rights (Ruud, 2019).

What is evidenced in the above case is the toxic relationship between economically driven, short term exploitive development and long term sustainability. The above case is largly not for the benefit of the environment or the local population, but for the demands of the wider world, i.e. minerals for export. This is a consistently seen current trend in the Arctic, from coal export and trans-national shipping in Russia, through mineral extraction in Greenland and Canada, and fossil fuel energy in Alaska, all of which promote infrastructure development. This development is believed to be for two principle reasons:

1. Development in general and by extension Arctic development is still perceived through an economic lens.

2. Current major development in the Arctic is for the benefit of the wider Arctic nations in service of global demand.

The major current infrastructure development activities can therefore be said to bring development, but largely not for the benefit of the Arctic, it's peoples or their harmony with nature. Considering the above Repperfjord case, the copper mine is relatively a short term development (25 -30 years operation (Ruud, 2019)), and although anticipated to provide up to 150 local jobs (EARTHWORKS, 2019) may not sustain the local population. The 150 jobs are likely positions that require specialised skills which are most easily imported. The local population could of course benefit from training, however after the conclusion of the mining activities, the jobs will disappear, which is arguably not socially sustainable. Separately, the exploitation of unrenewable materials is both un-environmentally friendly and unsustainable. Largely therefore the project appears unsustainable at a local scale, the reason of course being that the project is not locally focussed.

Sustainable development is resultant of both scale and focus.

Sustainable Arctic development then is development that holistically increases balance and harmony between humanity and nature within the Arctic regions. It is not the exploitation of the Arctic regions for the benefit of the wider world, whether for a 'green' agenda or not. That being said, sustainable Arctic development projects if undertaken within a holistic framework can provide some of the building blocks for national, pan-Arctic and global sustainability. This can become a reality if these building blocks are seen only as foundational, the combination of which, like 'jigsaw pieces', fit together to yield regional and national detailed 'tiles' which together build a comprehensive global 'picture'. In other words a bottom up approach to development in which any negative impacts, of for example built infrastructure development, are compensated for locally.

This approach however is difficult to achieve as evidenced by the current state of the developed world. An industrialising world with an ever increasing population now transgressing natural limits and following a globalisation agenda. A world instigated at the time of the first industrial revolution. A point in time similar to that at which the Arctic regions now stand and yet as Sherwin and Bishop, (2019) highlight, a point in time where there still remains the opportunity to build upon the existing development innovation seen in the Arctic to charter a new truly sustainable model for development. Regarding built infrastructure specifically, although new approaches to its development will be required, in general their implementation could likely be achieved through use of existing mechanisms such as policy, regulation and standards.

Indeed the principle of living in harmony with nature has become a keystone to sustainable development and 'forms the basis of many international laws and agreements, as well as civil society organisations, campaigns and projects' (United Nations, 2011). Unfortunately, as evidenced, within policy, regulation and standards etc. there exists an anthropogenic lens and the persistent idea of human entitlement, which overwhelms the concern for environmental well-being. In recent years however there has commenced a shift towards Earth Jurisprudence – 'legal provisions recognising the Rights of Nature' to 'exist, thrive and evolve' in partnership with humanity (United Nations, no date a). Since the United Nations General Assembly in 2009 proclaimed 22 April as International Mother Earth Day, Earth Jurisprudence has started to establish itself in constitutions along with national and local law.

The proclamation of Mother Earth Day recognised the necessity to 'promote Harmony with Nature in order to achieve a just balance among the economic, social and environmental needs of present and future generations'. It also recognised that since the industrial revolution 'Nature has been treated as a commodity that exists largely for the benefit of people, and environmental problems have been considered as solvable through the use of technology'. Additionally, it acknowledged that 'the world's depletion of natural resources and rapid environmental degradation are the result of unsustainable consumption and production patterns which have led to adverse consequences for both the Earth and the health and overall well-being of humanity' (United Nations, no date a).

1972 – The Limits to Growth

Over a century after the birth of the economic utopia, came perhaps the first joint consideration of the identified social, environmental, and economic components in 'The Limits to Growth'. Rather than an environmental component however, 'The Limits to Growth' proposed a natural component which is an important distinction. Firstly, the environment can relate either to nature, or one's surroundings. Assuming that the environment relates to nature, a definition can be given as 'the air, water, and land in or on which people, animals, and plants live' (Cambridge University Press, 2020). Even regarding

nature, the environment is something in which humanity is involved and something over which humanity can exercise its control. It is unsurprising then, that when considering the environment, nature becomes secondary to humanities needs and wants within built infrastructure. The definition of natural is 'as found in nature and not involving anything made or done by people' (Cambridge University Press, 2020). Lastly, 'The Limits to Growth' considered a fourth political component. These four components together control the substantial worldly problems identified as existing in all societies to varying degrees.

'The Limits to Growth' identifies that all of the common problems contain technical, social, economic and political elements. It is important to recognise the identification of technical elements as a problem with control through the political component. It is the technical element in today's society, through the economic and political elements, that is used to counter and / or provision for the main factors identified as limiting civilisation (worldly limiting problems), these factors being the increase in 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources' (Meadows et al., 1972).

These factors are all factors which occur as a result of disengagement from nature and the elevation of humanity above the natural world. To consider that technology and built infrastructure has facilitated this distance, brings into question the role of built infrastructure as a whole. For centuries, built infrastructure and technology has been used to further the human capacity, facilitating perceived societal development to a point of societal collapse. One such example is the collapse of the Mayan Civilisation in the 9th century. Although there are multiple explanations for the collapse, a likely and evidenced one is that of self-aware environmental change – over-deforestation and exacerbated drought (Stromberg, 2012). History then can warn us of our own potential future. Indeed 'The Limits to Growth' predicts the collapse of our current society as a result of non-renewable resource depletion (Bac, 2008).
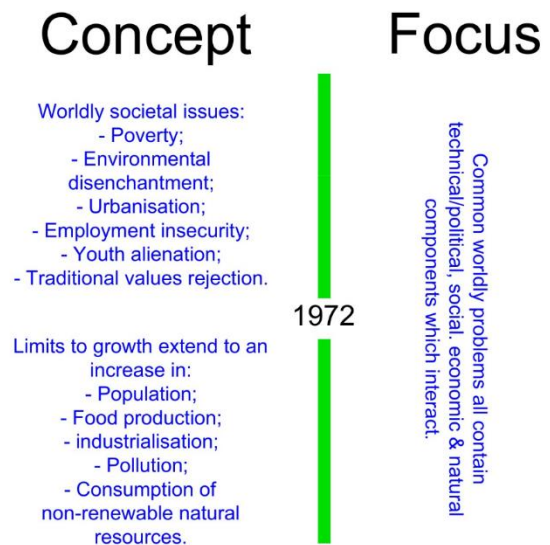
If societal collapse is the result of current development then, we should do our utmost to avoid it. To some extent preservation and extension of the world's 'developed' societies appears to be the underlying mandate of the United Nations Agenda 2030, with the SDGs seemingly targeting the seven worldly growth problems identified in 'The Limits to Growth' – poverty; environmental degradation; institutional disenchantment; urbanisation; employment insecurity; youth alienation and traditional values rejection – rather than the worldly limiting problems – the increase in 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources' (Meadows et al., 1972). Limiting civilisation could of course be a good thing, but not when the limit of that civilisation is unsustainable, and development towards achievement of the fullness of that civilisation for all, takes a development path away from a sustainable existence.

It is for the reason that current Arctic development policy focusses on addressing the worldly growth problems and for the achievement of a developed society for all, that built infrastructure in the Arctic is starting (and globally continues) to facilitate the progression towards an ultimately unsustainable future.

Rather, policy and subsequently built infrastructure must in the Arctic be directed to avoid (and globally reverse) the factors identified as limiting civilisation (worldly limiting problems), and to act as the thread that draws humanity and nature back together into harmony!

The future of built infrastructure development then, if not of the same scale, is bright, and can be utilised for monumental positive change. As identified by Sherwin and Bishop, (2019), the Arctic regions are currently in a unique position to enact this change, and to form a blueprint of sustainable development which the rest of the world can aspire to. This is deemed to be the case for the following reasons:

- The Arctic regions are relatively undeveloped regarding major infrastructure, and thus provide a clean canvas more easily accepting of fresh policy.
- The Arctic peoples demonstrate remarkable adaptability and resourcefulness.
- Within the Arctic regions there already exists the appetite for technological and built infrastructure innovation.
- Largely, the Arctic regions exist within wealthy nations with strong governance, which have the ability to enact real world change.

Further to 'The Limits to Growth', the 1972 United Nations Conference on the Human Environment focussed on environmental issues rather than nature itself and continued to see development and environmental protection as competing needs. It was however recognised that environmental problems resultant of development were different in developed and developing nations. What is resultant of the 1972 debate is that through the application of technological development, and a focus on the human environment rather than nature, humanity has ignored and outstripped natures limits. For the possibility of misunderstanding the direction of development for a sustainable outcome, perhaps a better understanding is formulated through the concept of sustainable ecosystem-based management.

7.2 Sustainable ecosystem-based management

Sustainable management is the employment of sustainable practices within the building blocks of civilisation, e.g. agriculture, business, construction, society and the environment to manage civilisation in such a way that it benefits current and future generations. Sustainable management allows the continued maintenance of a certain quality of life. This quality of life can extend to both humanity and nature and must be struck in balance. The pursuit of maintaining the 'developed' world's current quality of life – which transgresses natural limits – whilst progressing the 'developing' world to the same point is for example unsustainable.

Within sustainable management, sustainable development can still be of benefit, when the understanding of development is the coming into closer harmony with nature. This process can involve technological advancement and innovation, although development and technology are not mutually exclusive. The contribution of built infrastructure to establishing harmony with nature may be achieved though ecosystem-based management (EBM).

Ecosystem-based management (EBM), also known as ecosystem management (EM) as one would imagine with the inclusion of the ecosystem term, is a holistic, 'integrated approach to environmental issues' (Peine *et al.*, 2010). The environment, as previously outlined, describes humanities interaction with nature both directly and indirectly. Directly as a biotic (living) component utilising other living resources such as trees and animals, and indirectly through humanities influence over abiotic (non-living) components, such as water and air. Biotic and abiotic components interact and are interdependent on each other to form an ecosystem. In other words, an ecosystem is the name given to 'all the living things in an area and the way they affect each other and the environment' (Cambridge University Press, 2020).

The overall goal of EBM is the protection of the ecosystem as a whole. Peine *et al.*, (2010) identify that 'by focusing on an interdisciplinary solution to environmental challenges, EM can help to synthesize societal, economic, scientific, and governmental goals', of which built infrastructure is a part. Peine *et al.*, (2010) reference the environmentalist R. Edward Grumbine, (1994) for the identification of five specific goals in support of sustaining ecological integrity.

1. Maintain viable populations of all native species in situ.
2. Represent, within protected area, all native ecosystem types across their natural range or variation.
3. Maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles, etc.).
4. Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
5. Accommodate human use and occupancy within these constraints.

What is common amongst the above five goals and within the fundamental understanding that an ecosystem considers all the living things in an area, is scale. A necessary consideration for sustainable development previously identified.

Sustainable ecosystem-based management depends on both spatial and temporal scale.

Although the above five goals were originally considered to sustain ecological integrity, within ecosystem-based management they are equally applicable to built infrastructure. It was also previously suggested that rather than a focus on resultant worldly growth problems, the limiting factors of civilisation – the worldly limiting problems should be of primary concern.

This idea is particularly evident within an ecosystem setting, where human activities are identified as 'leading to global changes in most major ecosystem controls: climate (global warming), soil and water resources (nitrogen deposition, erosion, diversions), disturbance regime (land use change, fire control), and functional types of organisms (species introductions and extinctions)' (Chapin, Matson and Mooney, 2002). These biotic and abiotic effects are demonstrated in the below model (Figure 7-2).
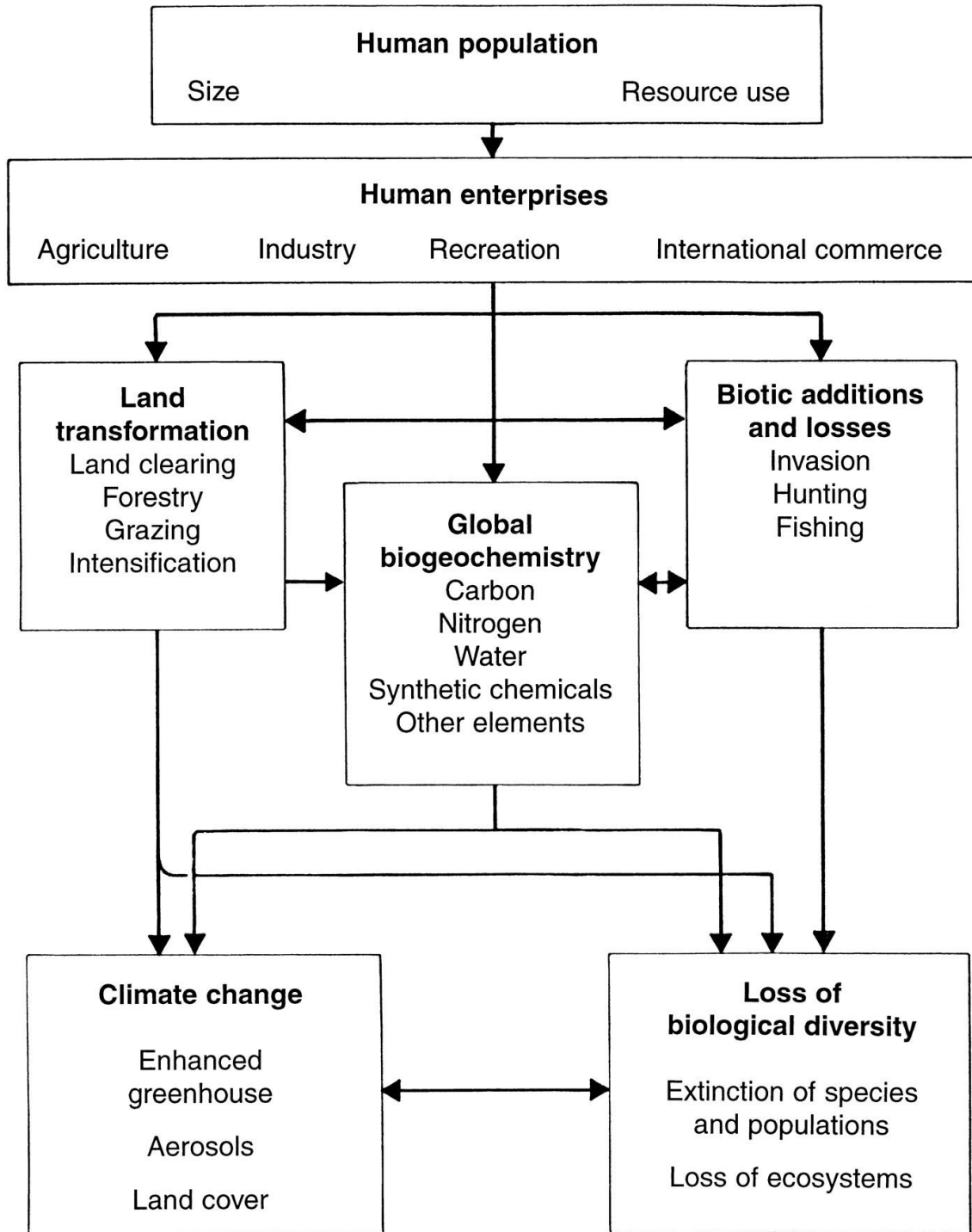
Figure 7-2: A conceptual model illustrating humanity's direct and indirect effects on the Earth system. From Vitousek et al., (1997). Reprinted with permission from AAAS.

Interestingly the overarching population and enterprise factors identified by Vitousek *et al.*, (1997) align well with the worldly limiting problems identified by Meadows et al., (1972). The identification of population size and resource use are directly consistent across both models at the top level. Where the models differ is in the level of the remaining identified factors. Meadows et al., (1972) proceeds to identify the increase in food production, industrialization and pollution at the top level, where as

Vitousek *et al.*, (1997) identifies agriculture, industry, recreation and international commerce at a subordinate human enterprise level. The different separation of factors makes sense given that the Vitousek *et al.*, (1997) model considers subordinate human activities affecting the Earth's ecosystems, whereas the Meadows et al., (1972) model is focussed on humanities limits.

In considering both models together it becomes clear that the limits of human civilisation correspond inextricably to humanities degree of influence above and beyond the earlier identified constraints on ecological integrity. In other words, when the influence of humanity and the rest of nature is out of balance. Whereas development of civilisation may compete with environmental protection, sustainable development of civilisation most certainly does not, i.e. when there is harmony with nature.

Sustainable development of built infrastructure in order to achieve a sustainable built environment considers spatial and temporal implementation scale and confinement within the constraints of ecological integrity.

1987 – Our Common Future

Fifteen years after 'The Limits to Growth' was published came 'Our Common Future' and the definition of sustainability that has held sway ever since – 'sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). The understanding of this definition has proven to contain a number of themes / areas of focus.

Ultimately, the definition is humancentric, that is targeted towards sustaining the needs of the human race. Within the further expansion of the definition contained in 'Our Common Future', it becomes clear that although the meeting of basic physical needs are of primary concern, it is that 'the satisfaction of human needs and aspirations is the major objective of development'. Regarding the environment, it is recognised that 'at a minimum, sustainable development must not endanger the natural systems that support life on Earth (World Commission on Environment and Development, 1987).

The first identified component of 'meeting the basic needs of all' is identified as depending 'in part on achieving full growth potential', through 'economic growth in places where such needs are not being met'. It is assumed that 'physical sustainability cannot be secured unless development policies pay
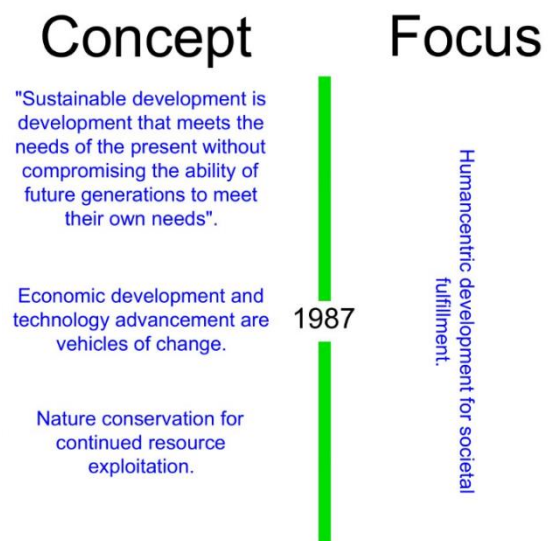
attention to such considerations as changes in access to resources and in the distribution of costs and benefits'. Regarding resources, there is the 'idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs' (World Commission on Environment and Development, 1987).

The second identified component of sustainable development is 'extending to all the opportunity to satisfy their aspirations for a better life' (World Commission on Environment and Development, 1987). The understanding of what a better life entails therefore is important. 'Our Common Future' aligns the understanding of sustainable development with consumerism through promotion of policy for economic growth and access to resources. It is however recognised that 'living standards that go beyond the basic minimum are sustainable only if consumption standards everywhere have regard for long-term sustainability. Perceived needs are socially and culturally determined, and sustainable development requires the promotion of values that encourage consumption standards that are within the bounds of the ecological possible and to which all can reasonably aspire' (World Commission on Environment and Development, 1987).

The understanding of sustainable development in the late 1980's then is that conservation of the natural planet is for the long-term benefit of humanity as an exploitive resource for material satisfaction, rather than conservation to ensure balance between humanity and nature. The understanding is a humancentric consumerist one focussing on utilising economic development and technology advancement as vehicles of change. Development is seen as the fulfilment of humanities requirements.

Where economics and technology can play a positive role in the betterment of under-developed areas of the world – where the basic needs of people are not met, and where a lack of development can lead to environmental degradation – the ideal portrayed within 'Our Common Future' also gives credence to the developed areas of the world in their continued exploitation of natural resources for the purposes of self-gratification.

7.3 Humanitarian fulfilment – A hierarchy of needs, synonymous with development

In the expansion of the definition of sustainable development 'Our Common Future' identifies that a range of human needs are required to be met. These are presented as 'the basic needs of all' (World Commission on Environment and Development, 1987), and the need to satisfy ones aspirations, with indication that fulfilment of these needs are required in that order. In its rough form, this idea is the same as that conceptualised by Abraham Maslow, (1943), who developed a theory of human motivation in the form of a hierarchy of needs.

Maslow's hierarchy of needs is a motivational theory in psychology, which, based on a tiered model predicts the fulfilment of human needs in a prioritised order. In general, 'needs lower down in the hierarchy must be satisfied before individuals can attend to the needs higher up' (Mcleod, 2018). Maslow based his theory on a deep understanding of the components of crucial consideration for the development of a definitive theory of human motivation. In its developed form, Maslow's hierarchy of needs consists of eight tiers in a pyramid form, see Figure 7-3. From the bottom up, these needs are: Biological and Physiological; Safety; Love and Belongingness; Esteem; Cognitive; Aesthetic; Self-actualisation; and Transcendence.
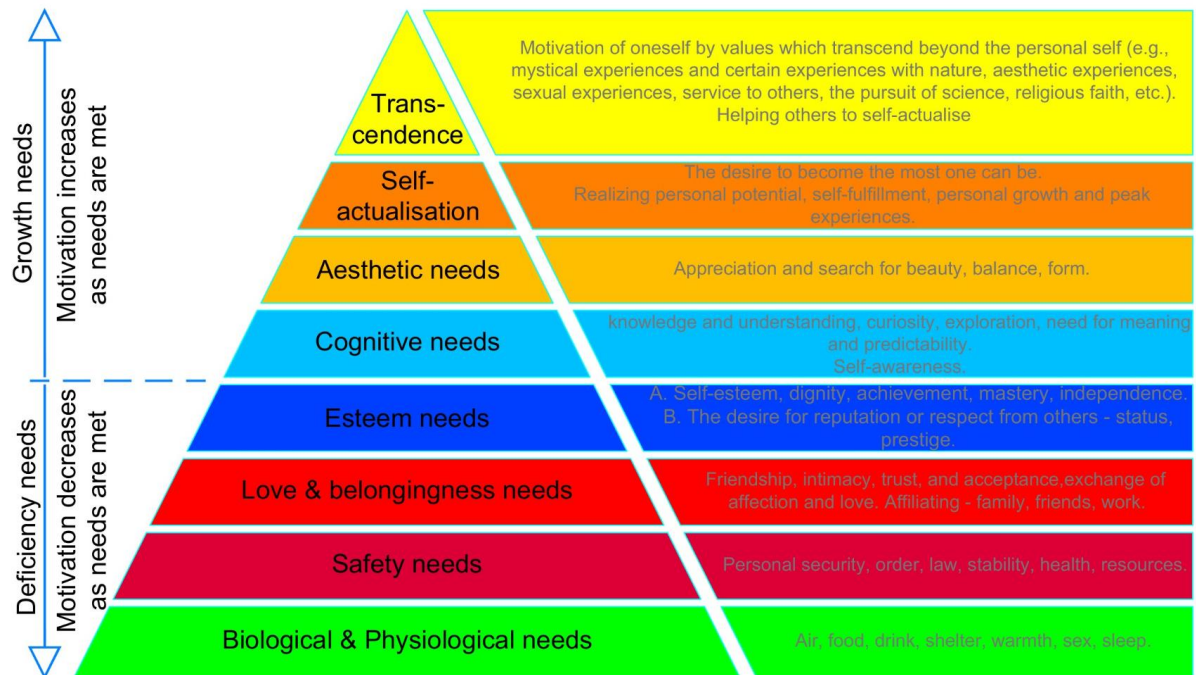
Figure 7-3: Maslow's Hierarchy of Needs - Eight tier model recreated

Some of the key components of crucial consideration for the development of a definitive theory of human motivation, that are presented by A.H. Maslow, (1943) include the following:

1. 'Motivation theory should be human-centered rather than animal-centered';

This first consideration hits home the focus of the model being squarely on humanity, rather than for example on nature. By extension, the model works well to explain the humancentric understanding of sustainable development put forth in 'Our Common Future', which describes meeting 'the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). However, what are human needs?

Further to the eight tiers of needs set out above, Maslow divided human needs into deficiency needs and growth needs. Deficiency needs are those in tiers one to four, where tiers one and two are often associated as basic needs, and where tiers three and four are physiological needs. Deficiency needs are resultant of deprivation, thus people will be motivated when the needs are unmet.

2. 'Human needs arrange themselves in hierarchies of prepotency. That is to say, the appearance of one need usually rests on the prior satisfaction of another, more prepotent need';

When a deficit is largely fulfilled, then the need disappears and a subsequent need comes to the fore. I.e. 'basic human needs are organised into a hierarchy of relative prepotency' (Maslow, 1943). However, the idea of prepotency is the idea of greater importance, and more than one motivation is usually present at any time. Only in extreme cases will a basic need form 100% of a persons motivation, such as in the case of extreme hunger. A.H. Maslow, (1943) himself states that 'a more realistic description of the hierarchy would be in terms of decreasing percentages of satisfaction as we go up the hierarchy of prepotency'. This includes both deficiency and growth needs. Growth needs, rather than stemming from deficiency, are needs posited by a humans desire for growth (Mcleod, 2018). This more holistic view of course expands the definition of basic needs from those that are purely physiological to further include psychological and social needs.

A.H. Maslow, (1943) identifies two implications of need relative prepotency. The first is 'that gratification becomes as important a concept as deprivation in motivation theory, for it releases the organism from the domination of a relatively more physiological need, permitting thereby the emergence of other more social goals' (Maslow, 1943). The second implication is that previously gratified needs can dominate once again if fulfilment is undermined.

7.3.1   The parallel of Maslow's hierarchy of needs with current civilization

Thus far, Maslow's hierarchy of needs – a theory of human motivation has been used to evidence the structure of the 1987 'Our Common Future' definition of sustainable development. As earlier alluded to, this general humancentric understanding of sustainable development, whether intentional or not still dominates today. Our current global civilisation and at a smaller scale the Arctic can be well considered and assessed with Maslow's theory of human motivation.

On a global scale, it is self-evident that the peoples of different areas of the world, in general terms, have different 'basic' needs. I.e. their primary motivations reside at different tiers of Maslow's hierarchy of needs. Remembering the definition of development – 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020), as collectives of people, countries can be recognised as being more or less developed. However, given the distributed percentages of satisfaction across tiers it is impossible to categorise a country as representative of any one tier on Maslow's hierarchy of needs. Rather, simpler forms of categorisation are used.

The appropriate method of categorisation, if categorisation should be applied at all, invariably depends on the primary subject of consideration, and depending on a countries position in relation to this subject will be disputable. However, there are a few methods of categorisation in common use.

7.3.2 Developed and developing

7.3.2.1   Developed and developing – Global economy

Categorisation as developed or developing is prolific in the consideration of economics, and is a common place country categorisation for the World Bank (Khokhar and Serajuddin, 2015). The primary comparative tool of the World Bank is Gross National Income (GNI) per-capita, with comparison portrayed through four threshold levels. These are low, lower-middle, upper-middle and high income groups, see Figure 7-4. Countries within the low, lower-middle, and upper-middle groups, are considered by the World Bank as the 'developing world' (Khokhar and Serajuddin, 2015).

The World Bank is not a bank of the traditional kind, but a 'unique partnership to reduce poverty and support development' (The World Bank group, 2020), with two goals for the world to achieve by 2030:

1. 'End extreme poverty by decreasing the percentage of people living on less than $1.90 a day to no more than 3%'.

2. 'Promote shared prosperity by fostering the income growth of the bottom 40% for every country'.

The World Bank seeks to achieve these goals through provision of 'low-interest loans, zero to low-interest credits, and grants', and through 'policy advice, research and analysis, and technical assistance' to developing countries (The World Bank group, 2020). These offerings are underpinned by rigorous analytics of world development indicators and population trends. The World Banks World Development Indicators are in close alignment with the UN SDG's and are organised into six data themes: Poverty and Inequality; People; Environment; Economy; States and Markets; and Global Links.
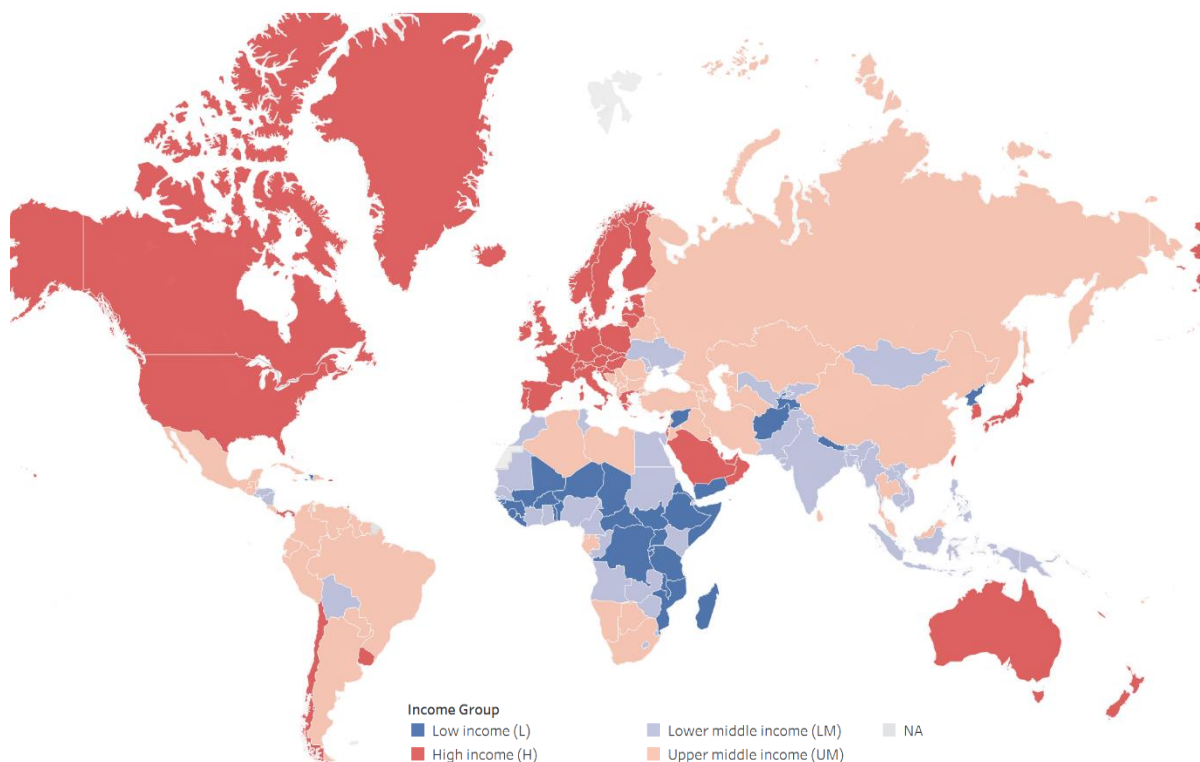
Figure 7-4: The World by Income – World Bank 2020 Income Group Classifications. Source – The World Bank group, (2020) © Mapbox (Mapbox Inc.) © OpenStreetMap contributors (OpenStreetMap)

As can be seen in the above Figure 7-4, the southern hemisphere is largely dominated by 'developing' countries, whilst the northern hemisphere is dominated by 'developed' countries. However, this trend is not totally uniform, hence the emergence of the terms global south and global north to delineate 'developing' and 'developed' countries globally. As can be seen by interrogating the country classification by GNI per-capita data of The World Bank, (2020), with the exception of the Russian Federation, all of the Arctic states consistently reside in the high income group, and thus are considered developed. For illustration the last 10 years of Arctic country classifications are shown in Table 7-1.

Table 7-1: Historical classification by income - GNI (current US$) per capita. Source: The World Bank, (2020)

Bank's fiscal year:	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Data for calendar year :	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Low income (L)	<= 975	<= 995	<= 1,005	<= 1,025	<= 1,035	<= 1,045	<= 1,045	<= 1,025	<= 1,005	<= 995	<= 1,025
Lower middle income (LM)	976-3,855	996-3,945	1,006-3,975	1,026-4,035	1,036-4,085	1,046-4,125	1,046-4,125	1,026-4,035	1,006-3,955	996-3,895	1,026-3,995
Upper middle income (UM)	3,856-11,905	3,946-12,195	3,976-12,275	4,036-12,475	4,086-12,615	4,126-12,745	4,126-12,735	4,036-12,475	3,956-12,235	3,896-12,055	3,996-12,375
High income (H)	> 11,905	> 12,195	> 12,275	> 12,475	> 12,615	> 12,745	> 12,735	> 12,475	> 12,235	> 12,055	> 12,375
United States	H	H	H	H	H	H	H	H	H	H	H
Canada	H	H	H	H	H	H	H	H	H	H	H
Denmark	H	H	H	H	H	H	H	H	H	H	H
Iceland	H	H	H	H	H	H	H	H	H	H	H
Norway	H	H	H	H	H	H	H	H	H	H	H
Sweden	H	H	H	H	H	H	H	H	H	H	H
Finland	H	H	H	H	H	H	H	H	H	H	H
Russia	UM	UM	UM	UM	H	H	H	UM	UM	UM	UM

N.B. Current 2020 classifications are the bank's FY20, which spans the period 01/07/2019 – 30/06/2020, and is based on 2018 calendar year data.

Classification of a country by income is useful for global comparison, but in reality without due consideration of population trends, and the distribution of wealth to that population it doesn't tell us all that much as to the extent of development within the Arctic. For that, as Alvarez, Yumashev and Whiteman (2020) highlight, in order to understand the economic impacts and opportunities resultant of Arctic change, and 'to get useful and more realistic results', Arctic and regional Arctic analysis is required over use of national and global values.

7.3.2.2   *Developed and developing – Global population trends*

Regarding population, the picture is complex, especially in the Arctic. Globally the human population is increasing and is projected to continue doing so until the end of the 21st century, albeit with a decreasing growth rate (UN DESA, 2019). Currently at around 7.7 billion (mid 2019), the global population is expected to plateau somewhere between 9.4 and 12.7 in year 2100, resulting in an increase of between 2.7 and 5 billion over the next 80 years (0.34 to 0.63 billion per decade), See Figure 7-5.
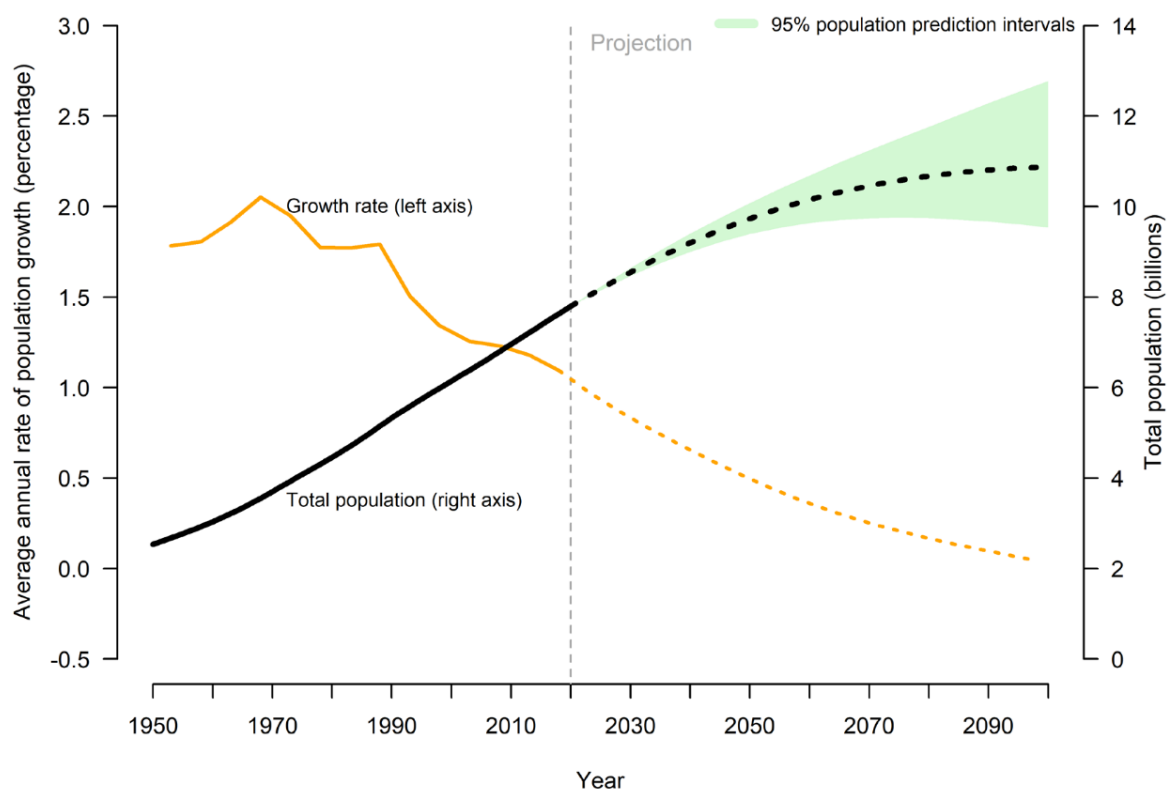
Figure 7-5: Population size and annual growth rate for the world: estimates, 1950-2020, and medium-variant projection with 95 per cent prediction intervals, 2020-2100 © UN DESA, (2019)

Comparatively, since 1800, which correlates with the commencement of the first industrial revolution (The Editors of Encyclopaedia Britannica, 2019), the global population increased from around 1 billion to 7.7 billion over the course of 220 years (0.31 billion per decade), see Figure 7-6. The fact that the growth rate is decreasing and that the 0.31 billion per decade figure is lower than the lowest predicted 0.34 figure for the next 80 years indicates that population growth over the course of the last 220 years

has itself not been consistent, rather growth has been greater in the latter years. This is indeed the case with population growth rate heaving peaked in 1962.
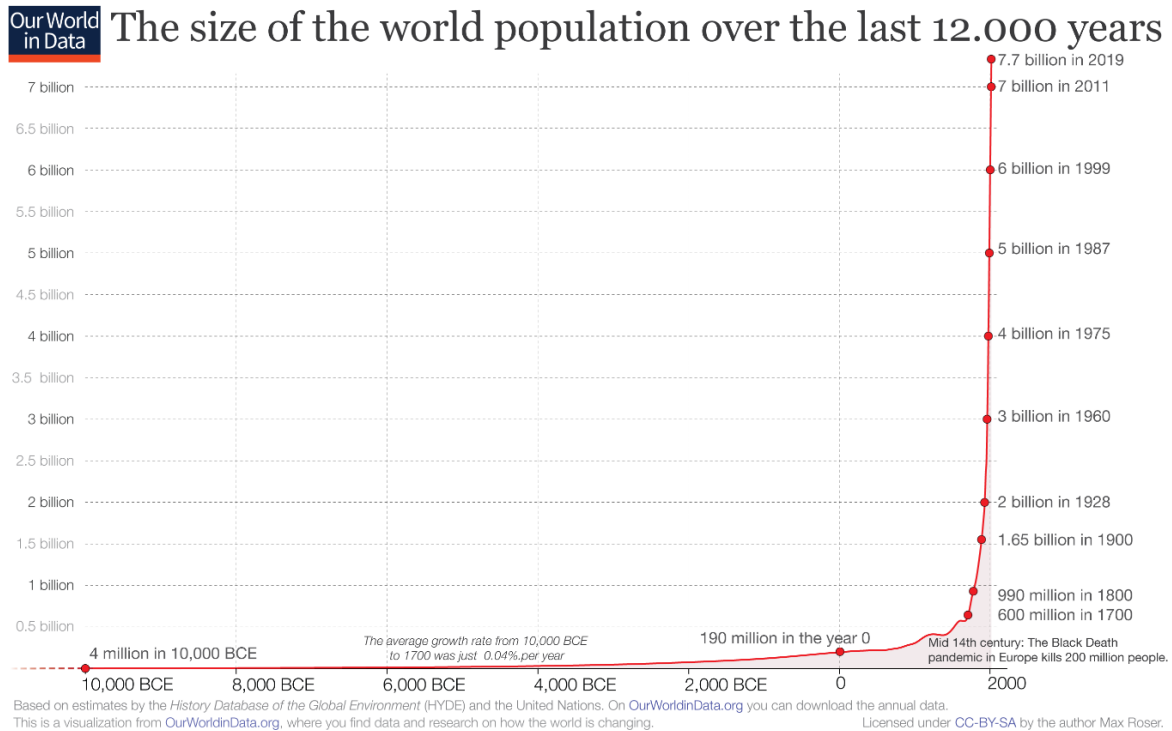
Figure 7-6: Annual world population 10,000 BCE to present. © (Roser, Ritchie and Ortiz-Ospina, 2020)

Globally then, population is set to continue to increase in the short term, but why will this occur and where? Regarding why population is set to increase in the short term, this is primarily (68 %) due to what is known as "population momentum", the relative larger level of births to deaths. Following the previous peak in growth, 'globally, the generation of young people now entering their reproductive years is larger than their parents' generation. Thus, even if the global level of fertility were to fall immediately to around two births per woman, the number of births would still exceed the number of deaths for several decades' (UN DESA, 2019). 'The remaining 32 per cent of the growth' 'is due to fertility above the level required to balance mortality, as well as improvements in survival'. Fertility above the level required to balance mortality is of particular increased percentage in the '47 countries designated by the United Nations as least developed' This includes many countries in sub-Saharan Africa and some Small Island Developing States (SIDS) (UN DESA, 2019).

The UN DESA, (2019) – Department of Economic and Social Affairs – tells us that greater than 50% of the projected population increase will occur in just 9 countries, namely 'India, Nigeria, Pakistan, Democratic Republic of the Congo, Ethiopia, the United Republic of Tanzania, Indonesia, Egypt and the United States of America'. Considering Figure 7-4, all of these with the exception of the USA are developing countries. It is evident then, that **population growth strongly correlates with development (as it is currently perceived).** This is true of both large and small countries / groups of people. Not only can development, of for example built infrastructure, facilitate fulfilment of peoples basic needs -

increased access to food, sanitation, shelter and clean water etc., thus providing more resource to support increased births, it can also increase health care and overall health, thus reducing mortality.

7.3.2.3   Developed and developing – Arctic population trends

Regarding the population of the Arctic, the 'Atlas of population, society and economy in the Arctic' (Jungsberg *et al.*, 2019) answers the question. Total Arctic Population amounts to around seven million inhabitants, about 0.09% of the global population, or between the population sizes of Norway and Sweden (worldometer, 2020). Of this, 9% or approximately one million people are indigenous, with their percentage population per Arctic region varying considerably, see Figure 7-7. Of the total Arctic population '74.3% live in settlements with populations of at least 5,000. The remaining 25.7% live either in settlements with fewer than 5,000 inhabitants or outside any established settlement (7.2%)'. Given that 90.5% of the settlements have 'fewer than 5,000 inhabitants', the majority of the population is seen to live in urbanised centres, especially in the Russian Arctic, see Figure 7-8 (Jungsberg et al., 2019).

Like anywhere in the world, population change can be split into natural change (though births and deaths), and net migration. Jungsberg *et al.*, (2019) tell us that between 2013 and 2017 the annual average natural population change was +0.66%, whilst the annual net migration rate was -0.4%, thus overall the population of the Arctic is increasing. These values are however Arctic wide and as Figure 7-9 shows cann't be taken as representative of each Arctic region which vary significantly. One key population trend of note is the consistent and propotionally larger decrease in population of Russia compared to the other Arctic nations. Between 1990 and 2018, 11 of the 13 Russian Arctic regions recorded have declined between -13.4% and -69% (Jungsberg *et al.*, 2019). In addition to sweeping net outward migration, this may be in part be due to higher infant mortality and general death rates in Russia than elcewhere in the Arctic (Jungsberg *et al.*, 2019). The other Arctic regions with decline over that period include Svalbard (Norway) (-39%), Lappi (Finland) (-10.4%), Norrbotten (Sweden) (-4.4%), and Newfoundland & Labrador (Canada) (-7%). All other Arctic regions have seen growth. Positive in migration is seen in 'the Nordic Arctic sub-regions, Yukon and Nunavut (Canada).

There appears above a general national correlation between declining population in Russia and their lower national income. **In the Arctic then it would appear that population is generally stable or increasing within the Arctic regions clasified by the World Bank as developed, and falling within the country classified as developing**. This is contrary to global trends.

Of further interest to note here is the correlation between national income, population trends, population health and development. Varying regions of Arctic Russia are seen to be amongst those with the highest birth rate, highest death rate, largest infant mortality rate and lowest life expectancy. This in part is contributing to a declining population, and is perhaps the result of a lack of finance for development, including infrastructure development.

Figure 7-7: Indigenous population in the Arctic. Source: Atlas of population, society and economy in the Arctic. © Jungsberg et al., (2019)
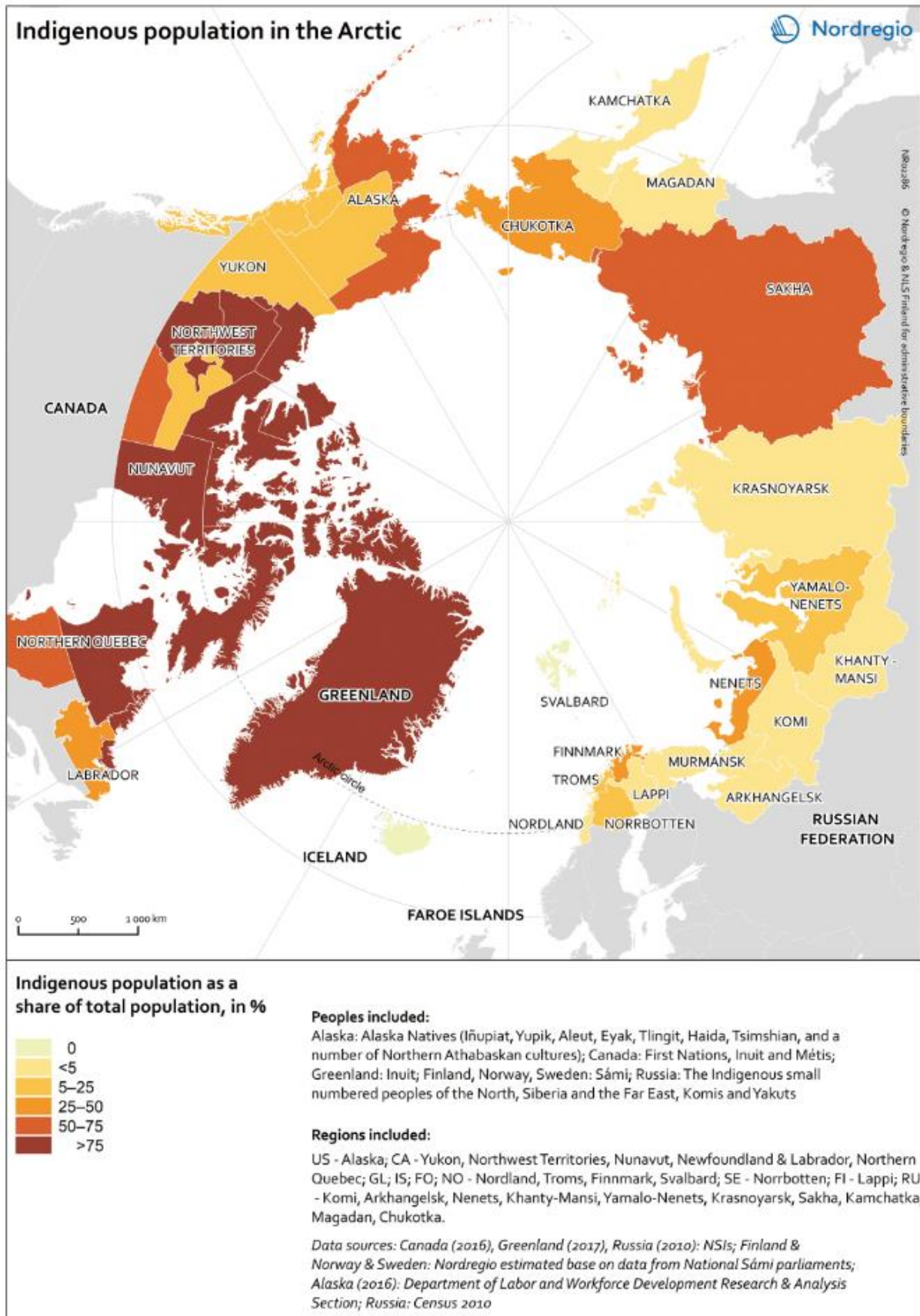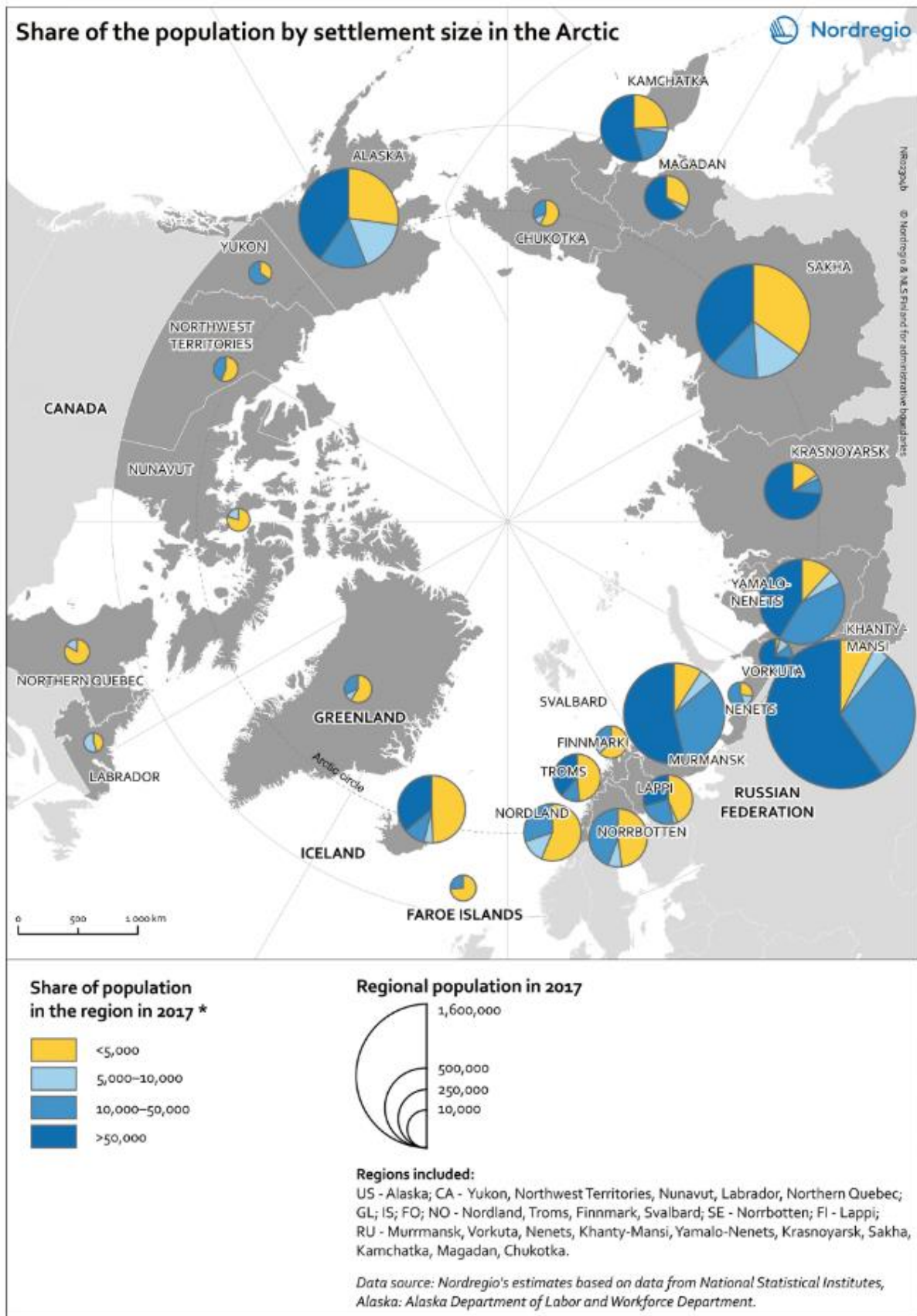
Figure 7-8: Share of the population by settlement size in the Arctic. Source: Atlas of population, society and economy in the Arctic. © Jungsberg et al., (2019)
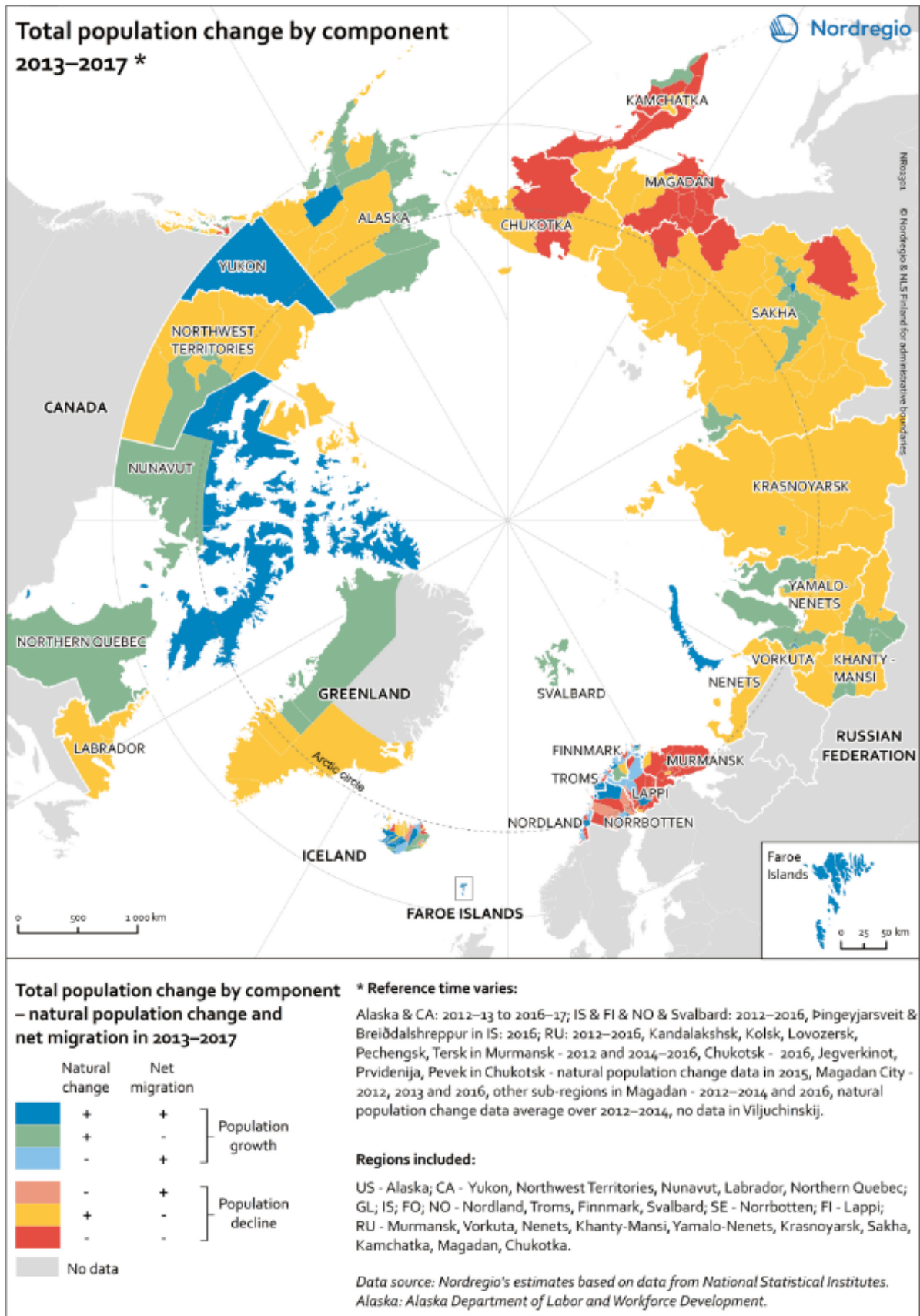
Figure 7-9: Population change by components. Source: Atlas of population, society and economy in the Arctic. © Jungsberg et al., (2019)

7.3.2.4   Developed and developing – Arctic economy

Although no guarentee of money being spent on public infrastructure to support human health and well-being, gross regional product (GRP) and disposable income of households (DIH) are better indicators of development than GNI. Where GNI 'measures all income of a country's residents and businesses, regardless of where it's produced', GRP 'measures the value of goods and services produced within a' region in terms of purchasing power parity – PPP, 'including regional output, expenditures, and income' (Amadeo, 2020).

As shown in Figure 7-10 and Figure 7-11, the regional financial picture of the Arctic is mixed. 'In most Arctic regions GRP per capita is higher than in corresponding non-Arctic areas, except in Norway, Sweden and Finland' (Glomsrød et al., 2017). This is most evident in Russia and the USA. These high returns are resultant of a large mineral extraction sector with a proportionally high share of the economies. In Russia however there is up to a six-fold disparity of GRP per capita between regions. This variability is resultant of the misbalance of the economic sectors, see Figure 7-13. Although the GRP per capita is higher in the Russian Arctic in general than many other Arctic countries, this is due to the economic domination of the Khanty-Mansii and Yamel-Nenets regions over all of the others which in many cases have lower GRP per capita than the rest of the Arctic as a whole, see Figure 7-12 and Figure 7-14.

At a country level, the DIH per capita reflects the GRP per capita trend of being larger in the Arctic regions than in the corresponding non-Arctic regions, with the exception of Norway, Sweden and Finland. Looking more closely at a regional level however it is seen that although GRP per capita can be larger or much larger in some regions, the DIH per capita is fairly consistent across the Arctic. What this shows is a stripping of profits – the use of the Arctic regions for the general benefit of the Arctic country. This is not bad per se, as long as sufficient money remains in the contributing Arctic region to promote sustainable development. Unfortunately, as CADTM, (2020) suggests, this is not always the case.

Despite there being a lot of money generated in the Arctic regions relative to the rest of the world and in some instances relative to the non-Arctic regions of the same country, the standard of living associated with a relatively developed country is not always seen. As revealed by a recent Arctic Council survey some small rural communities have little or no access to improved water and sanitation (Bressler and Hennessy, 2018). Despite this problem often being hidden in national statistics it occurs throughout the Arctic. Although the problem is worst Greenland, which does have the lowest GDP and DIH, it is second worst in Alaska which is one of the Arctic regions with the highest GDP and DIH.

Therefore, the world Bank's definitions of developed and developing, considering the distribution of monetary wealth and population, despite being based on world development indicators, does not fully apply to the Arctic. If the improvement of oneself and of humanities situation is development, then the World Bank's definitions themselves are flawed, and a more holistic consideration is required.
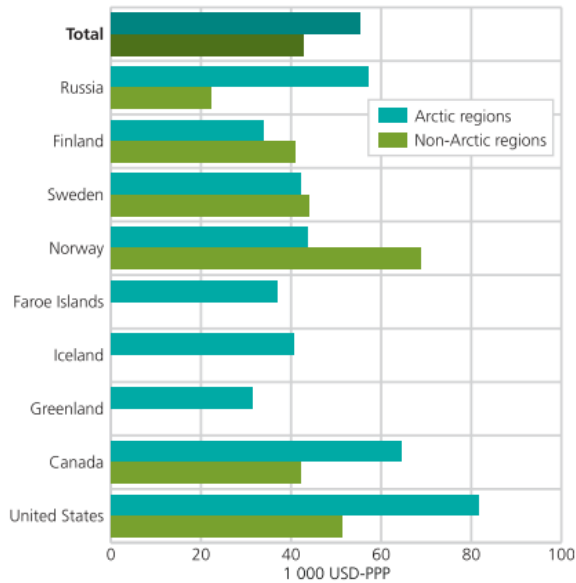
Figure 7-10: Gross regional product (GRP) per capita, by Arctic region in 2012. Source: Glomsrød et al., (2017)
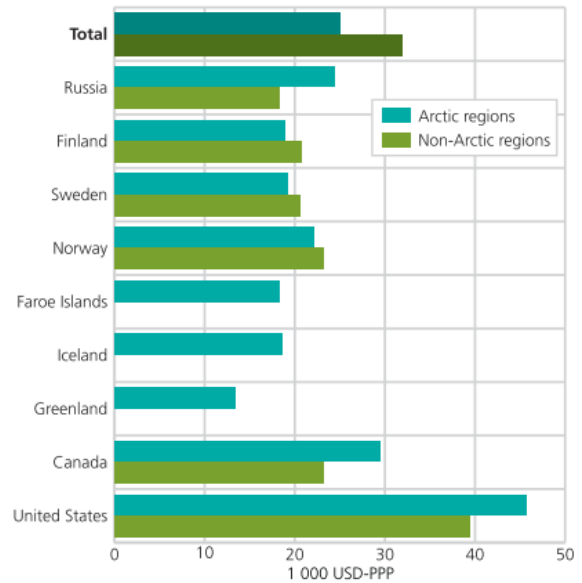
Figure 7-11: Disposable income of households (DIH) per capita, by Arctic region in 2012. Source: Glomsrød et al., (2017)
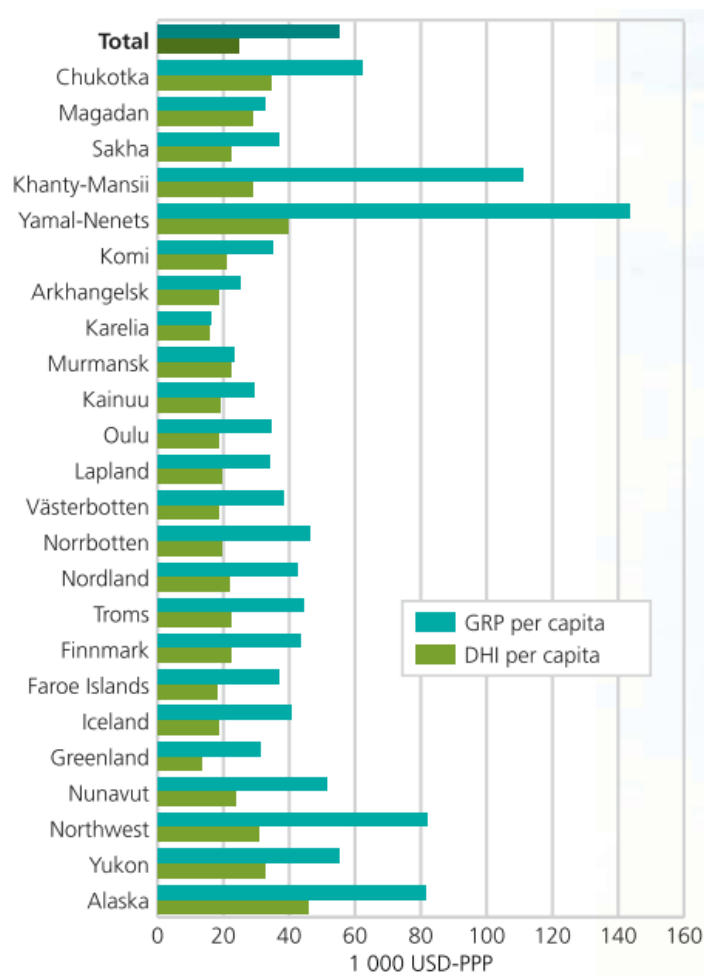
Figure 7-12: Gross regional product (GRP) per capita and disposable income of households (DIH) per capita, by Arctic sub-region in 2012. Source: Glomsrød et al., (2017)

126
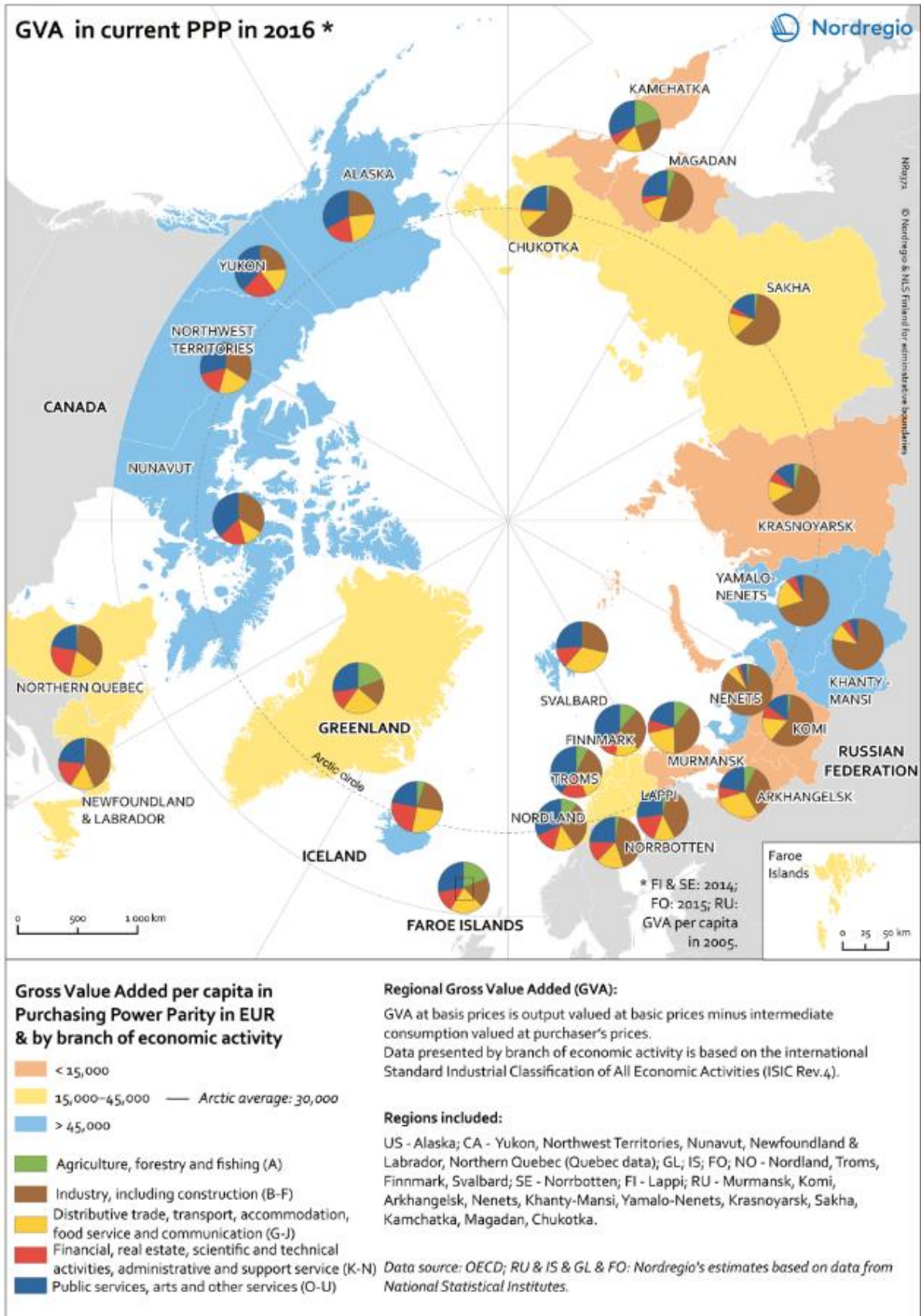
Figure 7-13: Gross Value Added in current PPP in the Arctic in 2016. Source: Atlas of population, society and economy in the Arctic. © Jungsberg et al., (2019)
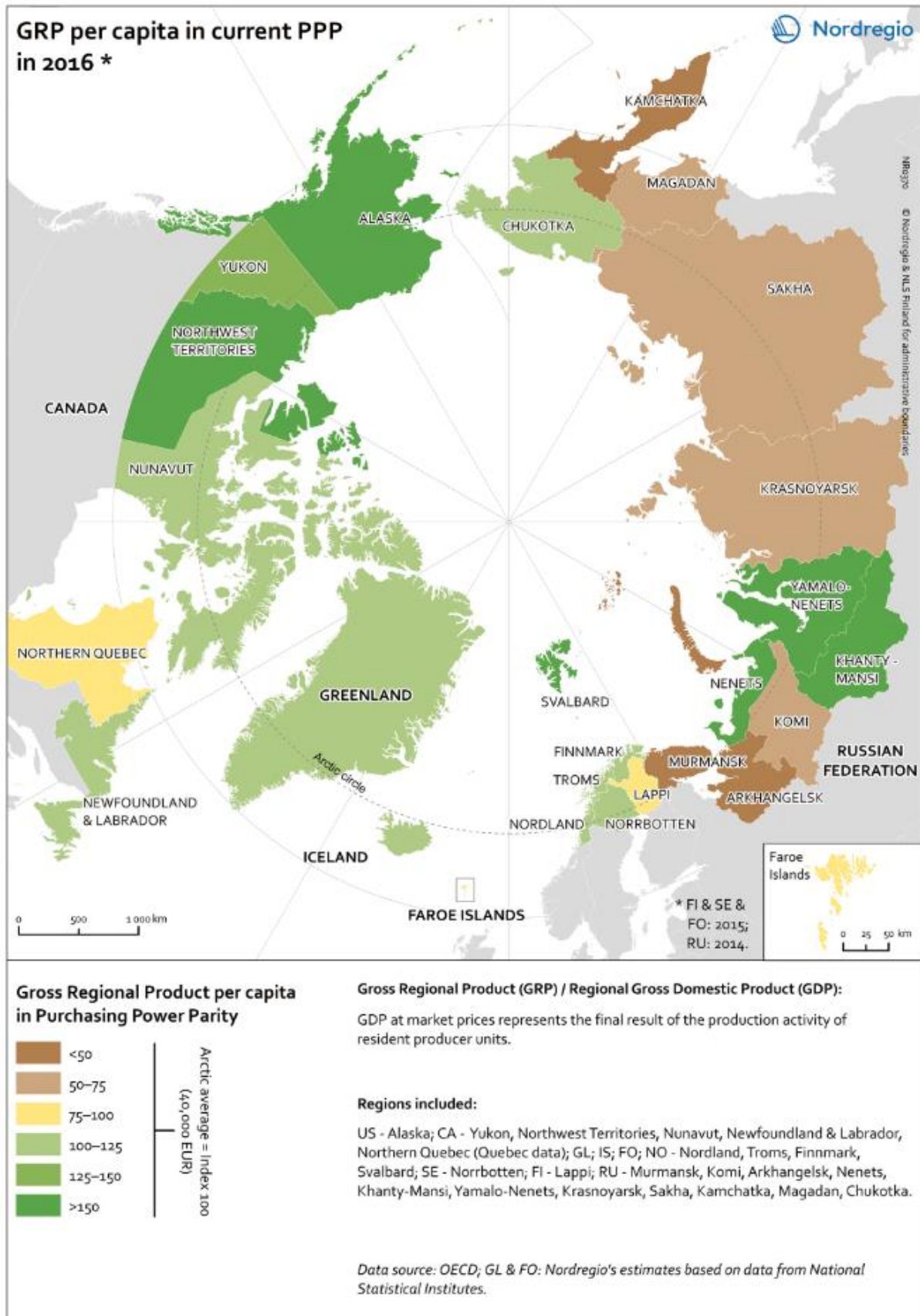
Figure 7-14: Gross regional product (GRP) per capita in current PPP in the Arctic in 2016. Source: Atlas of population, society and economy in the Arctic. © Jungsberg et al., (2019)

7.3.3   Human development

The idea that the World Bank definitions of development have lost their relevance is one shared with Khokhar and Serajuddin, (2015), who beleave that they have in general in a worldy capacity become too broard and are no longer distinctive. The now general closeness between developed and developing countries of low fertility and infant mortaility rates compared to 1960, and the increasing dissimilarity of GNI per capita, e.g. by 40 times, between developing countries is exemplified. A more inclusive characterisation of societies development is the Human Development Index (HDI).

7.3.3.1   *The international understanding of human development*

The HDI is the primary index used by the United Nations. It emphasises 'that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone' (United Nations Development Programme, 2020a). To this effect, the HDI is based on three dimentions considered to be key to human development. These are 'a long and healthy life, being knowledgeable and have a decent standard of living' (United Nations Development Programme, 2020a), see Figure 7-15. In a very basic way these three dimentions encapsulate the multiple tiers of Maslow's hierarchy of needs.
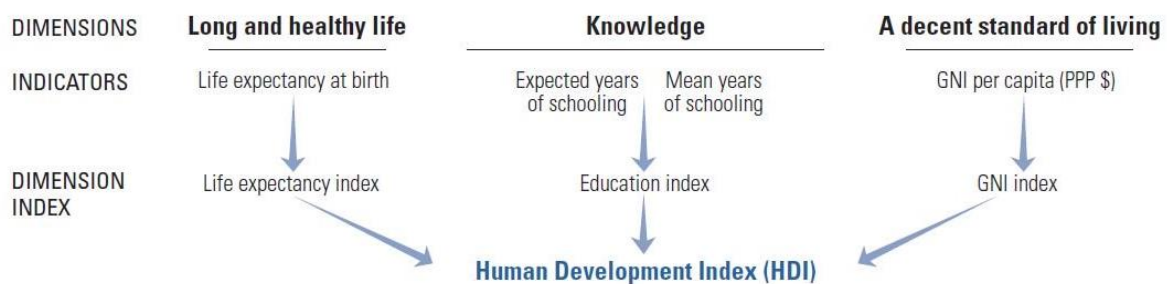
Figure 7-15: United Nations Human Development Index (HDI) Source: United Nations Development Programme. © (United Nations Development Programme, 2020a)

Despite the logarithm of income being used, 'to reflect the diminishing importance of income with increasing GNI' (United Nations Development Programme, 2020a), the HDI is limited in its capacity. As recognised by the United Nations Development Programme, (2020a), the HDI 'does not reflect on inequalities, poverty, human security, empowerment, etc.'. These aspects must be considered in addition. An attempt at doing this is seen in the additional four indexes produced by the United Nations Development Programme (UNDP). There are the Inequality-adjusted Human Development Index (IHDI); Gender Development Index (GDI); Gender Inequality Index (GII); and Multidimentional Poverty Index (MPI). Of these, the most relevant to the role of built infrastructure in sustainable development are the HDI, IHDI and MPI. The HDI and IHDI ranks of the Arctic nations are presented in Table 7-2 and Table 7-4, where Greenland and the Faroe Islands are included as part of The Kingdom of Denmark. Greenland and the Faroe Islands are not independent members of the United Nations.

The MPI unfortunatly only considers countries that are defined by the UN as developing and does not include any of the Arctic countries. The UN, like the World Bank, defines developing on an economic basis. In extention to the World Bank though, the UN considers three catagories: developed economies, economies in transition and developing economies (United Nations Secretariat, 2014).

Table 7-2: Human Development Index and its components 1. Source: United Nations Development Programme, (2019)

HDI rank	Country	Human development index (HDI)	Life expectancy at birth	Expected years of schooling	Mean years of schooling	Gross national income (GNI) per capita
		(index value)	(years)	(years)	(years)	(2011 PPP $)
1	Norway	0.954	82.3	18.1	12.6	68,059
6	Iceland	0.938	82.9	19.2	12.5	47,566
8	Sweden	0.937	82.7	18.8	12.4	47,955
11	Denmark	0.930	80.8	19.1	12.6	48,836
12	Finland	0.925	81.7	19.3	12.4	41,779
13	Canada	0.922	82.3	16.1	13.3	43,602
15	United States	0.920	78.9	16.3	13.4	56,140
49	Russian Federation	0.824	72.4	15.5	12.0	25,036

Table 7-3: Human Development Index and its components 2. Source: United Nations Development Programme, (2019)

	Human development index (HDI)	Life expectancy at birth	Expected years of schooling	Mean years of schooling	Gross national income (GNI) per capita
Human development groups					
Very high human development	0.892	79.5	16.4	12.0	40,112
High human development	0.750	75.1	13.8	8.3	14,403
Medium human development	0.634	69.3	11.7	6.4	6,240
Low human development	0.507	61.3	9.3	4.8	2,581
Developing countries	0.686	71.1	12.2	7.4	10,476
Least developed countries	0.528	65.0	9.8	4.8	2,630
Small island developing states	0.723	71.8	12.2	8.6	15,553

Table 7-4: Inequality-adjusted Human Development Index and its components. Source: United Nations Development Programme, (2019)

	Human Development Index (HDI)	Inequality-adjusted HDI (IHDI)			Inequality in life expectancy	Inequality-adjusted life expectancy index	Inequality in education	Inequality-adjusted education index	Inequality in income	Inequality-adjusted income index
Country	Value	Value	Overall loss (%)	Difference from HDI rank	(%)	Value	(%)	Value	(%)	Value
Norway	0.954	0.889	6.8	0	3.0	0.929	4.4	0.879	12.7	0.860
Iceland	0.938	0.885	5.7	4	2.4	0.944	2.8	0.892	11.7	0.822
Sweden	0.937	0.874	6.7	2	2.9	0.936	3.8	0.880	13.0	0.811
Denmark	0.930	0.873	6.1	4	3.6	0.901	3.0	0.892	11.4	0.829
Finland	0.925	0.876	5.3	7	3.0	0.921	2.3	0.894	10.4	0.816
Canada	0.922	0.841	8.8	-4	4.6	0.915	2.7	0.867	18.2	0.751
United States	0.920	0.797	13.4	-13	6.3	0.848	5.5	0.849	26.6	0.702
Russian Federation	0.824	0.743	9.9	1	7.1	0.749	3.1	0.807	18.7	0.679

From inspection of the HDI it appears that all of the Arctic countries either have high or very high human development, with all residing amoungst the most developed countries in the world. It is noted, that all countries considered reside above the HDI associated with Small Island Develping States (SIDS), this being important for the fact that many communities in the Arctic regions are remote and disconnected, and thus effectively act as Arctic island-economies.

7.3.3.2   Development and inequality

The culmination of the human development assessment undertaken by the UN is the 'Human Development Report 2019' (United Nations Development Programme, 2019b). This 2019 report is a positive step forwards in the recognition that human development should not only be assessed in relation to economics, but a wider set of indicators. **The report recognises that 'for all our progress, something in our globalised society is not working'. The identified reason for this is inequality** (United Nations Development Programme, 2019b). Where in the past the primary inequality amoungst people and nations was surrounding basic needs – food, water and healthcare etc., those foundational aspects of Maslow's hierarchy of needs – through substantial progress having been made in reducing fundimental poverty, todays inequalities surround higher tiers of human development such as 'tertiary education and access to broardband' (United Nations Development Programme, 2019b). Where the inequality gap in basic needs is diminishing, the inequality gap in higher needs is increasing. Consideration of inequalities between countries and within countries is therefore key to enhance our understanding of human development. This is the purpose of the IHDI, see Figure 7-16.
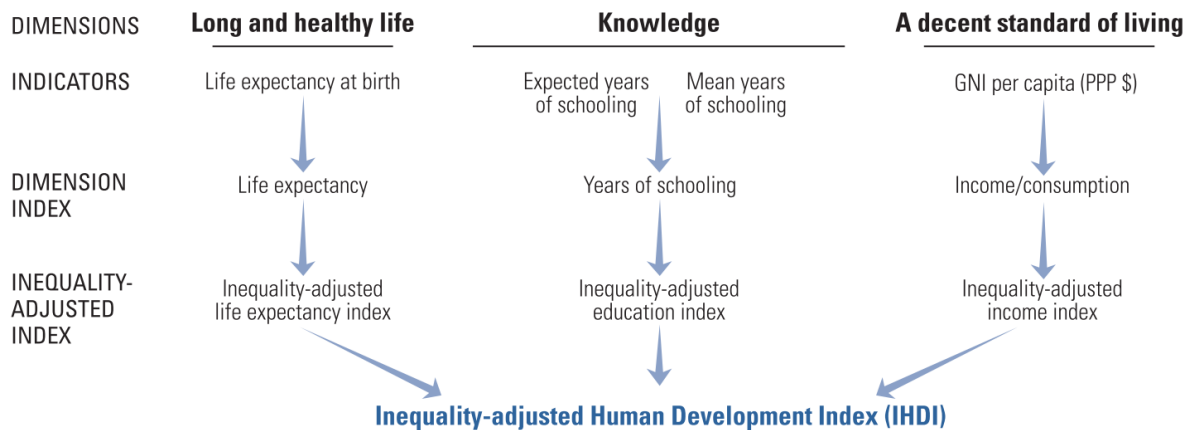
Figure 7-16: United Nations Inequality-adjusted Human Development Index (IHDI) Source: Human development report 2019 : Technical notes. © United Nations Development Programme, (2019c)

What is evident in the IHDI results is that inequality exists in all countries. Overall, there is little change in the HDI ranking order of the Arctic countries. However it is seen that those countries with an overall % loss in HDI value, moving down the rankings (Canada and the United States), do so primarily because of the large difference in income. These countries do however exhibit generally larger inequalities in life expectancy and education also.

The appreciation of the ongoing shift of inequalities has led to the recognition that making money is not the most important thing in life. Rather, the report recognises that todays inequalities stem from misbalance of power: 'the power of the few; the powerless of the many; and the collective power of the people to demand change'. 'The Human Development Report 2019' identifies that 'going beyond income will require tackling entrenched interests – the social and political norms embedded deep within a nation's or group's history and culture' (United Nations Development Programme, 2019b). **The consideration of society as a whole then, and societies holistic needs is an important underlying factor in development.**

7.3.3.3 Development and poverty

Although the UN considered Arctic countries do not appear on the MPI, see Figure 7-17, it is interesting to consider that the MPI, like the HDI and IHDI is built upon three components: a long and healthy life; knowledge; and a decent standard of living. However, where the standard of living in the HDI and IHDI is based upon per capita income, relating monetry wealth to human development, the MPI recognises that a decent standard of living is related to the provision of 'basic' needs. There appears a difference then in the focus of development between more and less developed countries.
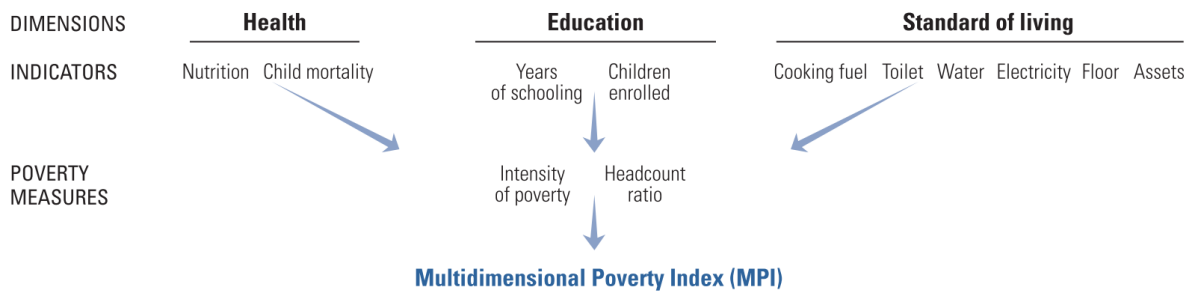
Figure 7-17: United Nations Multidimensional Poverty Index (IHDI) Source: Human development report 2019 : Technical notes. © United Nations Development Programme, (2019c)

The MPI consists of 10 indicators across the three dimensions. Those associataed with the standard of living are heavily reliant on the built environment and include: Electricity; Sanitation; Drinking water; Housing; Cooking fuel; and Assets. The MPI 'identifies multiple deprivations at the household level', thus if the 'deprivation score is 1/3 or higher', a 'household (and everyone in it) is considered multidimensionally poor' (United Nations Development Programme, 2019c). **A 'developed' built environment is here seen to be a factor associated with escape from multidimensional poverty.**

Given that there are housholds and communities in the Arctic who exhibit deprevation against the definitions utilised in the MPI, it is entirely possible, that if considered at a regional or local level, parts of the Arctic could be considered in multidimentional poverty. This raises two big questions of relevance to the development of built infrastructure: 1 – What is a deprived standard of living?; and 2 – What is ultimate poverty? Ultimately, these are two questions are beyond the scope of current considerarions. However, that being said, some key insight of relevance to the Arctic can be gained

from consideration of the 2014 'Arctic Social Indicators' Report (norden, 2014), 2015 'Arctic Human Development Report' (Nordic Council of Ministers, 2015), and 2019 'Atlas of population, society and economy in the Arctic' (Jungsberg et al., 2019).

Considering a deprived standard of living. The MPI itself is unclear on what a deprived standard of living is, with reference made to there being variation over surveys carried out. In considering the MPI indicators for the standard of living, especially housing and assets, two things stand out. Firstly, deprevation is considered an absence of material intensive construction. Deprevation is considered true if 'at least one of the household's three dwelling elements—floor, walls or roof—is made of inadequate materials—that is, the floor is made of natural materials and/or the walls and/or the roof are made of natural or rudimentary materials' (United Nations Development Programme, 2019c). Although use of the materials examplefied in a rudermentary way, or the lack of materials in general, would likely pertain to poor quality built construction, this is not neccicerrily the case. Amoungst the materal examples given are trunks, sod, thatch, bamboo, stone with mud, raw or reused wood and canvas. Many of these materials have been a staple of good quality and effective construction for centuries. For example, the use of turf and timber dwellings within the Arctic, turf being an effective insulator and timber being fairly readily available. Not only can construction from natural materials last a long time, the longevity of their continued use is testiment to their replenishable nature. The use of natural, local materials in construction within ecosystem limits is arguabley more sustainable than the use of imported manufacturing intensive materials.

Secondly, in reference to the standard of living, the MPI considers deprevation to be the lack of ownership of a car or truck, and not owning 'more than one of the following assets: radio, television, telephone, computer, animal cart, bicycle, motorbike or refrigerator'. Although ownership of some of these items may bring satisfaction, the acquisition of material wealth does not bring self-fulfilment (Psychology Today, 2020), i.e. the acquisition of material wealth or assets does not necessarily aid climbing Maslow's hierarchy of needs. Rather, it is the pursuit of happiness, self-fulfilment and transendence that is the key to achieving well-being (Psychology Today, 2020). The necessity to care for the natural world is prevelent in all of these aspects and exists at all levels of Maslow's hierarchy of needs. **A positive interaction with nature is not only necessary for human development in a physical and resource sense, it is also of great importance for social and psychological well-being** (Larson and Kreitzer, 2016).

7.3.3.4   *Development, well-being and harmony with nature*

Whereas the pursuit of material wealth provides humanity with limited gratification, human exposure to a healthy natural world improves mental well-being (Helliwell et al., 2020). Thus, the quantification of poverty within the UN MPI does not extend to the full range of indicators that allow assessment of overall well-being, and thus it is not a true representation of poverty. **If well-being and happiness are indicators of poverty, a less developed society, by the World bank, or UN categorisation, could**

through a greater positive connection with the natural world, a factor which pervades all tiers of human development, be more developed as a whole.

In the national average life evaluations based on data from 2017-2019, out of 153 countries, the Arctic countries rank highly as follows: Finland – 1; Denmark – 2; Iceland – 4; Norway – 5; Sweden – 7; Canada – 11; United States – 18; Russian Federation – 73 (Helliwell *et al.*, 2020). As per the earlier identified distribution of inequlity between countries seeking the higher tiers of human development, so to is well-being inequality distributed. Well-being inequality is decreasing slightly within the global north, whilst it is significantly increasing within the global south. Russia is noted as being a particular case (Helliwell *et al.*, 2020).

The above considerations strongly indicate that the pursuit of overall well-being should be the primary aim of development. Well-being is seen to be underpinned by the pursuit of harmony with nature and the reduction of inequality.

The current perception of development is humancentric, to allow the progression of humanity up Maslow's hierarchy of needs, and very often for the purposes of short term fulfilment, or self-gratification. Although varying in form with the extent to which humanities needs are met, this has led to inequlity. Additionally, in the pursuit of higher tiers of Maslow's hierarchy of needs, largly through technological advancement the worlds ecological footprint is increasing, see Figure 7-18, and collectivly humanity is transgressing natural limits. Most notable transgression relates to 'changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species (IPBES, 2019). This is seen to cause negative effects at all levels of Maslow's hierarchy of needs, thus fundimentally undermines **human progress to well-being, the holistic and true form of development.**
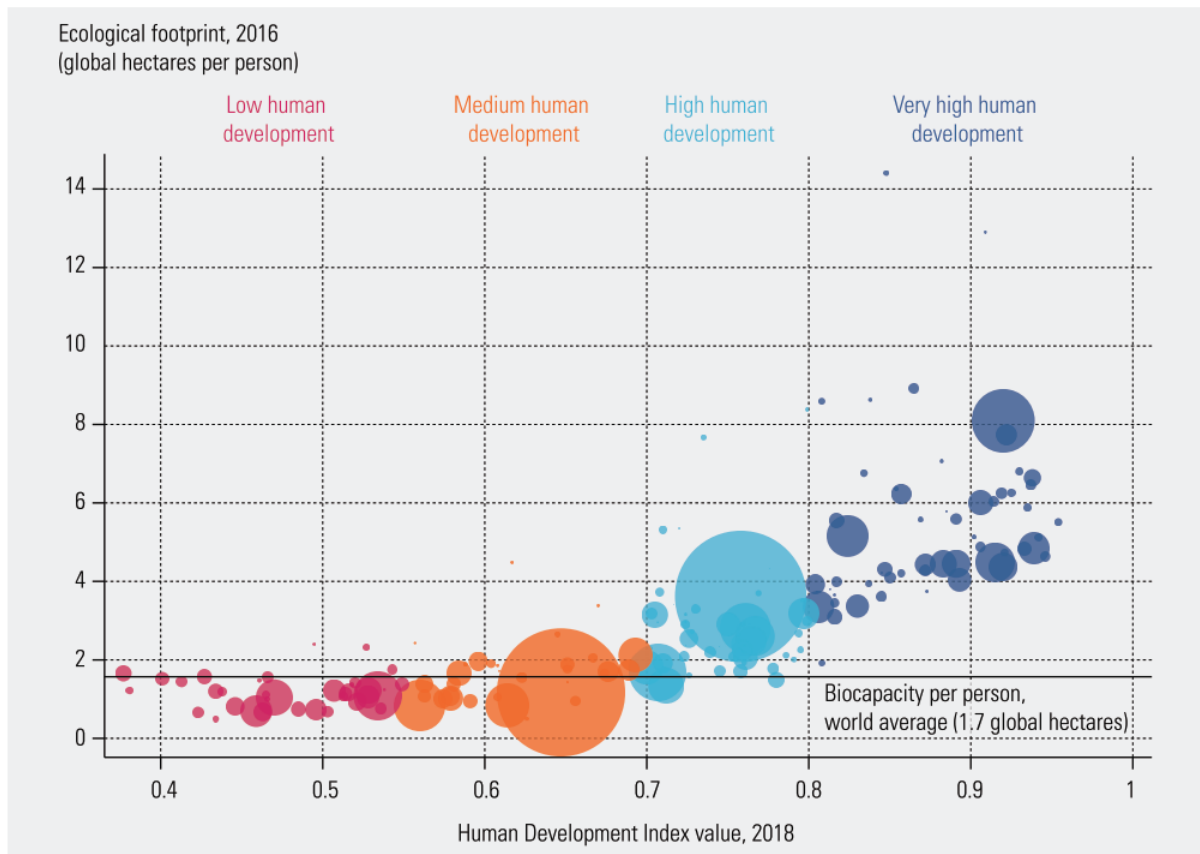
Note: Covers 175 countries in the Global Ecological Footprint Network database (www.footprintnetwork.org/resources/data/; accessed 17 July 2018). As used here, the ecological footprint is a per capita measure of how much area of biologically productive land and water a country requires, domestically and abroad, to produce all the resources it consumes and to absorb the waste it generates. Each bubble represents a country, and the size of the bubble is proportional to the country's population.

Figure 7-18: Per capita ecological footprint increase with human development. Source: Human Development Report 2019. © United Nations Development Programme, (2019b)

No country is in fact therefore developed, but we are all developing. The global south can be summarised as having less progress against Maslow's hierarchy of human needs, but equally more harmony with nature. The global north has reached (in a certain form) the upper tiers of Maslow's hierarchy of human needs, yet with overwhelming non-harmony with nature. **Multiple different approaches to future development are then required.** The rationale for this can be visualised in the squaring of Maslow's hierarchy of needs, see Figure 7-19.
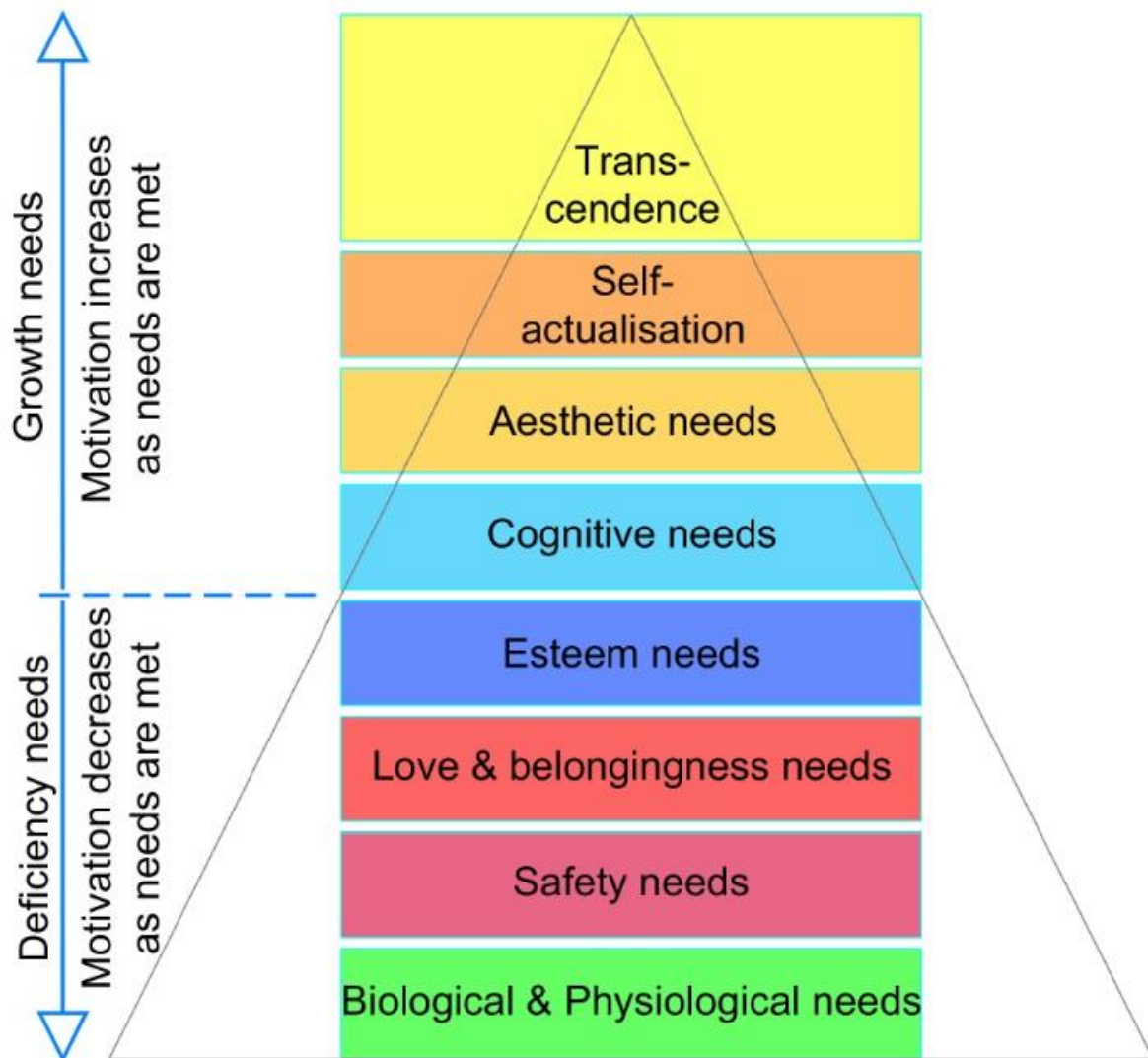
Figure 7-19: Maslow's Hierarchy of Needs - Squared eight tier model

As shown in Figure 7-19, Maslow's hierarchy of needs is normally considered as a pyramid, a pyramid having the features of a broad stable base in support of a reducing footprint with elevation. This describes well humanities ideal development with nature. As identified huanities need for a healthy natural environment pervades every tier of the hierarchy, but with greater intensity at the lower levels. For example, the need for adequate natural conditions to provide food and water.

7.3.3.5   Development of the global north and global south

At a worldly scale, the mean global south can be considered as residing in the lower half of the hierarcy of human development, i.e. the global south remains experiencing deficiency needs. The mean global north on the other hand resides in the upper half with growth needs. **Despite this general arrangement, there are a few key factors that are recognised to bring variation – Inequality; behaviour; and gratification.**

The first factor has already received attention. However, it is worth reiterating that inequality is seen at all levels. Between the global north and global south in a worldly context, between countries, especially in the global south, and within countries. The latter being of particular prominance in the Arctic countries **with inequalities experienced between the Arctic and non-Arctic regions of the High North. Based on the evidence set out thus far, this is seen to extend to built infrastructure. Whether infrastructure inequality in the Arctic is a hinderence to holistic development – that is the pursuit of well-being – remains to be seen.**

As A.H. Maslow, (1943) identifies, amoungst humanity there is a variation in the degree of fixity of the hierarchy of needs. For example, an individual, or group of people who have only ever 'experienced life at a very low level, i. e., chronic unemployment, may continue to be satisfied for the rest of his life if only he can get enough food'. 'That is to say, the less prepotent goals may simply be lost, and may disappear forever', i.e. 'the level of aspiration may be permanently deadened or lowered' (Maslow, 1943). On the flip side 'when a need has been satisfied for a long time' i.e. food and shelter in the global north, 'this need may be underevaluated'(Maslow, 1943), and can result in actions that undermine the ability to satisfy that need. For example anthropogenic forced negative changes in climate leading to coastal Arctic communities being put at greater risk of devistation from exposure to the oceans. This is all to exemplify the third key component of crucial consideration for the development of Maslow's definitive theory of human motivation:

3. 'Motivation theory is not synonymous with behavior theory. The motivations are only one class of determinants of behavior. While behavior is almost always motivated, it is also almost always biologically, culturally and situationally determined as well' (Maslow, 1943).

Thus the second variating factor to the placement of the global north and global south is behaviour**. The behaviour of Arctic residents, as driven by Arctic conditions, is not the same as of non-Arctic residents, even within the same country. Likewise, the behaviour of indigenous Arctic peoples' is not the same as that of non-indigenous Arctic peoples'**. For example, as identified within 'The global assessment report on Biodiversity and Ecosystem Services' (IPBES, 2019), nature managed by indigenous peoples', although still declining, is doing so 'less rapidly' 'than in other lands'. Likewise with 'the knowledge of how to manage it'.

The third variating factor is the gratification of prepotant needs. As one set of needs (tier) becomes fully gratified, a new set of needs (tier) gains prepotancy. Despite there being variation in percentage gratification distribution across the tiers for different individuals or groups of people, the progression of prepotancy predominantly occures in assending order up the hierarchy. The global north already sits in the upper, growth section of the hieracy, where current development is geared towards meeting cognitive, aesthetic, self-actualisation and trancendance needs.

7.3.3.6   *At a crossroads of development*

As the history of the concept of sustainable development has shown development to date has largely been driven by technological advancement, economic growth and globalisation. As a result, it is considered that rather than true fulfilment of the growth needs, humanity has since the first industrial revolution been pursuing an alternative path of self-gratification, reliant on natural resources and fueled by a consumerist idiology. **Humanities insatiable need for self-gratification is resulting in the transgression of natural limits and biodiversity loss and is ultimately undermining our own existance. Thus with a warped expansion of the upper tiers of Maslow's hierarchy of needs, and a reduction of capacity in the lower tiers, the pyramid hierarchy is becoming more of a square hierarchy.** Indeed, given the evidence of mass animal and plant extinctions (IPBES, 2019), it may be considered that further to a square hierarchy, the pyramid is already being inverted. The squaring of the hierarchy is true of both the global north, and due to the dominance of the global north over the global south, so to is it true of the world as a whole.

It has now been evidenced that the humancentric understanding of sustainable development as set out in 'Our Common Future' back in 1987 has since that time lead to changes in the level of human developemnt worldwide. Indeed humanity has been somewhat successful (International Development Association, 2020) in 'meeting the basic needs of all', and 'extending to all the opportunity to satisfy their aspirations for a better life' (World Commission on Environment and Development, 1987). However**, development still remains humancentric and exhibits an ultimately unsustainable global focus on reducing inequality through raising the development status of the global south to the level of the global north. Social equity is pursued at the expense of physical sustainability.** As the global north already far outstips ecosystem limits, developing all of humanity to the same point is unsustainable, if not impossible, and continued attempts to do so will catastrophically undemine humanities existance. **Rather, focus in development should be directed towards a drastic reduction in the per capita ecological footprint of the global north, whilst aiding the global south retain its position within the global bio capacity.** In this way, humanity will once again be pursuing well-being, rather than self-gratification.

How this is to be achieved is unclear, although it is fair to say that all sectors must play a part: academia for research and monitoring; governance for direction; and practice for implimentation. As a powerful component of human development, built infrastructure should also hold a dominant position in politics, academia and practice. Not for the sake of human self-gratification, but for the environment – humanities interaction with nature, and thus for nature itself and ultimatly human well-being. **In order to develop (the pursuit of well-being), the idea of development must be coherent across all sectors, and thus knowledge sharing is paramount**. Still, action towards true development will only occur under the will of society. As identified by A.H. Maslow, (1943), one of cultures main purposes is to mitigate physiological needs. Now that humanities basic needs (such as food, water and shelter) are being thwarted, thus are losing gratification, they may regain prepotancy.

It is therefore the task of built infrastructure to both eradicate the threats to humanities basic needs whilst also providing for fulfilment of humanities higher needs. In other words, it is the task of built infrastructure to achieve well-being.

7.3.4 Holistic development

If human progress is not to be categorised in terms of developed and developing, or in terms of human development alone, then another characterisation must be found. As Alvarez, Yumashev and Whiteman, (2020) point out, in assessing the impacts of Arctic change, a transdisciplinary approach is required. One which 'includes an integration of the natural sciences, economics and social sciences, as well as engagement with a wide range of stakeholders'. Whilst a transdisciplinary and holistic approach to development is surely required, the integration of 'natural sciences, economics and social sciences' (Alvarez, Yumashev and Whiteman, 2020) for assessment suggests the triple bottom line (TBL), see Figure 7-20.

Figure 7-20: Triple Bottom Line / Three pillars of sustainable development model

7.3.4.1 Triple bottom line – Societies current understanding of holistic development

It is perhaps however the ongoing use of the TBL concept and the understanding that sustainable development is built upon three balanced economic, social, and environmental pillars, that humanity continues to undermine its own future in the transgression of natural limits.

This is considered to be the case because of the fundamental humancentric focus of the TBL / three pillars of sustainability concept. As demonstrated by both Maslow's hierarchy of needs and the UN HDI, the considered components of development can either be recognised beneath the banner of sociology or economics. In their common understanding, these are both social sciences relating to human capacity. The third pillar is the environment, which as earlier described, even when referring to nature, is human focussed. Thus if a numerical description is used, **the TBL can be portrayed as 5/6ths human focussed, 1/6th nature focussed.** Given humanities ongoing transgression of natural limits, the common baseline understanding of sustainable development is therefore flawed and is ultimately unsustainable in future development.

Needless to say, **sustainable development – that is the path to well-being – is harmony with nature. I.e. in the recognition that nature pervades every tier of Maslow's hierarchy of needs, sustainable development is 1/2 human focussed, 1/2 nature focussed.**

One attempt at establishing a multidimensional index assessing the level of human development and the state of nature, is that promoted by the Global Footprint Network, (2020) which trades off the HDI and Ecological Footprint. The Global Footprint Network, (2020) defines the Ecological Footprint as:

'The Ecological Footprint is a measure of the biologically productive land and water area an individual, population or activity requires to produce all the resources it consumes, to accommodate its occupied urban infrastructure, and to absorb the waste it generates, using prevailing technology and resource management practices'.

The Ecological Footprint is 'the ratio of an individual's (or country's per capita) Footprint to the per capita biological capacity available on Earth' (Global Footprint Network, 2019). These metrics consider cropland; grazing; forest product; carbon; fish; and built up land areas. One way in which the Ecological Footprint can be visualised is by considering the number of earths required (planet equivalent) if all humans lived like the population of a given country. In 2019, the world average Ecological Footprint was 1.75 planet equivalents (Global Footprint Network, 2019). The global Ecological Footprint by country is shown in below Figure 7-21.

Figure 7-21: Ecological Footprint and Human Development Index of Countries. Source: National Footprint and Biocapacity Accounts, 2019 Edition. © Global Footprint Network, (2019)

Needless to say, the distribution of the number of earths country data (Figure 7-21) is the same as the global hectares country data earlier portrayed in Figure 7-18. Apart from the portrayal of Ecological

Footprint, the only difference between the two figures is colour coding for human development and global region respectively.

The Global Footprint Network approach to assessing the extent to which a country is exhibiting a sustainable existence is, as mentioned, based on the comparison between the UN HDI and Ecological Footprint. Within this comparison, a country is considered to be sustainably developed when it exhibits the minimum conditions of living 'within the means of nature' (Global Footprint Network, 2019), i.e. within the world biocapacity – 1.63 global hectares (gha) in 2019, or 1 world, whilst achieving "High Human Development" – an HDI higher than 0.7. Where a global hectare 'is a biologically productive hectare with world average biological productivity for a given year' (Global Footprint Network, 2019). Considering Figure 7-21, it is seen that under these conditions the world is performing poorly in regards to achieving sustainability. The best performing country, as shown by the dark green Asia-Pacific ID point within the shaded box of Figure 7-21 is currently Sri Lanka (HDI-0.77; No.Earths-0.9).

Based on the data available, all of the Arctic countries exhibit a per capita Ecological Footprint in excess of world per capita biocapacity. Not only that, as shown in Figure 7-22 – now considering global hectares, all of the USA, Canada, Denmark, Norway, Sweden, Finland and Russia exceed the world average Ecological Footprint of 2.7 gha. No data is available for Iceland. The size of the bubble represents the size of country population.

Global Footprint Network, 2019 National Footprint Accounts
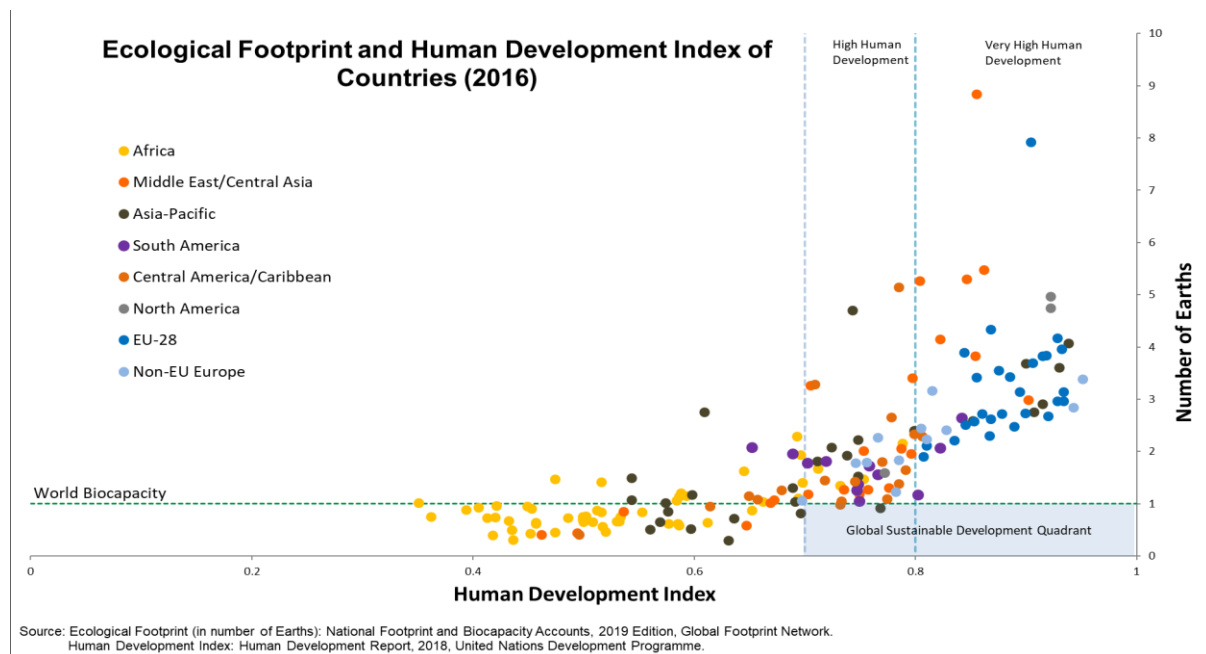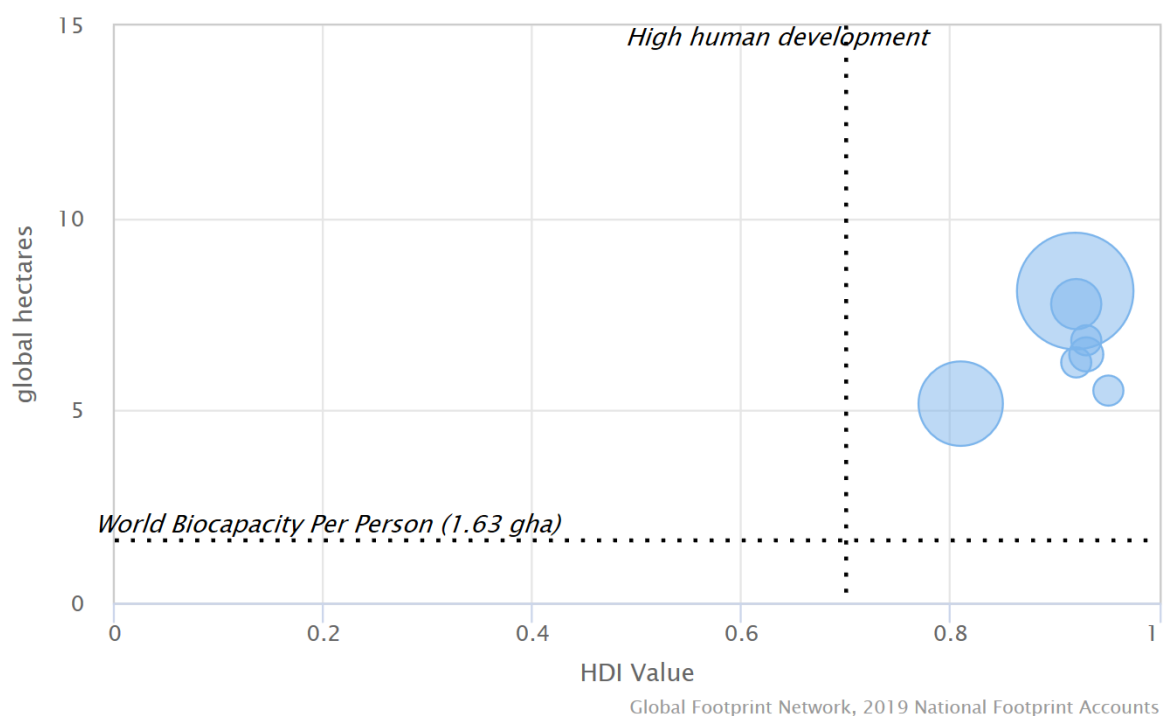
Figure 7-22: Ecological Footprint and Human Development Index of Arctic Countries. Source: National Footprint and Biocapacity Accounts, 2019 Edition. © Global Footprint Network, (2019)

However, many of the Arctic countries are either large and thus likely to also exhibit significant biocapacity, or exhibit a fairly low population to the size of the country, thus assessing them against the

world per capita biocapacity is not representative at a country scale. The Arctic countries are considered individually below in Table 7-5.

Table 7-5: Arctic country biocapacity and Ecological Footprint (2016)

Country	HDI	Population [millions]	Total Ecological Footprint [gha per capita]	Total biocapacity [gha per capita]	Biocapacity (Deficit) or Reserve [gha per capita]
World	-	7466.964	2.75	1.63	-1.12
USA	0.922	322.18	8.10	3.65	-4.46
Canada	0.922	36.29	7.74	15.12	7.38
Denmark	0.928	5.712	6.80	4.17	-2.63
Norway	0.951	5.255	5.51	7.27	1.76
Sweden	0.932	9.838	6.46	9.55	3.09
Finland	0.918	5.503	6.26	12.63	6.37
Russian Federation	0.815	143.965	5.16	6.96	1.80

In the most cases it is seen that despite their large Ecological Footprint, the Arctic countries have biocapacity reserve. The two countries that show a deficit are the USA and Denmark, arguably the two countries with the largest proportion of their populations living in non-Arctic areas. Indeed, upon inspection of the population figures it is seen that Greenland and the Faroe Islands are not included within Denmark and thus its consideration is needless. It does however suggest the importance of the Arctic regions to an Arctic countries biocapacity. In the same way as country consideration to world biocapacity, consideration of the Arctic countries is only somewhat indicative of the Arctic regions biocapacity. **The biocapacity of the Arctic regions must be assessed separately from the Arctic countries.**

The problem with the Global Footprint Network approach to assessment of sustainable development is twofold. Firstly, sustainable development is envisaged to only exist within the shaded sector of Figure 7-21, i.e. when all of humanity is thriving (exhibiting an HDI > 0.7) within the capacity of the planet (within ecosystem limits). Rather than sustainable development, this is a sustainable human existence. **Sustainable development is rather development that results in progression towards a sustainable human existence.** For a country or region currently existing with a per capita Ecological Footprint below the per capita biocapacity, then sustainable development can be the expansion of fulfilment of

Maslow's hierarchy of needs. For a country or region currently existing with a per capita Ecological Footprint in excess of the per capita biocapacity, then the focus of development must be reduction of the Ecological Footprint.

The second problem with the Global Footprint Network approach is the continued use of the HDI and its comparison to biocapacity. The Global Footprint Network states that 'the essence of sustainable development can be measured by tracking its two core dimensions: 1 – economic and social development; & 2 – environmental sustainability' (Global Footprint Network, 2019), which as discussed is fundamentally unsustainable. **True development is the pursuit of overall well-being, in which nature is integral. In other words sustainable human development is synonymous with sustainable nature.** The separation of nature even in part (through consideration of the environment) from society, yields the Global Footprint Network comparative index flawed.

Despite taking stock of nature's ability to provide for humanities basic needs, the Global Footprint Network index remains humancentric. Counter to the above developed understanding of overall well-being, the Global Footprint Network, (2019) considers well-being to be human well-being as defined by 'economic and social development', and thus trades an understanding of human development against environmental sustainability as if they are competing needs. Once again, in their understanding of human development, economic development is considered on par with social development. **As economics is a human construct to service society, then unless the needs of society are entirely based on wealth, then economic development forms only part of societal, or human development and cannot be considered an equal pillar or sustainability. Rather it is a subordinate tool.**

7.3.4.3   The well-being sandwich

Baring the above insights in mind, along with earlier conclusions, it is deemed that a more holistic model for development is required. A 50/50 split between nature and non-nature based human requirements, to achieve harmony with nature and ultimate well-being. In order to achieve harmony with nature and recognition of the true value of nature then both humanities focus for development must be altered and mechanisms put in place to prescribe and recognise the value of harmony with nature. As humanity is the dominant party in the relationship, then it must be humanity that enacts the transition to true well-being. This of course is limited by humans ingenuity and our ability to construct suitable mechanisms of change. Although currently of insufficient scope, two such human mechanism constructs are politics and economics. With the extension of these two constructs to incorporate nature, then harmony with nature can be achieved and a sustainable world established. Thus, the well-being sandwich sustainable development model is introduced, see Figure 7-23.
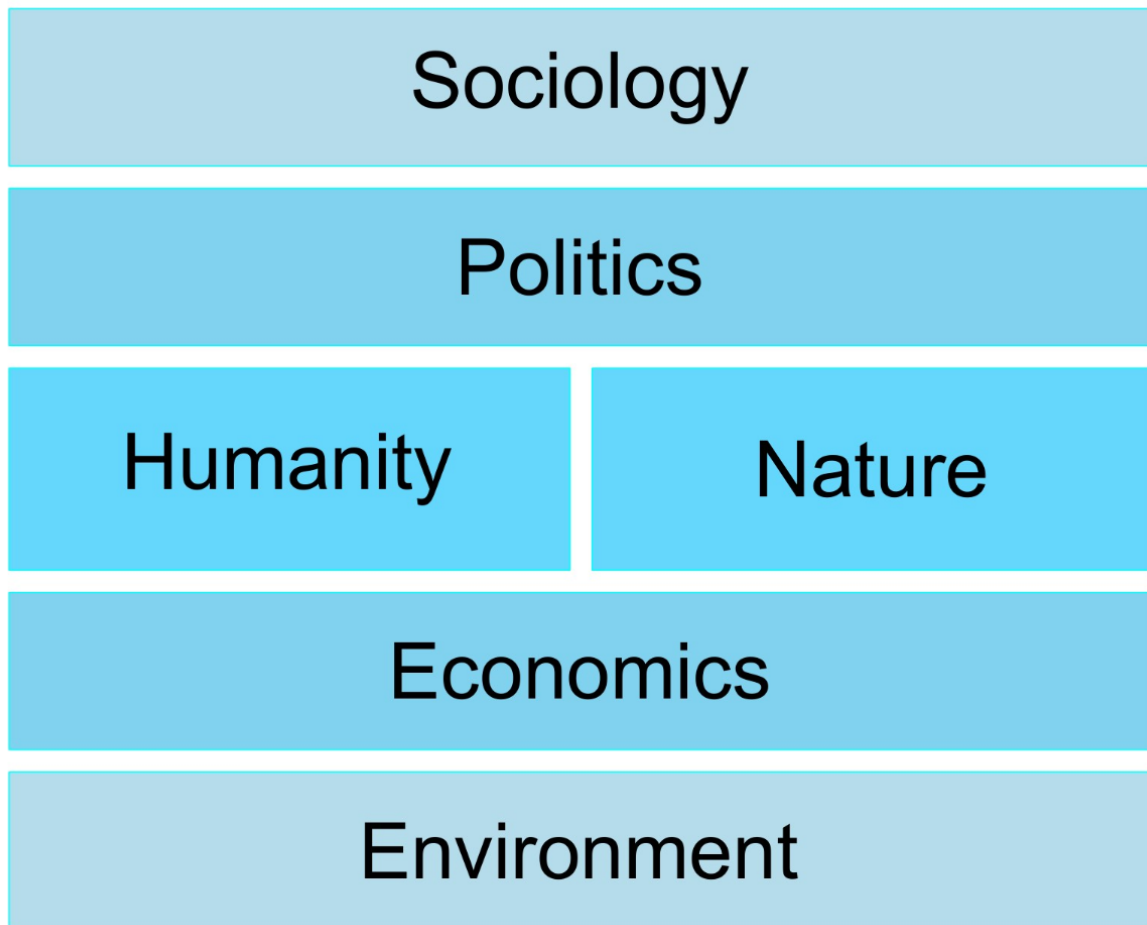
Figure 7-23: Well-being sandwich sustainable development model

As stated, and as evidenced by humanities continued transgression of natural limits, the two mechanisms of politics and economics are currently inadequate to achieve harmony with nature.

Politics is traditionally humancentric, in that it is concerned with social governance. In order to achieve harmony with nature, then **the realms of politics must be expanded to include the rights of nature, that is earth jurisprudence.** Similarly, **economics is traditionally related to the needs of humankind. Rather, if it is extended to ecosystems and biodiversity then the value of nature can be recognised.** To date it has proved difficult to put a monetary value on natural goods such as clean air, and thus nature has suffered. This may in part be due to the currency value trying to be prescribed. Rather than using a currency such as the dollar**, we should rather perhaps use a currency of biocapacity.** In this way the value of a development project within ecosystem limits could be determined. Physical money, such as the dollar could then be limited to use only within the constraints of the budgeted ecological footprint.

Within humanities current understanding of development – that is the widening of the upper growth tiers of Maslow's hierarchy of needs – technology has played a large role. Indeed, it has been used to increase the percentage focus on humanity at the expense of the percentage focus on nature. In the future technology will have to play a very different role. For example, **in the global south, the role of**

technology will be to seek an increased percentage focus on human development whilst maintaining the percentage focus on nature. In the global north technology must drive adaptation – adaptation of civilisation to reverse % focus inequality between humanity and nature. I.e. to maintain or lower the percentage focus on humanity whilst dramatically increasing the percentage focus on nature. The built environment, as it once transformed the world during the first industrial revolution, so to can it stimulate an ecosystem revolution.

In addition to practical mechanisms, as mentioned**, humanities focus for development must also be altered. Humanities perception of what human development is must be adjusted**. The constructs describing humanities understanding and consideration of nature, are arguably sociology and environment. Sociology considers social interaction, and thus pairs with politics. Social activism for change is a powerful tool to achieve it. Considering a biocapacity based economics, the environment describes humanities relationship with nature, and thus promoting the benefits of an enhanced environment, will ultimately promote harmony with nature.

Disregarding the latency of historic anthropogenic forced changes in nature, assuming such an approach to development now, at a temporal scale sufficient to remain within ecosystem limits, would secure a sustainable future. In comparison to elsewhere in the world, application at a pan-Arctic spatial scale would at this point in time be relatively easy.

8 Current considerations of sustainability and development in built infrastructure

8.1 Continued lessons learnt from the developing concept of sustainable development

1992 – UN Conference on Environment and Development

Five years after 'Our Common Future', came the first international Earth Summit, with a focus on the linked, yet unintegrated elements of environmental protection and development.

Building upon the recognition that common worldly problems contain technical/political, social, economic and natural elements which interact, the action plan developed for achieving sustainable development – 'Agenda 21' – diversified from the previous primary focus of economic development and technological advancement to include societal considerations.

Major environmental efforts took shape in the signing of the United Nations Framework Convention on Climate Change (United Nations, 1992c) and the Convention on Biological Diversity (United Nations, 1992a).
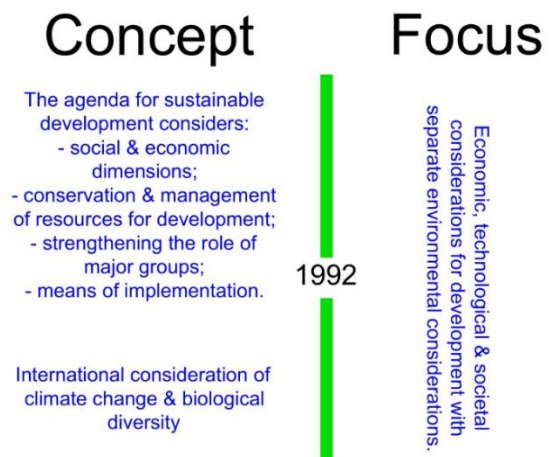
Small Island Developing States – BPoA (1994); BPoA+5 (1999); MSI (2005); MSI+5 (2010)

With the emerging and increased consideration of Small Island Developing States (SIDS), the focus of sustainable development expanded. Rather than consideration of generic economic, technological, social, and environmental categories, thought started to be given to more specific areas.

Although the areas of consideration did expand and merge to a certain extent over the course of the 16 years of SIDS conferences the focus was fairly consistent, and common themes emerged, see the timeline. Of note, themes included: Capacity building; Institutional development; Knowledge and technological transfer; Trade and economic diversification; Globalization; Resource mobilization and finance; and vulnerability (United Nations, 2020e).

As noted by the United Nations General Assembly, (2012), SIDS are particularly vulnerable because of their 'small size, remoteness, narrow resource and export base, and exposure to global environmental challenges and external economic shocks, including to a large range of impacts from climate change and potentially more frequent and intense natural disasters'. This is also very much the case of Arctic communities. Given their remoteness and lack of connection to neighbours, **Arctic communities are effectively Arctic Islands in their own right.**
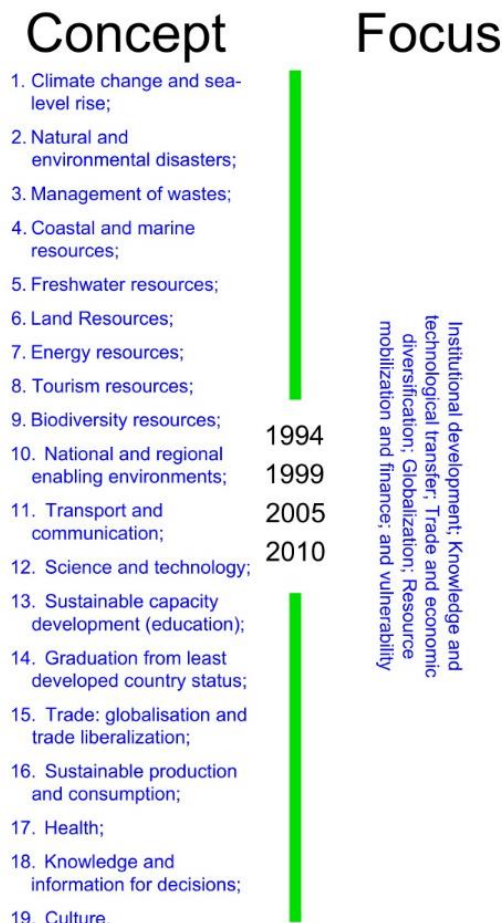
8.1.1   Arctic islands

The case for the Arctic being full of community islands is supported in the commonality of focus between the result of the SIDS conferences and that of Arctic bodies, such as the Arctic Council. The building of capacity through education and cooperation, the pursuit of strengthened collaborations, intensive scientific investigation, the development of digital infrastructure, increasing resource extraction and consideration of adaptation measures, are all strong Arctic examples of the SIDS themes. Indeed all 19 of the SIDS specific areas are prevalent in the Arctic. As such, **the study of the successes and failures of development attempts within SIDS could be useful in determining development limits and pathways within the Arctic.**

Such comparison could for example avoid the mistakes of urbanisation seen across Greenland resultant of a lack of situational understanding. Hendriksen, (2014) identifies mistakes of urbanisation resulting in 'limited livelihoods'; 'a lack of utilization of local resources and trade opportunities'; an 'unsustainable economical situation'; and 'limited export oriented value creation'.

2000 – The Millennium Summit

Whilst progress was being made within the SIDS in achieving a holistic view of the issues prevalent to sustainability in development, progress was stalling elsewhere. Although of great importance, and indeed of great success, the Millennium Development Goals (MDGs), resultant of the Millennium Declaration, were decidedly human focussed. Their purpose was to 'reduce extreme poverty' (United Nations, 2020c)

Indeed, over the 15 year application period, it was found that the MDGs had resulted in 'the most successful anti-poverty movement in history' (Department of Economic and Social Affairs, 2015).

That being said it was also recognised that there was further work to be undertaken. **The successful provision of basic needs for billions more people has resulted in the emergence of higher prepotent needs globally and a variance of inequality.**

2002 – The World Summit on Sustainable Development

Two years after the Millennium Summit, came The World Summit on Sustainable Development where the understanding of sustainable development remained as the need to tackle humanities worldly growth problems rather than addressing humanities worldly limiting problems.

2012 – The Future we Want

With the onset of 'The Future we Want', a more worldly holistic view of sustainable development finally began to emerge. This view blended the economic, technological, social, and environmental undertones of the 'Rio Declaration' and 'Agenda 21' of the UN 'Conference on the Environment and Development', with the SIDS areas of action. This blend formed a strong cohesion around the concept of a green economy, and sustainable consumption and production. Despite the expansion of the understanding of sustainable development to a more holistic set of areas of action, it remained focussed on the triple bottom line – the established aspects of 'economic growth and diversification, social development and environmental protection' (United Nations General Assembly, 2012).

Concept

1. Poverty eradication;
2. Food security and nutrition and sustainable agriculture;
3. Water and sanitation;
4. Energy;
5. Sustainable tourism;
6. Sustainable transport;
7. Sustainable cities and human settlements;
8. Health and population;
9. Promoting full and productive employment, decent work for all and social protection;
10. Oceans and seas;
11. Small island developing states;
12. Least developed countries;
13. Landlocked developing countries;
14. Africa;
15. Regional efforts;
16. Disaster risk reduction;
17. Climate change;
18. Forests;
19. Biodiversity;
20. Diversification, land degradation and drought;
21. Mountains;
22. Chemicals and waste;
23. Sustainable consumption and production;
24. Mining;
25. Education;
26. Gender equality and women's empowerment.

2012

Focus

Economic growth and diversification; social development; and environmental protection.

8.1.2 Green economy

A concept identified as an important method to achieve sustainable development, green economy recognises any 'theory that views the economy as a component of the environment in which it is based' (Halton, 2019). This is similar to the viewing of a piece of infrastructure as a component within an ecosystem.

As recognised by the United Nations Environment Programme (UNEP, no date), 'An inclusive green economy is one that improves human well-being and builds social equity while reducing environmental risks and scarcities'. Indeed, an economic model that seeks to reduce negative human impacts whilst bettering civilisation. Unfortunately UNEP do not consider the economy as a tool to value the rest of nature on par with humanity. Undoubtedly however this is required if we are to not only halt the tide of negative anthropogenic consequences, but reduce the global human footprint to within ecosystem limits.

8.2   The current and future understanding of sustainable development

Commencement of development of a set of Sustainable Development Goals (SDGs) by the UN in 2012 resulted in 2015 in the '2030 Agenda for Sustainable Development'(United Nations General Assembly, 2015). This is seen to be the current understanding of sustainable development globally. Indeed, **the SDGs are supposedly developed for all countries. However, as earlier evidenced in section 4.2.9 the majority of the UNs work is targeted towards the global south and is underpinned by a humancentric ideal, suggesting this is not the case**. Rather than goals for all countries, the SDGs are primarily goals for all peoples – goals to 'stimulate action' (United Nations General Assembly, 2015) for People, Planet, Prosperity (of people), peace (between people) and partnership (between people). **Although harmony with nature could be achieved in relation to these five areas, the sustainable fulfilment of the SDG's is nearly impossible if the current global north level of development is recognised as a benchmark. The humancentric triple bottom line on which the SDGs are built promotes continued development of the global south up Maslow's hierarchy of needs to this point. The global north level of development is in excess of the global ecosystem capacity, and thus pursuit of this is fundamentally unsustainable.**

The idea of the SDGs is now widespread, and they are interpreted in many different arrangements. For example, in some instances the SDGs are interpreted in a pyramid arrangement with those goals relating to people at the base and overlain with ecological and spiritual goals tiered above that. In other instances, they are represented as three economic, environmental, and social pillars. Alternatively, the SDGs are sometimes interpreted through a systems approach – A process commenced by building partnerships to enable better human engagement to stimulate well-being and eventual reduced inequalities. In every case however the interpretation is founded on the humancentric triple bottom line, as is inherent from the historical development of Agenda 2030.

The continued succession of the global south up Maslow's hierarchy of needs is one confirmed by the United Nations Development Programme, (2019b) in the 2019 Human Development Report. The 'developing' countries are catching up with the 'developed' countries with regards to the fulfilment of their deficiency needs. However, with diminishing 'basic' inequalities, such as food availability, comes an increase of higher tier 'growth' inequalities such as a connection to broadband internet. This is seen to be manifesting itself in an increasing global unsatisfaction with life, for example through demonstrations (United Nations Development Programme, 2019b).

The pertinent questions then, are, to what extent does the current global understanding of sustainable development transpose itself into the Arctic, can the Arctic be categorised within the global north or global south, to what extent does the Arctic facilitate global sustainability, and what relation do these understandings have to Arctic built infrastructure?

8.2.1   A review of development

To begin answering the above questions in aid of determining what is holistic sustainable Arctic coastal infrastructure, then a brief review of development is required. The development definition of reference is: 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020). Indeed, it was earlier concluded that **the growth or change towards an advanced state is the pursuit of overall well-being, a state underpinned by the pursuit of harmony with nature and the reduction of inequality. This is the role of built infrastructure.**

Harmony with nature can only be achieved with the reduction of the global human footprint, and thus, the pursuit of harmony with nature manifests itself as the prioritisation of tackling worldly limiting problems – the global increase in 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources' (Meadows *et al.*, 1972), over tackling more local growth problems – poverty; environmental degradation; institutional disenchantment; urbanisation; employment insecurity; youth alienation and traditional values rejection. The worldly limiting problems however, although global, are likely in a practical sense, only to be successfully tackled with initial focus at the local level. The idea that local building blocks (schemes and initiatives etc.) combine into regional and national tiles (coordinated schemes etc.), which together form a global picture (the reduction of humanities footprint to within ecosystem limits).

Despite periodic recognition of the fundamental need to prioritise nature and all that it provides for humanity from the 1100s through 1700s, development for the most part has been synonymous with human fulfilment and human dominance over the natural world. Since early humans began to shape the environment to their advantage, humanity has sought to move up the tiers of Maslow's hierarchy of needs. Although achieved throughout history, the commencement of the current manifestation of self-fulfilment and gratification, rather than overall well-being, correlates with the limiting problems.

In general, it could be argued that for as long as humans have existed, we have in balance had a negative impact on the remainder of the natural world. To the point where humanities actions are within ecological limits, our actions are sustainable. Past those limits and they become unsustainable. With a humancentric understanding of sustainable development, transgression of ecological limits is unfortunately set to continue. Humanity is thus not advancing but becoming more self-indulgent. Remembering the definition of development, if humanity has not holistically advanced, then our progress to date has not been true development.

Considering the above, **holistic human advancement can be expressed as both the improvement of one's self-capacity <u>and</u> one's relation to the natural world.**

By extension, development is growth or change that facilitates both improvement of one's self-capacity **and** one's relation to the natural world. To that end development must seek the repositioning of human influence to within natural ecosystem limits. Currently, development could be characterised as either 'worsening' (self-fulfilment / gratification is prioritised over ones relation to the natural world /

harmony with nature), 'stagnating' (self-fulfilment / gratification = harmony with nature), or at the very best, 'improving' (self-fulfilment / gratification < harmony with nature).

At least this is the case in the **global north**, where people generally reside in the upper half of Maslow's hierarchy of needs (growth needs), where progression (self-gratification) is very often departure from harmony with nature, and is the opposite of advancement. In the **global south**, this can also be the case. However, it is recognised, that much of the global south resides in the bottom half of Maslow's hierarchy of Needs (deficiency needs), where development can be beneficial for both the improvement of ones self-capacity **and** ones relation to the natural world. For example, the construction of sewers that contribute both to people's health and to decreasing humans' negative impact on nature. Although the UN SDGs lack sufficient focus on overall well-being through achievement of harmony with nature, here (in the global south) they are of some useful application.

8.2.2   The worldly scope of the SDGs

The UN SDGs, although supposedly for all nations, are seen to be of variable applicability in different areas of the world. The first case of development focus and SDG application, as indicated above, is **the global south. Consisting of a situation in which the majority of people still experience deficiency needs (despite huge progress having been made), and a human footprint less than their global per capita ecological limit, the SDGs can be applicable directly.** Although it is recognised that the SDG's are humancentric, and their continued long-term application will render them inapplicable.

The second case of consideration is the global north. With the majority of people experiencing an understanding of growth needs corrupted by self-gratification, and an ecological footprint in great excess of global per capita ecosystem limits, the SDG's do not effectively apply. Indeed there are numerous cases of specific relation to 'developing countries' within the SDG targets (Khokhar and Serajuddin, 2015). **Given that the global north, has not only fulfilled the upper tiers of Maslow's hierarchy of needs, but has also gone so far, through self-gratification, to square the hierarchy (see Figure 7-19), then a humancentric global development model is insufficient**. A model that promotes progress towards harmony with nature is rather required.

As demonstrated with the global north squaring of Maslow's hierarchy of needs, it is perhaps not the global south that needs to develop most, but the global north. Where development of the global south should focus on achieving a true pyramid manifestation of Maslow's hierarchy of needs, i.e. human fulfilment in harmony with nature, resulting in overall wellbeing, the global north, as is already exceeds ecosystem limits, must prioritise nature.

It is interesting to consider whether the positioning of the SDGs as global goals has allowed the global north to become complacent and ignore their responsibility in achieving global sustainability. Given that the global north resides in a powerful position at the top of the pyramid it is in the position, should the people of the global north be convinced, to **impose true holistic sustainable development – that**

is, use built infrastructure to advance society towards existence within ecological limits (harmony with nature). In this respect, some progress is starting to be made such as in the transition from fossil fuels to 'green energy', with transition being the operable description.

Transition is required to move the global north form a self-gratifying, ecosystem limit exceeding existence towards overall wellbeing through the pursuit of harmony with nature. To do this, a number of streams are surely required, as deduced in Figure 7-23, these are likely sociology, politics, economics, and environment. Chief among these is sociology, and the need for the global north to realise that their own current state of existence is simply undermining their own future development, as well as that of the global south. As the primary culprits of far reaching natural degradation (historical and current), and consideration of development through a humancentric lens, the global north has become blinded to its own predicament.

Although built infrastructure can be of use to improve the environment directly, such as through the construction of sewers, in the global north, mush of this infrastructure is already constructed. Likewise, this infrastructure is for the improvement of the environment rather than nature itself. For these reasons, **transition in the global north must focus infrastructure to address the worldly limiting problems: the increase in: 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources'** (Meadows *et al.*, 1972)**. This is the second case.**

Considering again the first case – that of the global south – and the recognition that continued long term application of the SDGs will render them inapplicable, a greater focus here is also required on mitigation of the worldly limiting problems. **Where the purpose of infrastructure in the global north is transition, the purpose of infrastructure in the global south is transitioned implementation. Implementation of infrastructure, such as sewers, as can be achieved through use of the SDGs, yet with a prefilter consideration of worldly limiting problems.**

In both the global north and the global south, a greater consideration of the worldly limiting problems to varying degrees is required. This suggests the need for subservience of the SDGs – to tackle the worldly growth problems – under consideration of the worldly limiting problems.

8.2.3   The SDGs subservient to worldly limiting problems

It has been deduced that in order to enact sustainable development, transition infrastructure is required in the global north, whilst transitioned implementation infrastructure is required in the global south. **This is to be achieved through the subservience of the worldly growth problems under the worldly limiting problems. In doing so the task of built infrastructure, to achieve overall well-being, is fulfilled.**

In extension of the definition of well-being, the argument for subservience is that it enables a holistic sustainable role of built infrastructure to both eradicate the threats to humanities basic needs whilst also providing for fulfilment of humanities higher needs.

8.2.3.1   The argument for subservience

The basis for subservience is the realisation that mitigation of the worldly limiting problems can to a large extent mitigate the worldly growth problems. Some examples of this may include:

- The reduction of industrialisation resulting in a reduction of urbanisation.
- The reduction of non-renewable natural resource consumption and pollution resulting in reduced environmental degradation.
- The reduction in population and thus food production resulting in a reduction of poverty and employment insecurity.
- By extention, the above reductions can lead to a reduction in institutional disenchantment, youth alienation and traditional values rejection etc.

Where (Meadows *et al.*, 1972):

- Worldly limiting problems: the increase in: 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources'.
- Worldly growth problems: poverty; environmental degradation; institutional disenchantment; urbanisation; employment insecurity; youth alienation and traditional values rejection.

In essence, mitigation of the limiting problems can lift people out of multidimensional poverty.

8.2.3.2   The implementation of subservience

There is of course a large step between the mitigation of the worldly limiting problems, and reduction of the worldly growth problems, and indeed there are many different paths between them. This, along with initial implementation of mitigation measures is the challenge to achievement of well-being through harmony with nature. Indeed, this is the challenge for the development of built infrastructure.

Initial implementation of mitigation measures and charting a path to the reduction of worldly growth problems requires practical, holistic, sustainable measures. In a general sense, this may include the reversal of globalisation and certain geographical focuses. At a more built infrastructure specific level this may include better consideration of spatial and temporal scale, and consideration of infrastructure as an ecosystem component. Of particular difficulty for built infrastructure to influence is the reduction in population. In the global south, the SDGs partially work towards this through the improvement of healthcare and education. In the global north, these considerations are less applicable and less

conventional approaches are likely required. Such an approach may be reducing house sizes whilst increasing their connectivity to nature and external space. A discouragement of reproduction coupled with an increased well-being and sense of freedom being connected with nature.

8.2.3.3   The degree of subservience

Despite suggestion that the SDGs should be subsumed, as indicated there is still a credible place for them. Above peoples most basic needs such as food and water which have a strong connection to nature, the fulfilment of people's pre-possessive needs will dominate over consideration of the environment and the rights of nature. **The SDGs – representative of a mixed economic, social, and environmental focus can be useful then to lift people out of deep poverty. Above this point however, the SDGs diminish in their standalone value in balance with the increasing necessity to focus more on mitigation of the worldly limiting problems.** The global south is positioned towards the bottom of Maslow's hierarchy of needs and thus its needs are weighted towards the value that can be provided by the SDGs, whilst the global north is towards the top of Maslow's hierarchy of needs and thus has a greater necessity for the mitigation of the worldly limiting problems.

Reconsidering the concept of 'worsening' (self-fulfilment / gratification > harmony with nature), 'stagnating' (self-fulfilment / gratification = harmony with nature), and 'improving' (self-fulfilment / gratification < harmony with nature) development, **both the global south and north are experiencing 'worsening' development**. Based on the above idea of balance between the SDGs and their subservience beneath pre-consideration of the limiting worldly problems, the global south should likely aim for 'stagnating' development, whilst the global north must aim for 'improving' development.

Now that the current and proposed positions of the global south and global north have been determined, attention can be turned to the Arctic.

8.2.4   SDGs and the scope of subservience in the Arctic.

From consideration of the Arctic focus throughout the previous chapters, it can be concluded that the Arctic represents a third development case, residing at some point in between the positions of the global north and global south. Given the uniqueness of the Arctic, this does not necessarily present itself as a middle seating on Maslow's hierarchy of needs.

8.2.4.1   The degree of subservience in the Arctic

In general, the Arctic could be considered as exhibiting 'stagnating' development, i.e. the need for self-fulfilment and gratification are fairly balanced with the people's pursuit of harmony with nature. This is ultimately a good place to be, as it is sustainable. It is a position that could continue

indefinitely. This position is also unique in that it differs from the remaining global north and global south. Indeed, although the Arctic regions are situated in countries considered part of the global north, one cannot automatically consider the Arctic itself part of the global north. Although the different Arctic regions vary considerably in their closeness to the overall situation of the countries in which they reside, they cannot be determined as either 'developed' or 'developing'. **The Arctic is unique! This uniqueness is apparent because of the Arctic's inability to be successfully described by standard global indicators, such as GDP and the HDI**. Some of these unique traits include:

- A strong indigenous representation whose traditional practices are closely linked to harmony with nature.
- A low population density.
- A large biocapacity reserve.
- The reliance on mixed economies – the provision for oneself based on both self-sufficiency practices such as hunting, and on money.

It is these traits, that have to some extent exempted the Arctic from experiencing a definite squaring of Maslow's hierarchy of needs, which is arguably a good thing. If not squared, then it may be assumed that Maslow's hierarchy of needs remains as a pyramid which would suggest well-being. Sadly however, this is not the case. The Arctic experiences some of the highest suicide rates in the world, with trends to indicate that many of these are within indigenous communities. As seen in Figure 8-1, the global average suicide rate in 2016 was around 11 per 100,000 population. In comparison, as shown in Figure 8-2, the suicide rate in the Arctic is significantly higher, especially in Greenland, Nunavut and Chukotka which exhibit a suicide rate of in excess of 50 per 100,000 population. Interestingly, it is also these three regions that exhibit some of the highest indigenous population proportions, see Figure 7-7. Although this does not necessarily correlate with happiness, it does appear that **there is a lack of overall well-being in the Arctic, especially amongst indigenous communities.**
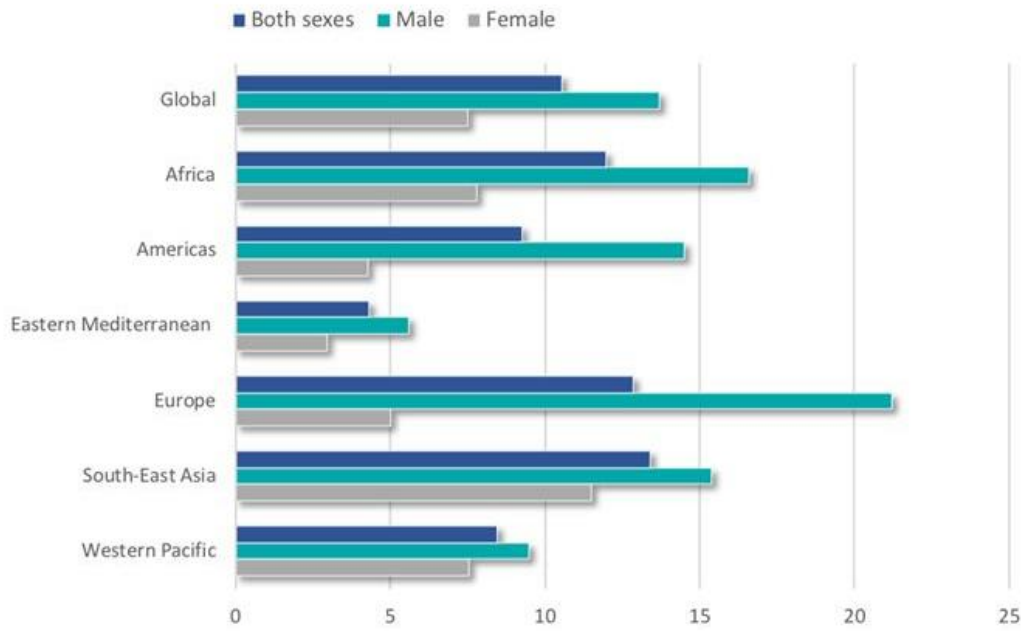
Figure 8-1: Suicide rate per 100,000 population by WHO region, 2016. Source: WHO Global Health Estimates. © (WHO, 2020)

Figure 8-2: Cause of death by suicide 2012-2016. Source: Atlas of population, society and economy in the Arctic. © Jungsberg et al., (2019)

It is suggested that the reason for an experienced lower well-being in the Arctic, and in particular within indigenous communities is the historic rate and direction of development and the transition from traditional livelihoods to those reliant on mixed economies. Indeed, there is a positive correlation between the prevalence of ind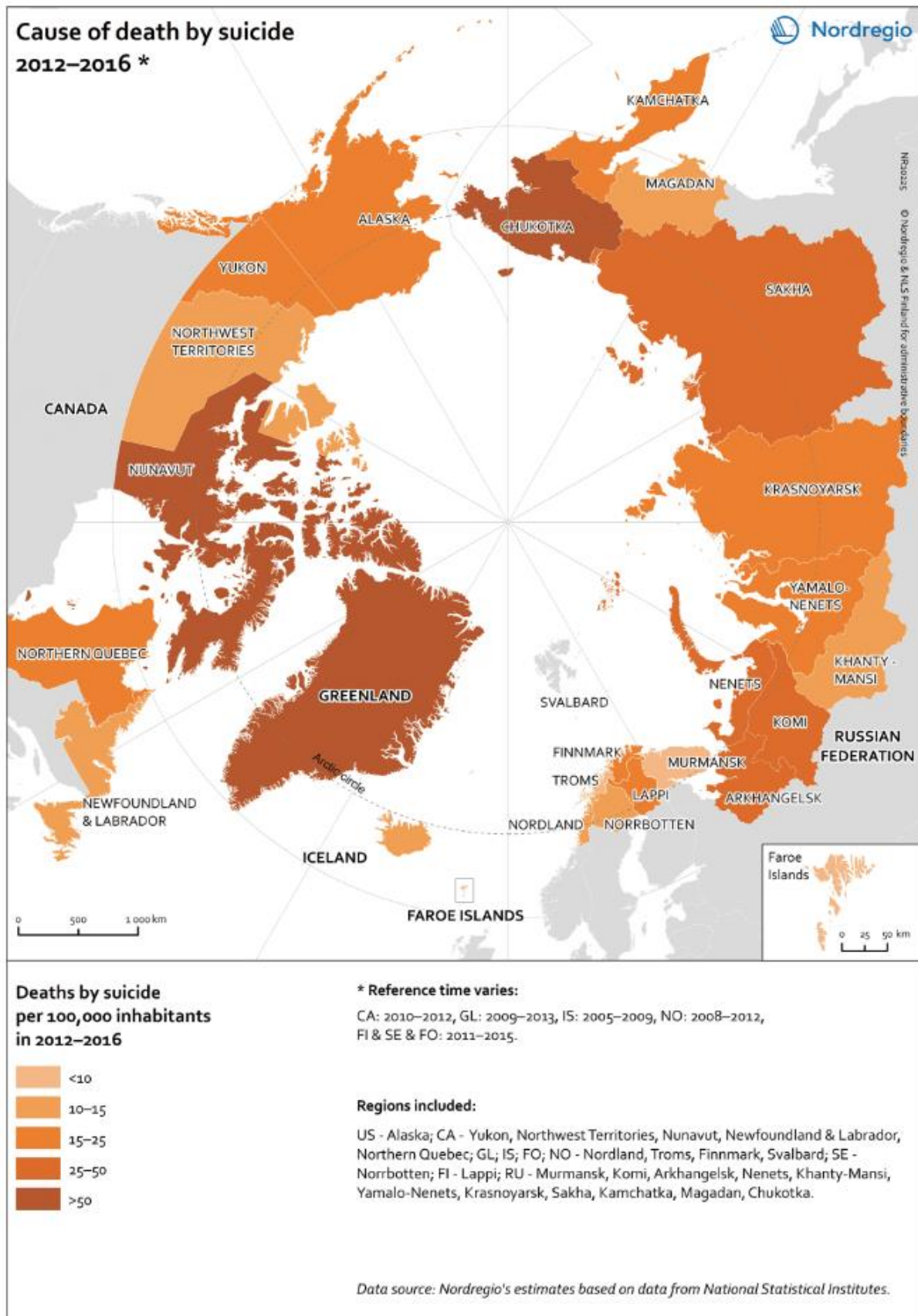igenous peoples and built environment conditions. With the exception of Svalbard, the Arctic regions with the three largest proportions of rented dwellings are Nunavut, Greenland and Chukotka (Russia), which as previously identified are also the three regions that have the highest suicide rates. The exception for Svalbard may either be resultantant of the lack of suicide data, or alternatively, any link between suicide rate and rented accommodation may be mitigated by the high employment rate and relative higher GRP per capita in Svalbard, see Figure 7-14. Additionally Nunuvut and Chukotka see the largest infant mortality rates.

Considering the above, the earlier identified Arctic misrepresentation of WASH services and the fact that many Arctic communities possess higher tier luxuries such as broadband internet, it would appear that **Maslow's hierarchy of needs manifests itself in the Arctic as an hourglass shape – a relatively broader base and top, and relatively narrower middle.**

A particularly representative case is that of Greenland. Greenland's base – biological, physiological and safety needs are to this day heavily influenced by Denmark. The food in the shops, the style of housing and the control of law and order are all largely Danish. Indeed Denmark retains control of many core functions of Greenlandic politics as per the 2009 Act on Greenland Self-Government (STATSMINISTERIER, 2009). Further to the disillusionment of the Greenlandic people to this notion, the elements of society that can be associated with the middle tiers of Maslow hierarchy of needs, such as work, social security and education etc. fall to the responsibility of the Greenland Self-Government. At the highest levels, Greenland boasts vibrant music and art, and connection to nature**. The hourglass shape of Greenlandic development has led to both real and perceived inequalities**, which may in part explain the troublesome suicide rates.

Of note is the consideration that governance, the direction of development (including infrastructure), and well-being are strongly linked. **This raises the question of whether Arctic governments (national, regional, or local), and those in decision making positions have sufficient knowledge and appreciation of the connection between infrastructure, well-being and development, to know which questions should be asked regarding this.**

In any case, it is clear that a re-balancing of the tiers of Maslow's hierarchy of needs is required in the Arctic to varying degrees. Unfortunately, this is difficult to achieve when Arctic communities now largely rely on imports for their basic needs, such as food and shelter. This is most true in the remotest areas of the Arctic, such as across Greenland, Nunavut, and northern Russia. As such, these Arctic communities are unsustainable from the very foundation. **A and more holistic approach to development would be the pursuit of well-developed tri societies. Societies in which there are all primary, secondary, and tertiary economic sectors working in collaboration**. Such holistic thinking can help build sustainability at varying temporal and spatial scales, be it local, regional, or national. By

way of example, rather than primary extraction of Greenlandic raw materials for export, extraction could be for secondary processing in country to fuel a subsequent tertiary sector. **This not only builds resilience but also reduces globalisation – a primary culprit of materialism over well-being. To achieve the re-balancing of the tiers of Maslow's hierarchy of needs, then a refocus on the role of infrastructure is required, in other words, adaptation to the direction of infrastructure development.**

Therefore, although in general the Arctic can be considered as exhibiting 'stagnating' development, it is also currently exhibiting numerous difficulties in its relation to built infrastructure. **The primary reason that the Arctic can be considered as exhibiting 'stagnating' development is for the lack of historic development in general.** This however is to be short lived. **Increasing interest in the Arctic regions from the Arctic nations themselves and internationally is pushing the Arctic towards a state of 'worsening' development (self-fulfilment / gratification > harmony with nature).** This is largely for the reasons of:

- Climate change.
- Increased industrialisation and extractive industries.

'Climate change in the Arctic has continued at a rapid pace', with temperatures 'rising faster than the global average'(AMAP, 2017e), making the Arctic particularly sensitive. With the vast majority of Arctic communities situated on permafrost and / or in the coastal zone, this is needless to say bad news for a whole host of infrastructure. Infrastructure subsidence and damage resultant of coastal erosion are but two of the many challenges facing built infrastructure in the Arctic today, resulting in a need for infrastructure adaptation.

Regarding the increase of industrialisation and extractive industries, although it could bring advantageous infrastructure and employment to local communities. The likelihood is it will rather increase the misbalance of tiers of Maslow's hierarchy of needs whilst increasing the in migration of external labour and globalisation. Extractive industries by nature are usually located away from established settlements and thus are unlikely to represent sustainable communities.

In any case, both to refocus the role of infrastructure to achieve sustainable well-being, to specifically reduce inequality, and to future proof existing communities, adaptation is required. **Where transition infrastructure is required in the global north, and transitioned implementation infrastructure is required in the global south, it is adaptation infrastructure that is required in the Arctic.**

Given the rapid environmental changes being seen in the Arctic, **time is of the essence to prioritise focus of infrastructure on mitigating the worldly limiting problems and avoiding a worsening development situation. As there is a pressing need for circum-Arctic infrastructure adaptation, so too is there a pressing need for a high-level pan-Arctic approach to its implementation**.

Ultimately, there is an identified need for the creation of a **pan-Arctic holistic sustainable infrastructure development framework.**

8.2.4.2 The implementation of subservience in the Arctic

The creation of such a pan-Arctic holistic sustainable infrastructure development framework is required for the lack of its current existence.

The problems faced by humanity and nature are inseparable, and thus in a subservient form Agenda 2030 can partially translate at scale to the Arctic. Surprisingly however, as based on the literature reviewed, there seems to be minimal active consideration of the SDGs in the Arctic. For example, although the Arctic council recognise that the 17 SDGs are integrated, and that action in one will cause an effect in others, specific mention of any SDG is usually in reference to pollution or climate. Although the Arctic Council Sustainable Development Working Group (SDWG) does provide a fairly holistic view of development, the focus of the Arctic Council as a whole remains on cooperation surrounding environmental protection rather than the pursuit of overall well-being – humanities harmony with nature. At a national level, although mention of sustainability within published policy is minimal, it is broader and extends to societal development, innovation, alternative financing, green infrastructure, and smart cities.

Additionally, although the Arctic Council considers some aspects of pan-Arctic infrastructure such as data infrastructure, this is often for the improvement of monitoring capabilities etc. rather than for the sustainable development of existing Arctic communities. **Pan-Arctic consideration of the environment is not seen to translate as sustainable pan-Arctic governance over built infrastructure development. Nor is there evidence of any considered relation between the worldly limiting problems and built infrastructure development.**

The Arctic regions reside within wealthy developed nations, and thus the Arctic regions are viewed by many as themselves being wealthy and developed. Although the Arctic is fairly wealthy, as demonstrated, it exhibits a completely different form of development from the global north. Therefore, the subsequent view that the Arctic can sustain global economies (such as mineral extraction for a global market) in the same way that the global north can, is likely misguided. Given the precarious hourglass picture of development, activities such as mineral extraction could either help rectify the problems faced by local communities, such as through appropriate adaptation of infrastructure for the benefit of the community, or it could merely be exploitive and weaken Arctic communities. In either case, significant, careful thought is required as to the direction and scope of development. Direction and scope that could well be achieved through a pan-Arctic holistic sustainable infrastructure development framework. Additionally, in either case, benefit could be achieved by consideration of mitigating the worldly limiting problems.

Although there is no holistic sustainable pan-Arctic framework for infrastructure development to date, there are a number of tools and models in existence that may be of use. These vary in scope to consider infrastructure both as a component of sustainable development, and the sustainable development of a piece of infrastructure, and include:

Standards:

- ISO 14000. A family of international standards for environmental management (ISO, no date);
- ISO 45001. Management systems of occupational health and safety (ISO, 2018);
- Ecological Footprint Standards 2009 (Global Footprint Network, 2009).

Sustainability Assessment Schemes:

- BREEAM (Building Research Establishment Environmental Assessment Method), including CEEQUAL (Civil Engineering Environmental Quality Assessment and Award Scheme) – Europe.
- LEED (Leadership in Energy and Environmental Design) – North America.
- WELL Building Standard® – Global.
- SuRe® –The Standard for Sustainable and Resilient Infrastructure – Global.
- International Green Construction Code (IgCC) – Global.

Other Tools and Concepts:

- Blue-green infrastructure.
- Carbon pricing.
- Ecosystem-based management.
- GLOBIO3 – Global biodiversity model for policy support (Alkemade et al., 2009).

Other Mechanisms:

- Citizen activism.
- Indigenous knowledge systems.
- Organisational activism.

8.2.4.3   The argument for subservience in the Arctic

The argument for subservience of the SDGs (to tackle worldly growth problems) under the worldly limiting problems, and in general the consideration of built infrastructure against the worldly limiting problems in the Arctic is both that the Arctic is in need of subservience, and has an increased ability to enact it. In extension to the arguments set out above:

There is a need for subservience because:

- The Arctic is more environmentally and socially fragile than other regions of the world.
- The biocapacity per capita in the Arctic is high. This is a valuable asset for both the Arctic and the world. An increased population and commercial activity will diminish this.
- As the population is low and the current scene of development delicate, worldly limiting problems may cause collapse.

- As the Arctic is currently largely exhibits 'stagnating' development, it is in a unique position to pursue truly holistic, sustainable development, and demonstrate to the rest of the world a better blueprint for its implementation.

There is an increased ability for subservience because:

- Of the beneficial value of the practices of indigenous peoples. 'Nature is generally declining less rapidly in indigenous peoples' land than in other lands' (IPBES, 2019).
- The Arctic is less populated and developed, and thus subservience can more easily be maintained.
- Subservience in the Arctic can help facilitate 'improving' development which can bring benefit both locally, regionally, nationally, and internationally.

And as previously identified:

- The Arctic regions are relatively undeveloped regarding major infrastructure, and thus provide a clean canvas more easily accepting of fresh policy.
- The Arctic peoples demonstrate remarkable adaptability and resourcefulness.
- infrastructure innovation.
- Largely, the Arctic regions exist within wealthy nations with strong governance, which have the ability to enact real world change.

Section III : Principles for holistic, sustainable pan-Arctic infrastructure development

Section three of this dissertation provides discourse. It draws together the conclusions of the previous two sections to challenge the current common understanding of holistic sustainable development and provides a contest to the current outlook of Arctic coastal built infrastructure development.

As Harlow, Golub and Allenby, (2013) conclude, an awareness of 'discursive streams can assist in the effective use of the tools and concepts available for sustainable development efforts'. This is for the fact that 'ideas within a discourse are debatable', where debate 'shapes the possible'. The discourse provided here is with the intention of stimulating the thoughts of those responsible for the development of built infrastructure to think holistically about how to develop the Arctic for the better.

9   Current limits to the understanding of development

In considering current literature for Arctic development, and for sustainable development, the general current understanding of development has been identified.

- Across both national and international literature, the understanding of sustainable development and development in general is humancentric.
- In development there exists an anthropogenic economic lens and the persistent idea of human entitlement, which overwhelms the concern for environmental well-being.
- It is considered that 'Motivation theory should be human-centered rather than animal-centered' (Maslow, 1943)
- The current overwhelming focus of development is the reduction of multidimensional poverty.
- The principle understanding of country development is developed or developing.
- The current understanding of sustainable development is that it is synonymous with the triple bottom line (TBL) – the understanding that sustainable development is built upon three balanced economic, social, and environmental pillars.
- The current understanding of sustainable development is that conservation of the natural planet is for the long-term benefit of humanity as an exploitive resource for material satisfaction.

- Current major development in the Arctic is for the benefit of the wider Arctic nations in service of global demand.
- Built infrastructure in the Arctic is starting (and globally continues) to address the worldly problems for human growth and for the achievement of a developed society for all, resulting in the progression towards an ultimately unsustainable future.

10 Themes for sustainable Arctic development

As is understood by the Government of Canada, (no date) 'knowledge and understanding guides decision-making'. It is the concluded knowledge in this chapter which it is hoped will provide the necessary discourse in the understanding of sustainable development to develop a common understanding of the questions that should be asked for development of holistic sustainable Arctic coastal built infrastructure, at the political, scientific and practitioner, and pan-Arctic, national, and municipal / local levels.

The questions that should be asked will come from the enclosed common set of considerations. These are organised into themes which represent the who, why, where, when, how and what of Arctic coastal built infrastructure development. These discursive common considerations are to serve all decision makers, academics, and practitioners.

The themes of common considerations include:

- Who – Arctic uniqueness.
- Why – Limits and problems.
- Where and when – Geographical focus.
- Where and when – Scale focus.
- How – Harmony with nature.
- How – Civilisation.
- How – Mechanisms of application.
- What – Scope of focus.

Asking the generated questions shall, in particular reference to built infrastructure:

1. Aid more developed countries, who currently exhibit a more holistic consideration of development from pursuing an increased human focus as a result of an opening Arctic.
2. Aid more developing countries in pursuing a holistic sustainable development path, over activities restricted to human fulfilment.
3. Aid countries with particularly fragile development profiles from making poor decisions that could increase fragility rather than decrease it.

10.1 Arctic uniqueness

In concluding that this common set of considerations was necessary it was identified that:

- The Arctic regions now stand in a position to avert from a path of unsustainable development as is being followed globally to realise a truly holistic sustainable course of development.
- The Arctic is in a unique position to pursue truly holistic, sustainable development, and demonstrate to the rest of the world a better blueprint for its implementation.

- The Arctic regions are relatively undeveloped regarding major infrastructure, and thus provide a clean canvas more easily accepting of fresh policy.
- The Arctic peoples demonstrate remarkable adaptability and resourcefulness.
- Within the Arctic regions there already exists the appetite for technological and built infrastructure innovation.
- Largely, the Arctic regions exist within wealthy nations with strong governance, which have the ability to enact real world change.
- All of the Arctic countries either have high or very high human development, with all countries residing amongst the most developed countries in the world.
- Excepting the Russian Federation, all of the Arctic states consistently reside in the high-income group, and thus are considered developed.
- In the Arctic, the population is generally stable or increasing within developed Arctic regions and falling within developing regions. This is contrary to global trends.
- There is an inability to successfully describe the Arctic by standard global indicators, such as gross domestic product (GDP) and the human development index (HDI).
- Infrastructure inequalities are experienced between the Arctic and non-Arctic regions of the High North. Whether this is a hindrance to holistic development remains to be seen.
- The behaviour of Arctic residents, as driven by Arctic conditions, is not the same as of non-Arctic residents, even within the same country. Likewise, the behaviour of indigenous Arctic peoples' is not the same as that of non-indigenous Arctic peoples'.
- Indigenous peoples' management of nature is better than non-indigenous peoples'.
- The Arctic has a large biocapacity reserve.
- The Arctic has a strong indigenous representation whose traditional practices are closely linked to harmony with nature.
- The Arctic has a low population density.
- The Arctic relies on mixed economies – the provision for oneself based on both self-sufficiency practices such as hunting, and on money.
- The shape of Arctic development is an hourglass manifestation of Maslow's hierarchy of needs – a relatively broader base and top, and relatively narrower middle.
- There are seen ethnically distinct interests of indigenous Arctic peoples'.
- Green colonialism is causing a loss of traditional knowledge in the Arctic.
- Traditional knowledge is shared if and when deemed appropriate by the community.
- There is Indigenous non-support of collective knowledge pooling to be picked and chosen from.

10.2 Limits and problems

In concluding that this common set of considerations was necessary it was identified that:

General:

- At a national level there is a general focus of stability, development, and control. This is in difference to the international level, which has a general focus on scientific and indigenous knowledge, human well-being, sustainable development, and environmental protection.

- At increased depth within literature, where it becomes more specific, national and international priorities start to align.

- Although international collaboration / literature has a positive effect, the more holistic thinking that it provides is largely not being fully transferred to national policy. This is an issue for the fact that it is largely national policy that shapes the future of the Arctic.

- The world Bank's definitions of developed and developing – considering the distribution of monetary wealth and population – only partially apply to the Arctic.

- If considered at a regional or local level, parts of the Arctic may be considered in multidimensional poverty.

- The triple bottom line (TBL) is 5/6ths human focussed, and 1/6th nature focussed.

- Humanity has since the first industrial revolution been pursuing an alternative path of self-gratification, reliant on natural resources and fuelled by a consumerist ideology, rather than seeking true fulfilment of one's growth needs.

- Four components (social, environmental, economic & political) together control the substantial worldly growth problems identified as existing in all societies to varying degrees.

- Worldly growth problems include poverty; environmental degradation; institutional disenchantment; urbanisation; employment insecurity; youth alienation; traditional values rejection.

- Worldly limiting problems, those factors that limit civilisation include the increase in: 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources' (Meadows et al., 1972).

- In the Arctic there is no evidence of any considered relation between the worldly limiting problems and built infrastructure development.

- The limits of human civilisation correspond inextricably to humanities degree of influence above and beyond the constraints of ecological integrity.

- The World Bank's World Development Indicators are in close alignment with the UN SDG's and are organised into six data themes: Poverty and Inequality; People; Environment; Economy; States and Markets; and Global Links. These represent a human focus.

- Population growth strongly correlates with development (as it is currently perceived).

- Development of built infrastructure can both facilitate fulfilment of peoples basic needs - increased access to food, sanitation, shelter and clean water etc., more resource to support increased births, and it can increase health care and overall health, thus reducing mortality.

- In the multidimensional poverty index (MPI), the 10 indicators associated with the standard of living are heavily reliant on the built environment.

- A developed built environment can aid the escape from multidimensional poverty.

- Today, in general, the global north is experiencing growth needs and the global south is experiencing deficiency needs.

- Variation to the needs of the global north and global south is brought through the key factors of Inequality, behaviour, and gratification.

- The primary inequalities of the past amongst people and nations was surrounding basic needs – food, water, and healthcare etc., those foundational aspects of Maslow's hierarchy of needs.

- The primary inequalities of today surround the higher tiers of human development such as 'tertiary education and access to broadband' (United Nations Development Programme, 2019b).

- Where the inequality gap in basic needs is diminishing, the inequality gap in higher needs is increasing.

- Humanities insatiable need for self-gratification is resulting in the transgression of natural limits and biodiversity loss, ultimately undermining humanities very existence.

- The global south exhibits an ecological footprint less than the global per capita ecological limit. It has biocapacity reserve.

- The global north exhibits an ecological footprint in excess of the global per capita ecological limit.

- Globally, the ecological footprint exceeds biocapacity.

- Globally, there is being seen a warped expansion of the upper tiers of Maslow's hierarchy of needs, with a reduction of capacity in the lower tiers. The pyramid hierarchy of needs is becoming squared.

- The global north has exceeded the fulfilment of the upper tiers of Maslow's hierarchy of needs and has squared the hierarchy through self-gratification.

- In the global north, the humancentric SDG global development model is insufficient.

- Both the global south and north are experiencing 'worsening' (self-fulfilment / gratification > harmony with nature) development.

Arctic:

- The Arctic is sparsely populated but is experiencing net population increase. Most people live in urbanised centres. Around 9% of people are indigenous.

- 'In most Arctic regions' gross regional product (GRP) 'per capita is higher than in corresponding non-Arctic areas' (Glomsrød et al., 2017).

- A large proportion of the Arctic economy is based on the large mineral extraction sector.

- The disposable income of households (DIH) per capita reflects the GRP per capita trend of being larger in the Arctic regions than in the corresponding non-Arctic regions.

- Although GRP per capita can be larger or much larger in some Arctic regions, the DIH per capita is fairly consistent across the Arctic. There is a stripping of profits.

- In the Arctic, the standard of living associated with a relatively developed country is not always seen.

- Many Arctic communities are remote and disconnected and share similarities with Small Island Developing States (SIDS).

- The Arctic countries exhibit an HDI greater than the average HDI associated with Small Island Developing States (SIDS).

- There is a discrepancy in human development between the Arctic and non-Arctic portions of Arctic countries.

- In general, the Arctic could be considered as exhibiting 'stagnating' development, i.e. the need for self-fulfilment and gratification are fairly balanced with the people's pursuit of harmony with nature (self-fulfilment / gratification = harmony with nature).

- The primary reason that the Arctic can be considered as exhibiting 'stagnating' development is for the lack of historic development in general.

- There is a lack of overall well-being in the Arctic, especially amongst indigenous communities.

- It is suggested that the reason for an experienced lower well-being in the Arctic, and in particular within indigenous communities is the historic rate and direction of development and the transition from traditional livelihoods to those reliant on mixed economies.

- The hourglass shape of Arctic development has led to both real and perceived inequalities.

- Increasing interest in the Arctic regions from the Arctic nations themselves and internationally is pushing the Arctic towards a state of 'worsening' development (self-fulfilment / gratification > harmony with nature).

- In the Arctic, time is of the essence to prioritise focus of infrastructure on mitigating the worldly limiting problems and avoiding a worsening development situation.

- As there is a pressing need for circum-Arctic infrastructure adaptation, so too is there a pressing need for a high-level pan-Arctic approach to its implementation.

- Pan-Arctic consideration of the environment is not seen to translate as sustainable pan-Arctic governance over built infrastructure development.

10.3 Geographical focus

In concluding that this common set of considerations was necessary it was identified that:

General:

- The limit of our civilisation is unsustainable, and thus development towards achievement of the fullness of our civilisation for all takes a development path away from a sustainable existence.
- Environmental problems resultant of development are different in the global north and global south.
- Through the application of technological development, and a focus on the human environment rather than nature, humanity has ignored and outstripped natures limits.
- The successful provision of basic needs for billions more people has resulted in the emergence of higher prepotent needs globally and a variance of inequality.
- the SDGs are supposedly developed for all countries. However, the majority of the UNs work is targeted towards the global south and is underpinned by a humancentric ideal, suggesting this is not the case.
- Sustainable fulfilment of the SDG's is nearly impossible if the current global north level of development is recognised as a benchmark.
- The global north level of development is in excess of the global ecosystem capacity.
- The pursuit of continued development of the global south up Maslow's hierarchy of needs to the level of development of the global north as per the SDGs is fundamentally unsustainable.
- No country is in fact developed. We are all developing.

Arctic:

- It is for the reason that current Arctic development policy focusses on addressing the worldly growth problems and for the achievement of a developed society for all, that built infrastructure in the Arctic is starting (and globally continues) to facilitate the progression towards an ultimately unsustainable future.
- Arctic wide statistical descriptions cann't neccesserily be taken as representative of each Arctic region which vary significantly.

10.4 Scale focus

In concluding that this common set of considerations was necessary it was identified that:

- Sustainable development is resultant of both scale and focus.
- Sustainable ecosystem-based management depends on both spatial and temporal scale.
- There is a necessity for horizontal (between local, municipal, national, and pan-Arctic), and vertical (between politics, science, and practice) knowledge transfer.

- The biocapacity of the Arctic regions must be assessed separately from the Arctic countries.
- Scientific and traditional unintegrated knowledge co-production is required in the Arctic.
- The Arctic requires balanced attention and funding for the preservation and development of traditional and scientific knowledge. Specifically, in the coastal zone.

10.4.1 Temporal scale

- Sustainability can be understood as 'the quality of being able to continue over a period of time' (Cambridge University Press, 2020).
- Development can be understood as 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020).
- In built infrastructure construction, materials utilised should be able to be reinserted into the temporal scale of the ecosystem from which they came – At the end of life of the piece of built infrastructure.
- Cradle to grave / system thinking spans humanity and nature through politics, economics, sociology, and environment.
- In development, consideration must be given to both the long- and short-term time scales.

10.4.2 Spatial scale

- Sustainable Arctic development projects if undertaken within a holistic framework can provide the local building blocks for national, pan-Arctic, and global sustainability.
- Knowledge extends from local to international scales, and thus the application of knowledge is also required at these scales.
- It is perhaps not the global south that needs to develop most, but the global north.
- In the global south, where there is spare biocapacity, and where the majority of people still experience deficiency needs, the UN Sustainability Goals (SDGs) may currently be applicable directly.
- Global south development must focus on achieving a true pyramid manifestation of Maslow's hierarchy of needs, i.e. human fulfilment in harmony with nature, resulting in overall wellbeing.
- Global north development, as is already exceeds ecosystem limits, must prioritise nature.
- The global north must in particular impose true holistic sustainable development – that is, use built infrastructure to advance society towards existence within ecological limits (harmony with nature).
- Built infrastructure construction should utilise materials of like qualities as the local spatial ecosystem provides.
- Built infrastructure should be in sync with the spatial scale of ecosystem networks.
- Built infrastructure should be developed as a priority for the local spatial scale.

- Arctic and regional Arctic analysis is required over use of national and global values.
- Many Arctic communities are effectively Arctic islands.

10.5 Harmony with nature

In concluding that this common set of considerations was necessary it was identified that:

- Transgression of natural limits.is seen to cause negative effects at all levels of Maslow's hierarchy of needs, thus fundamentally undermining human progress to well-being – the holistic and true form of development.
- The main factors identified as determining growth and limiting civilisation are all factors which occur as a result of disengagement from nature and the elevation of humanity above the natural world.
- Living in harmony with nature is necessary for prosperity.
- Within sustainable management, sustainable development can still be of benefit, when the understanding of development is the coming into closer harmony with nature.
- Sustainable Arctic development is development that holistically increases balance and harmony between humanity and nature within the Arctic regions.
- Infrastructure connects protection of the natural environment with society.
- Built infrastructure must be considered in relation to climate and its impacts.
- Built infrastructure must be constructed, maintained, and decommissioned within ecosystem limits, and in support of sustaining ecological integrity, achieved through five goals:
  - Maintain viable populations of all native species in situ.
  - Represent, within protected area, all native ecosystem types across their natural range or variation.
  - Maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles, etc.).
  - Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
  - Accommodate human use and occupancy within these constraints.

10.6 Civilisation – Challenging societies view on development

In concluding that this common set of considerations was necessary it was identified that:

General:

- 'For all our progress, something in our globalised society is not working'. The identified reason for this is inequality (United Nations Development Programme, 2019b).

- Consideration of inequalities between countries and within countries is key to enhancing ones understanding of human development.

- Today's inequalities stem from misbalance of power: 'the power of the few; the powerless of the many; and the collective power of the people to demand change' (United Nations Development Programme, 2019b).

- 'Going beyond income will require tackling entrenched interests – the social and political norms embedded deep within a nation's or group's history and culture' (United Nations Development Programme, 2019b).

- One of cultures main purposes is to mitigate physiological needs. Now that humanities basic needs (such as food, water, and shelter) are being thwarted (losing gratification) as a result of environmental change, they are likely to regain prepotency.

- 'Gratification becomes as important a concept as deprivation in motivation theory, for it releases the organism from the domination of a relatively more physiological need, permitting thereby the emergence of other more social goals' (Maslow, 1943).

- Previously gratified needs can dominate once again if fulfilment is undermined.

- The consideration of society as a whole, and societies holistic needs is an important underlying factor in development.

- In difference to the common understanding that deprivation of the standard of living is an absence of material intensive construction, construction from natural materials can last a long time, with the longevity of their continued use testament to their replenishable nature.

- The use of natural, local materials in construction within ecosystem limits is arguably more sustainable than the use of imported manufacturing intensive materials.

- The acquisition of material wealth does not bring self-fulfilment.

- It is the pursuit of happiness, self-fulfilment and transcendence that is the key to achieving well-being (Psychology Today, 2020).

- A positive interaction with nature is not only necessary for human development in a physical and resource sense, it is also of great importance for social and psychological well-being.

- 'Motivation theory is not synonymous with behavior theory'. 'While behavior is almost always motivated, it is also almost always biologically, culturally and situationally determined as well' (Maslow, 1943).

- Currently social equity is pursued at the expense of physical sustainability.

- Action towards true development will only occur under the will of society.

- The direction of development is subject to social understanding, and thus social development brings sustainable development.

- The focus of development should be the drastic reduction of the per capita ecological footprint of the global north, whilst aiding the global south to retain its position within the limits of global per capita bio capacity. In this way, humanity will once again be pursuing wellbeing, rather than self-gratification.

- The reduction of the global ecological footprint requires academia for research and monitoring, governance for direction, and practice for implementation.
- Poverty is a lack of well-being, and thus all of humanity is in some form of poverty.
- If well-being and happiness are indicators of poverty, a less developed society, by the World bank, or UN categorisation, could through a greater positive connection with the natural world be more developed as a whole.
- Well-being inequality is minimally decreasing in the global north, whilst it is significantly increasing in the global south.
- As a powerful component of human development, built infrastructure must hold a dominant position in politics, academia, and practice. Not for the sake of human self-gratification, but for humanities interaction with nature, and ultimately human well-being.
- In order to develop, the idea of development must be coherent across all sectors, and thus knowledge sharing is paramount.
- Rather than existing in a sustainable state, Sustainable development is development that results in progression towards a sustainable human existence.
- True development is the pursuit of overall well-being, in which nature is integral. In other words, sustainable human development is synonymous with sustainable nature.
- In order to achieve harmony with nature and recognition of the true value of nature then both humanities focus for development must be altered and mechanisms put in place to prescribe and recognise the value of harmony with nature.
- A different view of sustainable development must be cemented.
- Humanities perception of what human development is must be adjusted.
- Rather than the use of a hard currency in determining the value of a development project, a currency of biocapacity within ecosystem limits should be utilised.
- In the future, technology within built infrastructure will have to play a very different role to what it is today.
- In the global south, the role of technology will be to increase percentage focus on human development whilst maintaining the percentage focus on nature.
- In the global north technology must drive adaptation – adaptation of civilisation to reverse percentage focus inequality between humanity and nature. I.e. to maintain or lower the percentage focus on humanity whist dramatically increasing the percentage focus on nature.
- Holism is based on knowledge sharing and transfer.

Arctic:

- There is a need for increased cooperation between the political, scientific, and practitioner levels.
- Likewise, there is a need to focus on cooperation with and between Arctic peoples, their well-being, and the protection of indigenous cultures.

- There is an increased need for pan-Arctic knowledge sharing, partnerships, and engagement of political, scientific, and practice stakeholders across local, municipal, and national boundaries.
- There is a need for flexibility in policy and development strategies.
- Knowledge of the Arctic can be generated through educating the people of the Arctic.
- Resource development requires special thought about the rights of indigenous peoples.
- Resource development requires special thought about the toxic relationship between economically driven, short term exploitive development and long-term sustainability.
- Anthropogenic forced negative changes in climate are leading to coastal Arctic communities being put at particular risk of devastation from exposure to the oceans.
- Sustainable development is the pursuit of a closer connection to our gratified needs – e.g. source of food etc.
- There is a greater connection to one's gratified needs in the Arctic than globally in general.
- The pursuit of a closer connection to one's gratified needs can be achieved through mechanisms such as education and localisation etc.

10.7 Mechanisms of application

In concluding that this common set of considerations was necessary it was identified that:

- Different approaches to future development are required for different regions of the earth.
- In development of a new truly sustainable model for built infrastructure development, new approaches will be required. Implementation of built infrastructure could however likely be achieved through use of existing mechanisms such as policy, regulation, and standards.
- A new holistic sustainable model for built infrastructure development should consider Earth Jurisprudence – 'legal provisions recognising the Rights of Nature' to 'exist, thrive and evolve' in partnership with humanity (United Nations, no date a).
- Green economy recognises any 'theory that views the economy as a component of the environment in which it is based' (Halton, 2019).
- A piece of infrastructure should be viewed as a component within an ecosystem.
- The SDGs – representative of a mixed economic, social, and environmental focus can be useful to lift people out of deep poverty. Above this point however, the SDGs diminish in their standalone value in balance with the increasing necessity to focus more on mitigation of the worldly limiting problems.
- In both the global north and the global south, a greater consideration of the worldly limiting problems to varying degrees is required.
- The SDG's must be considered subservient to mitigation of the worldly limiting problems – to tackle the worldly growth problems.

- Where the global north requires significant subservience for its lack of harmony with nature, subservience in the global south is required to a lesser degree.
- Subservience of the SDGs below the worldly limiting problems enables a holistic sustainable role of built infrastructure to both eradicate the threats to humanities basic needs whilst also providing for fulfilment of humanities higher needs.
- A more holistic approach to development is the pursuit of well-developed tri societies. Societies in which there are all primary, secondary, and tertiary economic sectors working in collaboration.
- Tri societies not only build resilience but also reduce globalisation – a primary culprit of materialism over well-being.
- To achieve the re-balancing of the tiers of Maslow's hierarchy of needs, then a refocus on the role of infrastructure is required, in other words, adaptation to the direction of infrastructure development.
- Policy and subsequently built infrastructure must in the Arctic be directed to avoid (and globally reverse) the factors identified as limiting civilisation above the worldly growth problems, to act as the thread that draws humanity and nature back together into harmony!

Other mechanisms of application currently in existence that may be considered include:

Standards:

- ISO 14000. A family of international standards for environmental management (ISO, no date).
- ISO 45001. Management systems of occupational health and safety (ISO, 2018).
- Ecological Footprint Standards 2009 (Global Footprint Network, 2009).

Sustainability Assessment Schemes:

- BREEAM (Building Research Establishment Environmental Assessment Method), including CEEQUAL (Civil Engineering Environmental Quality Assessment and Award Scheme) – Europe.
- LEED (Leadership in Energy and Environmental Design) – North America.
- WELL Building Standard® – Global.
- SuRe® –The Standard for Sustainable and Resilient Infrastructure – Global.
- International Green Construction Code (IgCC) – Global.

Other Tools and Concepts:

- Blue-green infrastructure.
- Carbon pricing.
- Ecosystem-based management.
- GLOBIO3 – Global biodiversity model for policy support (Alkemade et al., 2009).

Other Mechanisms:

- Citizen activism.
- Indigenous knowledge systems.
- Organisational activism.

There is a need for SDG subservience below mitigation of the worldly limiting problems in the Arctic because:

- The Arctic is more environmentally and socially fragile than other regions of the world.
- The biocapacity per capita in the Arctic is high. This is a valuable asset for both the Arctic and the world. An increased population and commercial activity will diminish this.
- As the population is low and the current scene of development delicate, worldly limiting problems may cause collapse.
- As the Arctic currently largely exhibits 'stagnating' development.

There is an increased ability for SDG subservience below mitigation of the worldly limiting problems in the Arctic because:

- There is beneficial value of the practices of indigenous peoples. 'Nature is generally declining less rapidly in indigenous peoples' land than in other lands' (IPBES, 2019).
- The Arctic is less populated and developed, and thus subservience can more easily be maintained.
- Subservience in the Arctic can help facilitate 'improving' development (self-fulfilment / gratification < harmony with nature), which can bring benefit both locally, regionally, nationally, and internationally.
- The Arctic regions are relatively undeveloped regarding major infrastructure, and thus provide a clean canvas more easily accepting of fresh policy.
- The Arctic peoples demonstrate remarkable adaptability and resourcefulness.
- Within the Arctic regions there already exists the appetite for technological and built infrastructure innovation.
- Largely, the Arctic regions exist within wealthy nations with strong governance, which have the ability to enact real world change.

10.8 Scope of focus

In concluding that this common set of considerations was necessary it was identified that:

- Experience and knowledge exchange are extremely important for reasonable development of the high north.
- Clarity is required at national and pan-Arctic levels as to the role of infrastructure in the Arctic.
- In the Arctic, increased clarity and consideration of the coastal zone is required.
- A common understanding of what the coastal zone it is required.

- There is little literature (policy, regulation, standards etc.) itself on the topics considered in relation to the Arctic coastal zone.

- Where, national literature has a minimal consideration of sustainable development, international literature is fairly holistic in its consideration.

- Sustainable management is the employment of sustainable practices within the building blocks of civilisation, e.g. agriculture, business, construction, society, and the environment to manage civilisation in such a way that it benefits current and future generations.

- Holistic consideration of built infrastructure is twofold:
  - Consideration of sustainable development of a piece or system of infrastructure.
  - Consideration of the role of built infrastructure in sustainable development.

- Sustainable development must be considered within ecosystem constraints.

- The contribution of built infrastructure to establishing harmony with nature may be achieved though ecosystem-based management.

- The environment describes humanities interaction with nature both directly and indirectly. Directly as a biotic (living) component utilising other living resources such as trees and animals, and indirectly through humanities influence over abiotic (non-living) components, such as water and air.

- Ecosystem based management can help to synthesize societal, economic, scientific, and governmental goals', of which built infrastructure is a part.

- Important to human development are 'a long and healthy life, being knowledgeable and have a decent standard of living' (United Nations Development Programme, 2020a).

- In consideration of human development, a more holistic consideration is required.

- A decent standard of living is related to the provision of 'basic' needs.

- There is a difference in the focus of development between more and less developed countries.

- It is the task of built infrastructure to both eradicate the threats to humanities basic needs whilst also providing for fulfilment of humanities higher needs. In other words, it is the task of built infrastructure to achieve well-being.

- In assessing the impacts of Arctic change, a transdisciplinary approach is required. One which 'includes an integration of the natural sciences, economics and social sciences, as well as engagement with a wide range of stakeholders' Alvarez, Yumashev and Whiteman, (2020).

- Sustainable development – that is the path to well-being – is harmony with nature. I.e. in the recognition that nature pervades every tier of Maslow's hierarchy of needs, sustainable development is 1/2 human focussed, 1/2 nature focussed.

- A more holistic model for development is required. A 50/50 split between nature and non-nature based human requirements, to achieve harmony with nature and ultimate well-being.

- As economics is a human construct to service society, then unless the needs of society are entirely based on wealth, then economic development forms only part of societal, or human

development and cannot be considered an equal pillar or sustainability. Rather it is a subordinate tool.

- Although currently of insufficient scope, the two human constructs politics and economics can be used to aid in achieving harmony with nature.

- The realms of politics must be expanded to include the rights of nature, that is earth jurisprudence.

- Economics is traditionally related to the needs of humankind. Rather, if it is extended to ecosystems and biodiversity then the value of nature can be recognised.

- The growth or change towards an advanced state is the pursuit of overall well-being, a state underpinned by the pursuit of harmony with nature and the reduction of inequality. This is the role of built infrastructure.

- Holistic human advancement can be expressed as both the improvement of one's self-capacity and one's relation to the natural world.

- Infrastructure transition in the global north must focus infrastructure to address the worldly limiting problems.

- Where the purpose of infrastructure in the global north is transition, the purpose of infrastructure in the global south is transitioned implementation.

- Transitioned implementation of infrastructure can be achieved through use of the SDGs in subservience to worldly limiting problems.

- Transition is required to move the global north form a self-gratifying, ecosystem limit exceeding existence towards overall wellbeing through the pursuit of harmony with nature.

- Where transition infrastructure is required in the global north, and transitioned implementation infrastructure is required in the global south, it is adaptation infrastructure that is required in the Arctic.

- There is an identified need for the creation of a pan-Arctic holistic sustainable infrastructure development framework.

- With the exception of lateral scientific knowledge transfer, there is a need for improved knowledge transfer in all directions. Increased knowledge transfer is particularly required from the practitioner and local / municipal levels upwards.

- Meaningful dialogue and utilisation of indigenous and local knowledge is key for mitigating environmental degradation.

- Robustness must be inherent in built infrastructure to allow effective adaptation to economic and technological changes.

# 11 A Holistic sustainable Arctic built infrastructure development framework

After having developed a greater understanding of the considerations necessary to achieve holistic sustainable Arctic coastal built infrastructure development, through development of scale appropriate questions that need to be asked, there is then required a framework in which to ask these questions.

Such a framework would provide the basic structure and understanding against which the questions are asked when considering built infrastructure. This could apply to a whole infrastructure scheme, a piece of infrastructure, or an element of infrastructure. Such a framework would adjust humanities focus for development and aid in ensuring that all levels are 'singing from the same hymn sheet', i.e. their basic understanding of sustainable development is the same. Similarly, the same framework could be used to monitor that construction of Arctic built infrastructure is actually being done sustainably. In addition, use of such a framework would lead to the better assessment of 'the costs and benefits of Arctic change', as was assessed as necessary by Alvarez, Yumashev and Whiteman, (2020).

A high-level interpretation of what this framework may look like, based on the learnings of this study, is set out as below. This framework is in a tiered form, where the top tier houses the idea that should be consulted first when testing answers to the developed questions. Each tier acts as a consideration prefilter to the subsequent tiers.

11.1 Tier zero

Tier zero consists of the well-being sandwich. Recreated in below Figure 11-1, the well-being sandwich is a sustainable development model centred around humanities harmony with nature, holistically supported with the human constructs of politics, economics, sociology and environment in a modified form of understanding.
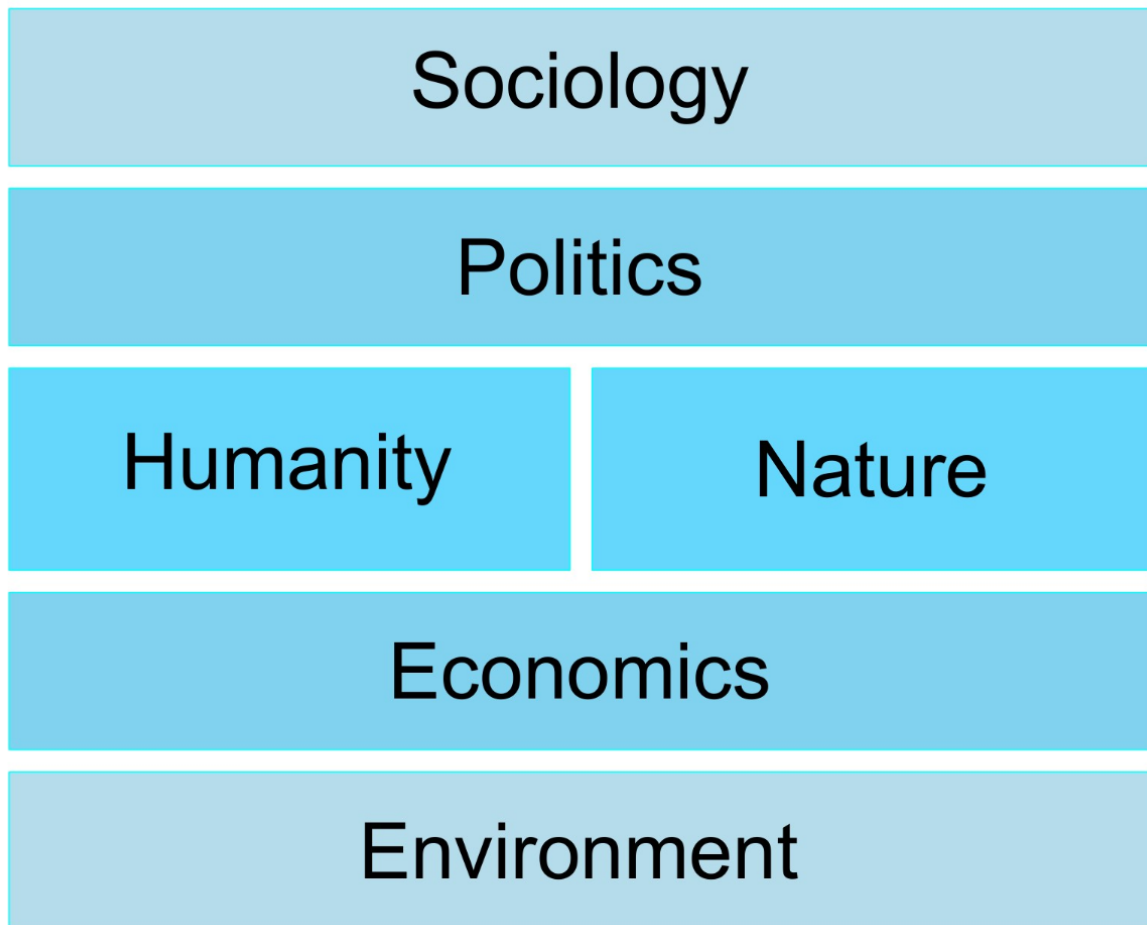
Figure 11-1: Well-being sandwich sustainable development model – repeated

The overarching purpose of the well-being sandwich sustainable development model is to pursue well-being for all. The pursuit of well-being is the pursuit of what is ultimately good for you as a person, and goes beyond happiness to bring balance between positive and negative elements, see chapter 2 – definitions and terminology.

Well-being is the value that must be achieved to attain a truly sustainable existence on our shared planet. The pursuit of well-being aligns with the pursuit of the true pyramid manifestation of Maslow's hierarchy of needs (Maslow, 1943), see Figure 7-3, which to date in the Arctic and elsewhere in the world has been misshapen by the unsustainable pursuit of happiness through self-gratification. The misshapen nature describes the presence of inequalities.

The pursuit of the true pyramid manifestation of Maslow's hierarchy of needs stipulates changes and advancement towards a state that can be maintained through time, and thus the pursuit of well-being is the true form of sustainable development. See, chapter 2 – definitions and terminology for the understanding of sustainability and development.

The reason for a current misshapen manifestation of Maslow's hierarchy of needs, as caused by the pursuit of happiness through self-gratification, is the result of dis-harmony with nature. The wants of

humanity have globally driven civilisation to a point of having an ecological footprint in excess of the global biocapacity. As such humanity is fundamentally undermining its own existence.

As such, sustainable development, that is the pursuit of well-being, is underpinned by the pursuit of harmony with nature and the reduction of inequality. This should be the aim of built infrastructure.

11.2 Tier one

Given that humanity will likely never achieve full harmony with nature, we will likely never be fully developed. We can and must however become sufficiently developed that the human domination of nature is within ecosystem limits.

Experienced inequality within Maslow's hierarchy of needs consists of 'commercial, social, cultural and ecological' (Expert Group on Ecosystem-Based Management, 2013) elements. Of these elements, 'the ecosystem aspect is "first among equals" because ecosystem failure would compromise all other values or goals' (Expert Group on Ecosystem-Based Management, 2013). It is for this reason that harmony with nature is at the heart of the well-being sustainable development model, and it is for this reason that harmony with nature forms the first tier for consideration in this framework.

Where the aim of built infrastructure is the pursuit of harmony with nature and the reduction of inequality, the role of built infrastructure must be primarily to achieve an existence within ecological limits.

Harmony with nature stems from balance, thus the 50/50 split between nature and non-nature based requirements in the well-being sandwich. The 1/2 human focus, 1/2 nature focus recognises that nature pervades every tier of Maslow's hierarchy of needs, given that nature is not only required in a physical and resource sense, but also for social and psychological well-being (Larson and Kreitzer, 2016).

Achieving harmony with nature, and thus the security to achieve well-being requires a number of steps. Firstly, society needs to recognise the true value of nature in the betterment of humanities existence. Secondly humanities focus for development must be altered to that of well-being and mechanisms put in place to achieve it. Mechanisms to achieve true sustainable development include the supporting human constructs of politics, economics, sociology, and environment in a modified form of understanding.

A required principle modification to understanding across these constructs is the necessity to prioritise basic needs over higher needs that are subject to over-gratification. The most basic needs of all are our ecological needs, those needs that are being undermined because of humanities exceedance of ecological limits.

In undermining humanities basic needs, humanity is limiting civilisation, and the pursuit of well-being. Meadows et al., (1972) identify the worldly limiting problems as the increase in: 'population, food production, industrialization, pollution, and consumption of non-renewable natural resources'.

11.3 Tier two

Sustainable development is principally the mitigation (lessening the force) of the worldly limiting problems. Practically, this involves a decrease in population, food production, industrialisation, pollution, and consumption of non-renewable natural resources. This consideration forms tier two of this framework.

As ecosystem stability is paramount for civilisation integrity, mitigating the worldly limiting problems must be a priority over tackling worldly growth problems. Meadows et al., (1972) identify the worldly growth problems as poverty, environmental degradation, institutional disenchantment, urbanisation, employment insecurity, youth alienation, and traditional values rejection.

Mitigating the worldly limiting problems will organically address the worldly growth problems. Unfortunately, because of their greater human element, today, the worldly growth problems are prioritised over and at the expense of the worldly limiting problems. This is seen in the ultimate reliance of the humancentric United Nations Agenda 2030 sustainable development goals (SDGs) (United Nations General Assembly, 2015) to direct the course of development.

Thus, in its role to achieve an existence within ecological limits, built infrastructure must progress the prioritisation of mitigating the worldly limiting problems over tackling worldly growth problems.

In this way, given built infrastructures prevalence throughout Maslow's hierarchy of needs (like harmony with nature), built infrastructure will act as a thread that draws humanity and nature back together into harmony. The directing of infrastructure development to prioritise the mitigation of the worldly limiting problems over the tackling of worldly growth problems is ultimately reliant on the modification of the human constructs of politics, economics, sociology, and environment. That being said, there already exists a system of thinking that would help built infrastructure development fulfil its role. That system of thinking is ecosystem-based management (EBM).

11.4 Tier three

Ecosystem-based management (EBM) is the management of and based on interdependent biotic and abiotic constituents contained within a limiting spatial and temporal scale.

The focus of EBM is to achieve a holistic synthesis of 'societal, economic, scientific, and governmental goals' whilst ensuring an 'interdisciplinary solution to environmental challenges' (Peine *et al.*, 2010). In other words, 'Ecosystem-based management is the comprehensive, integrated management of human

activities based on best available scientific and traditional knowledge about the ecosystem and its dynamics, in order to identify and take action on influences that are critical to the health of ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity' (Expert Group on Ecosystem-Based Management, 2013).

In relation to built infrastructure, EBM generates development (cradle to grave consideration through construction, maintenance, and decommissioning in pursuit of well-being) within the constraints of the ecosystem, I.e. within ecosystem limits. The ecosystem scale considered is reflective of the infrastructure scale(s). The infrastructure scales relate to all aspects of a piece of infrastructure and may include infrastructure service life (temporal scale) and material choice (spatial and temporal scale) etc. A pan-national road network would for example have a different spatial and temporal scale to that of a local individual building, and thus consideration of construction materials available from the pan-national and local ecosystems respectively should be considered.

The construction of infrastructure within ecosystem limits is for the purpose of sustaining ecological integrity, which as noted is paramount for human well-being and humanities ultimate survival. The five goals in support of sustaining ecological integrity (Grumbine, 1994) include:

1. Maintain viable populations of all native species in situ.
2. Represent, within protected area, all native ecosystem types across their natural range or variation.
3. Maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles, etc.).
4. Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
5. Accommodate human use and occupancy within these constraints.

Like ecosystems, individual pieces of infrastructure combine to form a network. If infrastructure is developed within local ecosystem limits, then it acts as a sustainable building block. Networking these sustainable building blocks like 'jigsaw pieces' then yields sustainable regional and national 'tiles', which together build a comprehensive holistic sustainable global 'picture'. Thus, the third tier of this framework is the undertaking of development within an EBM system of thinking. This approach aids in developing balanced tri societies, and the reversal of globalisation and consumerist mindset.

In similarity to the Vitousek et al., (1997) model, seen in Figure 7-2, built infrastructure development must be undertaken within ecosystem limits through consideration of the biotic and abiotic ecosystem components that are part of the worldly limiting problems. A positive change in these lead to a positive change in the worldly growth problems.

It is recognised however that in some instances, construction of a piece of infrastructure within the limits of ecosystem in which it is based may be difficult. Where this is the case, and an aspect of the piece of infrastructure exceeds the ecosystems limits (for example, construction requires use of a

material that is not available from within that ecosystem), then a form of economic exchange is required. The exceedance of an ecosystem limit also becomes a political issue. Holistic cradle to grave / system thinking thus spans humanity and nature through politics, economics, sociology, and environment.

Politics and economics

Regarding politics and economics, it is recognised that a modification of humanities understanding is required. This modification is to place the human constructs of politics and economics in support of achieving harmony with nature as a priority.

With regards to politics, one way to adjust humanities understanding is to extend the realms of politics to include the rights of nature, that is earth jurisprudence – 'legal provisions recognising the Rights of Nature' to 'exist, thrive and evolve' in partnership with humanity (United Nations, no date a).

Regarding economics, the true value of nature must be recognised. Nature must hold a value other than in relation to money. The United Nations Development Programme, (2019) tell us that 'going beyond income will require tackling entrenched interests – the social and political norms embedded deep within a nation's or group's history and culture'. Although the recognition of natures value has varied throughout history, todays culture does largely associate nature as something that can be offset with money. This attitude is so engrained that now even the Arctic is being utilised for the exchange of money and natural goods.

It is suggested that rather than using a hard currency such as the dollar to determine the value of a development project, a currency of biocapacity within ecosystem limits should be utilised. This is green economy in its truest sense – a 'theory that views the economy as a component of the environment in which it is based' (Halton, 2019). Such an economic system would value a construction project, its required materials and impact etc. based on a comparison of its proportional ecological footprint to the available biocapacity of the ecosystem in which it is based. A hard currency, such as the dollar, could then be limited for use within the constraints of the budgeted ecological footprint.

Lastly, valuing built infrastructure in terms of its ecological footprint would likely build robustness, particularly in the Arctic. Not only in terms of resilience against rapidly changing environmental and developmental conditions, but also in allowing effective adaptation to economic and technological changes.

11.5 Tier four

The last tier of this framework is concerned with the holistic targeting of the worldly growth problems, and those gratifying elements which furnish happiness. It is this subservient tier in the framework that focusses on the other needs (apart from harmony with nature) of human beings. It is this tier that

includes consideration of reducing human inequality (other than that generated by disharmony with nature).

A well-developed humancentric model for tackling the worldly growth problems is of course the United Nations sustainable development goals (SDGs), where the SDGs represent a mixed economic, social, and environmental consideration of the challenges faced by humanity. Subservience of the SDGs below the worldly limiting problems enables a holistic sustainable role of built infrastructure to both eradicate the threats to humanities basic needs whilst also providing for fulfilment of humanities higher needs.

Sociology and environment

Like politics and economics, it is recognised that a modification of humanities understanding of society and environment is required. In other words, there is need for cultural enlightenment. As stated by Maslow, (1943), 'it is too often not realized that culture itself is an adaptive tool, one of whose main functions is to make the physiological emergencies come less and less often'. The reduction of physiological emergencies, through increasing the security of humanities basic needs is the primary purpose of this framework, and the reason for elevation of worldly limiting problems over worldly growth problems. A change in culture, i.e. a change in the will of society is therefore required for action towards true development.

A change in culture extends to a change in humanities focus for development, and understanding of development. As the direction of development in general is subject to social understanding, then social development can bring general sustainable development, dependent on the culture of that society. Cultural change is resultant of knowledge.

It was identified within this dissertation that meaningful dialogue and utilisation of indigenous and local knowledge is key for mitigating environmental degradation. Thus, although there are significant challenges to implementing truly holistic sustainable development in the Arctic, due to limited knowledge transfer, given the recognition of required engagement, there is also a relatively larger chance of achieving it than elsewhere in the world. Away from meditated social engagement, another tool for cultural enlightenment is social activism.

Despite one of cultures main functions being to effectively mitigate worldly limiting problems, society is fickle. As Maslow, (1943) tells us, 'motivation theory is not synonymous with behavior theory'. 'While behavior is almost always motivated, it is also almost always biologically, culturally and situationally determined as well'. This means that although there may be recognition of the need to place the mitigation of worldly limiting problems above worldly growth problems, human behaviour is likely to result in the human happiness inducing worldly growth problems being put first.

In answer to this, it is concluded that holistic human advancement is expressed as both the improvement of one's self-capacity <u>and</u> one's relation to the natural world. As humanities relation to the natural world is in the disadvantaged position, concern for it must be put first.

12 Application to Svalbard coastal infrastructure

Further to the considerations made in chapter 5.5, there is one element in the port of Longyearbyen that is of particular interest. That is the current floating pontoons, serving as an effective alternative solution to traditional quay infrastructure for small to medium sized vessels. Given cooperative and environmental challenges as earlier described, the floating pontoons stemmed from the need to find a capacity solution in an alternative way to satisfy the priority need for more physical infrastructure.

Traditional methods of providing quay length are for a multitude of reasons very difficult in port Longyear. First to consider is the large size of traditional infrastructure required to provide the same quay length as that of the floating pontoons. Not only is concrete and steel faced quay infrastructure economically extravagant in Svalbard – priced at around 200,000 euro per metre of either concrete or steel quay wall (Bråten, 2020) – it is also often not physically possible. The seabed conditions in the vicinity of port Longyear are silt and sand, and thus rockfill construction is also largely prohibitive give its tendency to sink into the subsoil. If that were not enough, rocks locally have a tendency to show non-competent material properties given their susceptibility to freeze-thaw attack. There are competent sources of rock elsewhere on Svalbard that would suffice, however, should the Svalbard Environmental Act allow it, such a source is still more expensive than procuring rock from mainland Norway (Bråten, 2020)

Considering all of the above, it became increasingly efficient to develop the now existing floating pontoons. Originally developed to act as a temporary 10-year solution, the plastic pontoons have proved resilient, and have had their expected lifespan extended to 30 years. Although plastic may be a controversial choice, it does in this situation have many benefits. Firstly, the plastic pontoons deal well with sea ice. Where large ice features could cause damage to the pontoons and split the segments apart, the primary concern relates to their freezing in. In freezing, ice expands, and induces lateral stress. In close proximity to the coastline, landfast ice can in this situation can be very destructive. The advantage of plastic pontoons over for example steel pontoons is there lighter weight, and ease of construction in appropriate shapes. Together, these features cause the pontoon to lift up with freezing and avoid being crushed. Plastic pontoons are also easier to repair than steel pontoons. Further, a pontoon solution in general allows for its complete removal from Svalbard in the future (Bråten, 2020).

In considering the appropriateness of floating plastic pontoons in port Longyear, they can be tested against the established development decision making framework.

Tier zero: In regard to whether the development of floating plastic pontoons pursues well-being, the answer is likely yes. As the purpose of the pontoons is to serve an existing under resourced need, whilst seeking a better solution than is commonly available, then there is a pursuit towards well-being.

Tier one: Assessing whether the plastic pontoons seek harmony with nature is based on an extensive set of parameters. Although too extensive to consider fully here, some arguments for the pontoons achieving harmony with nature include: working with environmental conditions, such as sea ice, rather

than against them, adaptability and flexibility to facilitate future use, easy to repair, and cost effective. Arguments against the pontoons seeking harmony with nature may include the use of a material outside of its immediate environment.

Tier two: In regard to whether the use of pontoons seeks to mitigate worldly limiting problems, the answer is ambiguous. In relation to population there is not seen an increase in population that would not have otherwise been there, and there is no promotion of an increase in large vessels. The pontoons cause little noticeable positive or negative affect in relation to food production, industrialisation or pollution. The pontoons do however have a negative effect in relation to non-renewable resources. In balance, the pontoons are viable for consideration at the next tier.

Tier three: Perhaps the most obvious consideration at this tier is the material choice. Consideration of material choice within an EBM system of thinking extends to spatial and temporal scale. Materials should be considered for construction that are available from within the scale appropriate ecosystem. In the very local ecosystem, the most obvious construction material would be rock. The movement of rocks from the mountains down into the sea is a natural process, and although operated within a different timescale is acceptable within ecosystem limits, as defined by the earlier identified Grumbine, (1994) goals. Rocks within the immediate vicinity however, either for rockfill, or for concrete pontoons are not suitable. Rocks could be imported from elsewhere on Svalbard; however, they would remain in an unnatural position.

The presence of plastic as a material is also however unnatural. That being said, the plastic pontoon elements were resourced and manufactured in Troms, northern Norway, and as such the materials came from within the regional ecosystem. The largest concern regarding plastics is the change in temporal scale. Where hydrocarbons may reside for millions of years in the ground, above ground the design life of the product created from it is significantly shorter. The trade-off is that plastic pontoons could be recycled and/or repurposed. In general therefore, plastic as a material choice also fulfils the Grumbine, (1994) goals, especially for the fact that the pontoons can be entirely removed.

Tier four: Having passed the scrutiny of tiers zero to three, the plastic pontoons can be considered for their ability to address the worldly growth problems. Without exploring in detail, the pontoons are arguably neutral in their effect on environmental degradation, institutional disenchantment, urbanisation, employment insecurity, youth alienation, and traditional values rejection, etc.

In summary, for the fact that any infrastructure to increase quay capacity in the Longyearbyen situation (i.e. there is already an excessive demand) has a fairly neutral purpose, then the floating plastic pontoons result in a fairly neutral position against the framework. The pontoons are likely however a much better solution than some traditional alternatives, that would likely result in a more negative position. Needless to say, had quay capacity been developed for the express purpose of increasing traffic, then it most likely would have resulted in a negative position. Examples of infrastructure that may achieve a positive position include infrastructure to transition away from imported food to locally produced food, and infrastructure to transition away from coal-based power generation.

Section IV : Summary and future work

13 Summary of findings

13.1 The Arctic

In introducing this dissertation, the Arctic was identified as a social-ecological system. This is most certainly the case. As a social-ecological system, the Arctic can be described as a problem of inequality. Inequality is seen in the state of development between Arctic and non-Arctic regions of Arctic countries, it is seen in the rate of environmental change inside and outside of the Arctic, and it is seen between the peoples who live in the Arctic, and those who control the Arctic. These inequalities are yielding both threats and opportunities for the Arctic regions which must be appropriately considered.

In terms of built infrastructure development in the Arctic, many of the currently perceived threats and opportunities are one and the same. Arctic environmental changes are for example allowing easier access and operations to be carried out in the Artic resulting in an increased interest in its exploitation, which given fragile ecosystems and human communities is a major threat.

Inequality is the identified reason by the United Nations Development Programme, (2019) for the understanding that 'our globalised society is not working'. One of the major conclusions of this dissertation is that society is not working, in part because society focusses development on the fulfillment of worldly growth problems such as poverty, employment insecurity, and humanities higher needs that furnish happiness through self-gratification, rather than focussing on mitigation of worldly limiting problems such as increasing industrialisation and consumption of non-renewable natural resources.

Globally, the focus for development has resulted in an ecological footprint in excess of global biocapacity. In the Arctic however, given minimal development, this trend does not follow. Likewise, it is seen that the Arctic cannot be successfully described by standard global indicators, such as gross domestic product (GDP) and the human development index (HDI). The Arctic therefore features a unique existence, and as such is in a unique position to pursue a truly holistic, sustainable course of development.

Similarly, inequalities are experienced between different Artic regions, and between Arctic indigenous and non-indigenous peoples. Many of these inequalities are determined by the current shape of development and the communities historic and ongoing relationship with nature. Through this study, it is identified that a positive interaction with nature is not only necessary for human development in a physical and resource sence, it is also of great importance for social and pychological well-being. Unfortunately, nature receives little attention in regards to the latter, and other forms of social equity are pursued at the expence of physical sustainability.

Although the Arctic is unique, it is clear that this uniqueness is not being successfully utilised to enable a future sustainable existance. Part of the reason for this is a lack of knowledge in regards to how Arctic built infrastructure, and the Arctic in general should be developed. Across politics, science, and engineering, there is a lack of knowledge as to the questions that should be asked when considering pan-Arctic, national, and local infrastructre development. Other than a general lack of knowledge, a major reason for this is the lack of knowledge transfer.

13.2 Knowledge and literature

One of the largest reasons for a lack of knowledge transfer in the Arctic is the lack of literature. Literature is of large importance because it is a structured, concise, easy to interpret method of communicating ideas and requirements. Currently in the Arctic there is both a lack of regulatory literature that demands holistic sustainable development, and a lack of focus within the literature that does exist on aspects which generate holistic sustainable development.

In review of the currently available and applicable Arctic literature in general and in relation to built infrastructure there appears, with the exception of lateral scientific knowledge transfer, a need for improved knowledge transfer, partnerships, and engagement in all directions between political, scientific, and practice stakeholders across local, municipal and national boundaries. Increased knowledge transfer is particularly required from the practitioner and local / municipal levels upwards.

Within current literature, at national level there is seen to be a general focus of stability, development, and control of the Arctic. This is in difference to the international level, which has a general focus on scientific and indigenous knowledge, human well-being, sustainable development, and environmental protection.

Unfortunately, although international collaboration does have a positive effect on the direction of Arctic development, the more holistic thinking that it provides is in general not being fully transferred to national policy. This is an issue for the fact that it is largely national policy that shapes the future of the Arctic. The lack of transfer of holistic sustainable thinking is as a result of national sovereignty and the international focus on scientific collaboration. There are seen to be difficulties in articulation of scientific knowledge both up to the political level, and down to practitioners. There is also the added Arctic complexity of balancing easily processible scientific knowledge with traditional knowledge.

Regarding literature that is applicable in guiding the direction of development, in general, the bulk of it is either technically focussed literature at the practitioner level or general literature at the political level, there is little in between. In regard to literature specifically for infrastructure development, it is primarily nation based, and is guidance, targeted towards the practitioner level. There is especially little guidance to high level decision makers as how to develop infrastructure within the coastal zone, and the mechanisms to achieve it.

Across the literature reviewed, there is evidenced the need for a consistent understanding of what holistic sustainable Arctic coastal infrastructure development is. For the establishment of a common understanding it is concluded that guidance is required that serves both decision makers commissioning Arctic built infrastructure development and those engineers who have to design it. To serve all political, scientific and practitioner levels, at pan-Arctic, national and municipal / local scales then this guidance is proposed in the form of a common set of considerations (themes) to aid the generation of the questions that should be asked for the development of holistic sustainable built infrastructure, along with a development decision making framework to filter and aid implementation of the answers.

It is additionally identified that there is need for both an exemplified practical application approach to facilitate the capture of local and indigenous knowledge and learning, and a network of practical design knowledge.

13.3 Development

Development can be understood as 'the process in which someone or something grows or changes and becomes more advanced' (Cambridge University Press, 2020). The current understanding of this progression is humancentric. Based on the triple bottom line (TBL) concept, which considers social, economic, and environmental aspects, current development is undertaken for the benefit of humanity and not for a holistic sustainable existence. The TBL for example is concluded to be 5/6ths human focussed, and 1/6th nature focussed, and targeted towards human betterment. This of course is important, but not at the expense of the planets ability to fundamentally support human existence.

Despite an attempt to consider all of humanity on an equal level, through for example the United Nations sustainable development goals (SDGs), currently, the world is regarded as either developed or developing. Development is thus seen to be the movement of a developing country towards that of a developed one, even if the level of existence of developed countries is unsustainable. The primary focus of development is the reduction of inequality, particularly poverty. Once again however, the current consideration of poverty, past basic needs such as food and shelter, is humancentric and not rooted in humanities ongoing need for nature.

Rather than seeking an overall state of well-being, humanity has, since the first industrial revolution, been pursuing an alternative path of self-gratification, reliant on natural resources and fueled by a consumerist idiology. Despite this, built infrastructure plays a major role in the development of well-being. Given that built infrastructure is so closely tied to humans standard of living, it can have a huge role in aiding an escape from multidimensional poverty. Muldimentional poverty however includes elements defined by humanities relationship with nature, and thus there must also be recognition of the close ties between infrastructure and nature.

Development in general can be portrayed as the movement up Maslow's hierarchy of needs – A motivational theory concerned with human progression through a series of prepotent needs, based on

the fulfilment of underlying supporting needs. This idea is demonstrated in a pyramid or triangular form. Unfortunately, this perfect form does not exist. Whilst the global south has largely just achieved the lower tiers of Maslow's hierarchy of needs, the global north is exceeding the capacity of the upper tiers. This capacity exceedance is self-gratification, and is resulting in the transgression of natural limits and biodiversity loss, which ultimatly is undermining humanities very existance.

The shape of Arctic development is rather more complicated and is seen to exhibit an hourglass manifestation of Maslow's hierarchy of needs – a relatively broader base and top, and relatively narrower middle. This has led to both real and perceived inequalities. This hourglass shape is fragile, and sensitive to change. Where built infrastructure development could bring substantial benefits to Arctic resilience, it could also bring devastation. With an increasing interest of infrastructure development in the Arctic, the need for appropriate holistic sustainable thought as to how the Arctic should be developed is critical. Guidance is required to induce this thought.

The current major developments in the Arctic are for the benefit of the wider Arctic nations in service of global demand. In addressing the global demand to tackle the worldly growth problems above the worldly limiting problems, commencing built infrastructure in the Arctic is facilitating the global progression towards an ultimately unsustainable future. An alternative focus for built infrastructure development is required. One system of thinking that would aid in this is ecosystem-based management (EBM).

In considering the future of Arctic development, it is easy to conclude that it must be sustainable development. Therefore, in addition to understanding the current position of development, there must also be an understanding of sustainability.

13.4 Sustainability

In comparison to development, the concept of sustainability is relatively simple. Whereas development considers the variability of human requirements, perhaps in relation to nature, sustainability is simply 'the quality of being able to continue over a period of time' (Cambridge University Press, 2020). Fundamentally, to be sustainable, humanity must ensure its ability to survive. As mentioned, nature pervades every level of human development, and thus sustainability is harmony with nature. As nature is both relied upon for human fulfilment and for the fact that nature can undermine our progression, harmony with nature is at the heart of human well-being, where well-being is the value that must be achieved to attain a truly sustainable existence on our shared planet.

Regarding infrastructure, if a piece of infrastructure is developed within local ecosystem limits, then it can act as a sustainable building block. Networking these sustainable building blocks like 'jigsaw pieces' then yields sustainable regional and national 'tiles', which together build a comprehensive holistic sustainable global 'picture'. The development of a piece of sustainable infrastructure may for example include consideration of green economy, blue-green infrastructure and indigenous practices.

13.5 Sustainable development

In review of the developing concept of sustainable development it is seen that historically there have been, and currently there are many different definitions of sustainable development. Given that sustainable development considers the sustainability of the various abstract components of development, variability in understanding is to be expected. Sustainable development means different things in different contexts and different industries.

Apart from problems caused by an insufficient definition specifically created for an industry, problems arise from using a definition in a situation other than that for which the definition was created. Arguably the most common understanding of sustainable development in use today is that of the World Commission on Environment and Development, (1987) report, 'Our Common Future', which states: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. As concluded herein, this definition, although being used for consideration of built infrastructure development is fundamentally for human development rather than harmony with nature.

This is evidenced across both national and international literature in their general humancentric focus, despite international literature being fairly holistic in its considerations. The consideration of sustainable development is essentially the same as that of development, which as it is based on the TBL is ultimately unsustainable. The current understanding of sustainable development is that conservation of the natural planet is for the long-term benefit of humanity as an exploitive resource for material satisfaction.

For the fact that there is a need to enact a pursuit of harmony with nature, and for the understanding that human behaviour is not the same as human motivation, sustainable development includes also the human constructs of politics, economics, sociology and environment. In drawing these together, a new understanding of holistic sustainable development is created in a 'well-being sandwich sustainable development model'.

Holistic sustainable development can thus be defined as the pursuit of well-being through the pursuit of harmony with nature and the reduction of inequality.

Realistically, in the Arctic this means:

- Policy and subsequently built infrastructure must in the Arctic be directed to avoid (and globally reverse) the factors identified as limiting civilisation (worldly limiting problems).
- Sustainable development of built infrastructure, in order to achieve a sustainable built environment, must consider spatial and temporal implementation scale and confinement within the constraints of ecological integrity.
- Sustainable development is development that results in progression towards a sustainable human existence.

- Sustainable development is the pursuit of a closer connection to our gratified needs – e.g. source of food etc.
- Sustainable development is the drastic reduction of the global per capita ecological footprint.
- Sustainable human development is synonymous with sustainable nature.
- There is a need for recognition of the true value of nature, to alter humanities focus for development, and to implement mechanisms to prescribe and recognise the value of harmony with nature.
- Built infrastructure development must be undertaken within ecosystem limits through consideration of the biotic and abiotic ecosystem components that are part of the worldly limiting problems.

13.6 Holism

Holism has been considered throughout this study and culminates in development of the holistic well-being sandwich sustainable development model. This model provides for holistic consideration of infrastructure at multiple levels, through cradle to grave / system thinking, pieces of infrastructure forming part of wider networks, and through inclusion of political, economic, sociological, and environmental elements.

It is identified that holistic consideration of built infrastructure is twofold:

1. Consideration of sustainable development of a piece or system of infrastructure.
2. Consideration of the role of built infrastructure in sustainable development.

It is recognised that there is currently a lack of holistic thinking in the Arctic resultant of a lack of consensus across political, scientific and practitioner literature on the approach to development. Holism is thus based on knowledge sharing and transfer.

13.7 Infrastructure

There is little insightful consideration of infrastructure within national and international literature. However, where consideration is given it aligns well with the general focus of the literature. For example, in national policy, infrastructure is referenced in relation to facilitating national priorities, thus built infrastructure is seen as a tool to address human concerns rather than developing the link between humanity and nature. There is a definite need for clarity at national and pan-Arctic levels as to the role of infrastructure in the Arctic.

Nature pervades every level of human development, and the built environment is a principle regulator in the counter pervasion of humanity into nature. Built infrastructure is thus also an influential component in achieving harmony with nature – the balance required to achieve a sustainable future.

Built infrastructure therefore plays a significant role in both achieving harmony with nature, and in reducing inequalities. In the Arctic, and elsewhere, the primary aim of built infrastructure development should thus be the pursuit of well-being. Under this aim, the role of built infrastructure must be to achieve an existence within ecological limits, and as such must progress the prioritisation of mitigating the worldly limiting problems over tackling worldly growth problems. In this way, built infrastructure shall both eradicate the threats to humanities basic needs whilst also providing for fulfillment of humanities higher needs. In the Arctic, time is of the essence to prioritise a focus of well-being to avoid a worsening development situation. The contribution of built infrastructure to establishing harmony with nature may be achieved though ecosystem-based management.

Specifically in the Arctic, built infrastructure requires a focus of adaptation. Adaptation is required both to the direction of infrastructure development, and physical adaptation of infrastructure to counter ongoing environmental and societal changes in the Arctic. Adaptation is ultimately required to build resilience. Resilience is required at both local, national and pan-Arctic level, and as such there is also a pressing need for a high level pan-Arctic approach to its implementation.

Although sustainable development is the ongoing pursuit of well-being, in reality humanity will likely never be fully developed, for our inability to achieve full harmony with nature. We can (and must) however become sufficiently developed that the human domination of nature is within ecosystem limits. The building of resilient Arctic infrastructure is strongly linked to the valuing of the infrastructure in terms of its ecological footprint. Developing built infrastructure within ecosystem limits, through for example ecosystem-based management (EBM), and valuing infrastructure in terms of biocapacity would build resilience against both rapidly changing environmental and developmental conditions, whilst also allowing for effective adaptation to economic and technological changes.

The directing of infrastructure development to achieve the above is ultimately reliant on the modification of the human constructs of politics, economics, sociology, and environment. As a powerful component of human development, built infrastructure must hold a dominant position in these constructs, and must be a priority for politics, science and practice across the local / municipal, national and pan-Arctic levels.

13.8 The coastal zone

Despite the coastal zone being a particularly sensitive component of the Arctic social-ecological system, across both national and international literature it is given very little consideration. This is likely for the fact that there is no common understanding of what the coastal zone is. This is of particular concern given the rise of development reliant on this zone. This includes for example shipping, tourism, and extractive industries.

Part of the reason for the lack of clarity surrounding the Arctic coastal zone is the lack of literature (policy, regulation, standards etc.) on both the changes and developments occurring there. There is thus

a particular need for guidance, as may be found in the conclusions of this dissertation, to aid decision makers in asking the correct questions for holistic sustainable development of coastal Arctic built infrastructure.

Of particular concern in the Arctic coastal zone are indigenous peoples'. With their direct reliance on the marine and terrestrial resources contained in the coastal zone, there is an increased requirement for balanced attention and funding for the preservation and development of traditional and scientific knowledge.

13.9 Final themes and framework

In response to the identified need for increased guidance for decision makers surrounding the questions that should be asked for development of holistic sustainable Arctic coastal built infrastructure, this dissertation concluded with the generation of a common set of considerations. These considerations are organised into themes to aid decision makers at the political, scientific and practitioner, and pan-Arctic, national, and municipal / local levels in making the correct development choices, in particular within the fragile Arctic.

The need for such a common set of questions is resultant of the lack of knowledge, and in particular literature in the Arctic to guide those in decision making positions on how Arctic built infrastructure should be constructed to facilitate a sustainable future. It also stems from the lack of understanding of the importance of built infrastructure to Arctic well-being. Specific to the current Arctic there is expected an increase in built infrastructure development in relation to activities such as shipping, mining, and tourism, which if not considered holistically could result in wholly unsustainable development.

Further to a common set of considerations, it was identified that there was need for an implementation and monitoring framework to guide and focus the asking of the generated questions. In recognition that built infrastructure is inextricably linked to both humanity and nature throughout the Arctic, the framework aids in providing a common approach to development. A common approach to development, at a high level, was identified during consideration of Arctic literature to be beneficial in generating cooperation and holistic thinking across geopolitical boundaries, which in turn was recognised as generating holistic development policy in its own right. Holism was also positively correlated with the level of general development and the degree of power devolution, which would be made easier with all parties considering infrastructure development from within a common framework. The framework itself is in a tiered form, with the top tier preceding the following tiers in the order of consideration.

Tier zero: The pursuit of well-being is identified as being the true form of sustainable development, and the well-being sandwich sustainable development model prescribed for consideration.

Tier one: The first tier posits that harmony with nature is at the core of well-being, and thus harmony with nature is the first precondition.

Tier two: The second tier introduces the pursuit of well-being as the mitigation of the worldly limiting problems.

Tier three: The third tier identifies the need to undertake development within an ecosystem-based management (EBM) system of thinking.

Tier four: The fourth tier considers the final subservience of the worldly growth problems, which can be addressed though existing models such as the United Nations sustainable development goals (SDGs).

In final conclusion to the research question, holistic sustainable Arctic coastal infrastructure is infrastructure in the coastal zone that pursues well-being through seeking harmony with nature and the reduction of inequality. Such infrastructure can in the future be developed through the assessment of appropriate questions within the well-being sandwich model as based on the common set of considerations.

14 Further work

The scope of the subject dealt with in this dissertation is very large. In reality, given its abstract nature the subject is inexhaustible, and may in other hands have been interpreted differently. To that end, it is recognised that the assessment undertaken herein is limited to a high-level perspective and would benefit from further detailed consideration. Further beneficial work would extend to the following.

- Further identification and review of national and international literature of pertinence to Arctic development. In particular, the study would benefit from increased consideration of municipal and local level literature such as regulation and acts, and further consideration of national standards.
- The undertaking of a study to assess the successes and failures of development attempts within small island developing states (SIDS) to aid in determining development limits and pathways of applicability to the Arctic.
- Further refinement and reduction of the common set of considerations to allow easier formation of scale specific questions.
- Development of a set of common general questions that should be asked for the pan-Arctic political, scientific and practitioner levels. Outside of a national context it would not be appropriate to formulate questions for the national level and below.
- Further detailed expansion of the outlined development decision making framework.
- Facilitation of an accessible network of case studies exemplifying practical approaches to local and indigenous engagement and partnership for infrastructure development.
- Development of a network of practical design knowledge ranging in scale from the consideration of unique solutions to simple engineering problems through larger infrastructure systems.

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