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A systematic overview of the barriers to building climate adaptation of cultural and natural heritage sites in polar regions

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ABSTRACT

This paper systematically reviews publications for the period 2002–2020 addressing the barriers to climate adaptation of cultural and natural heritage in the Northern and Southern poles. Climate change and its socio-economic implications deteriorate different forms of cultural and natural heritage, including archaeological sites, historic buildings, and indigenous heritage in the polar regions. Climate adaptation of cultural and natural heritage of polar regions is challenged due to the barriers, constraints, and limitations of various factors such as lack of awareness of polar heritage, remoteness of the sites, and lack of tools and facilities. This paper first presents the general characteristics of 76 documents out of 218. It then analyzes the barriers derived from the content analysis of the publications. Despite growing interest in polar studies, incomplete and inaccurate data and inventories and facilities and tools as technological constraints negatively affect building climate adaptation of polar heritage. Following that, existing regulations and organizations are found to be ineffective and slow to address the issues of communication and collaboration for building climate adaptation of polar heritage. The findings will discuss the policy implications of understanding barriers and tackling them to facilitate the climate adaptation of polar heritage.

1. Introduction

This article systematically reviews publications for the period of 2002–2020 that address the barriers to climate adaptation of cultural and natural heritage in the Northern and Southern polar regions. Arctic and Antarctic share a rich legacy of the history of humankind and nature. While the Antarctic stands isolated, the Arctic and its unique heritage have been exposed to the hazards from global industrial, administrative, and technological developments in the polar regions (Rey, 1987). Both polar regions are exposed to the threats of melting permafrost, loss of icebergs, climate change, seismic risks, and pollution. The remoteness, wilderness, and uniqueness have not prevented the exploration and exploitation of the North and South Poles.

Climate change is altering the cultural and natural landscapes of the polar regions (Arctic and Antarctic) combined with anthropogenic influences such as oil and gas explorations and developments. Thawing permafrost, induced by global warming, triggers changes in ice sheets and glaciers (Barber et al., 2008; Wunderling et al., 2020), snow cover (Royer et al., 2021), floods (Sakai et al., 2016), erosion (Bodansky and Hunt, 2020), sea-level rise (Post et al., 2019), and carbon release to the atmosphere (Bruhwiler et al., 2021). Tourism (Shijin et al., 2020), mining activities (Tolvanen et al., 2018), shipping (Hussain et al., 2021), and land developments further accelerated the speed of the impacts of climate change. As a result, these rapid changes adversely affect the socio-economic activities of locals over biodiversity (Djoghlaf, 2008), the vegetation (Raj et al., 2020; Singh et al., 2018), food (Bogdanova et al., 2021), and traditions. First and foremost, "the common heritage" of both polar regions has been vanishing under the direct and indirect impacts of climate change (Barr, 2008).

Polar regions are characterized by cultural (archaeological sites, objects, former industrial sites, historic mining sites, timber buildings), natural (marine biodiversity, mountains, glaciers), and intangible heritage (hunting activities, fishing, indigenous languages, bio-cultural heritage, spiritual practices) (Barr, 2019). The material and immaterial heritage of polar regions is significant as it creates avenues for socio-economic incomes for local populations and promotes the protection of heritage assets. The cross-cultural heritage in the area also enhances an understanding of diversity. However, polar heritage is being eradicated because of abandonment, loss of traditions and settlements, extinction of indigenous languages, crop failures, and

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over-tourism (G. Aktürk, 2022).

In the adaptation to climate change and its associated risks, there have been significant steps taken in both policy and practice in various sectors. Adaptation to climate change requires “adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate”(Adger, 2007). Considering the anticipated risks of climate change in the fragile polar regions (Weller, 1998), there is an urgent and immediate need for attention to climate adaptation of heritage assets (Carroll and Aarrevaara, 2021; Riesto et al., 2021) in the polar regions (Barr, 2008) before they are irreversibly lost.

There are various barriers, constraints, and limitations of various factors in the way to building climate adaptation (Adger, 2007). A large number of studies have identified and categorized the main barriers as four different types in the existing literature, including (1) institutional, (2) social and cognitive, (3) uncertainty, (4) and cost and resources (Waters et al., 2014). The most common barriers known as economic, technological, and natural barriers are more recognized by scholars than the least mentioned barriers such as social, cognitive, or institutional barriers (Chenani et al., 2021). The majority of studies that theorise the role of barriers in climate adaptation are derived from the literature and they often fail to exemplify it in practice (Waters et al., 2014). Therefore, these categories and typologies of barriers are not backed up by the stakeholders’ experiences in climate adaptation (Waters et al., 2014). However, in practice, there is a discrepancy between the barriers that come from stakeholders’ experiences and the barriers recorded in the literature. Nevertheless, studies focusing on the small case studies can inform policy-makers on individual barriers (Biesbroek et al., 2013).

The commonly reported barriers derived from the literature (Eisenack et al., 2014) have been adapted and extended in the context of cultural heritage sites (Daly, 2011; Fatoric and Seekamp, 2017a; Orr et al., 2021; Reimann et al., 2018; Sabbioni et al., 2008; Sesana et al., 2019). However, the body of literature on the identification of barriers to climate adaptation of cultural heritage is still relatively small (Orr et al., 2021), especially in the polar regions (Barr, 2017; Barr, 2008; Hall et al., 2016; Harmsen et al., 2018b). Most importantly, there has been a great deal of research focusing on the systematic literature review of the climate change adaptation in the Arctic and Antarctic (Canosa et al., 2020; Ford et al., 2014). Limited knowledge of climate change risks is recognized as a barrier in the Arctic along with the socio-economic and institutional and governmental barriers, especially in Russia where political leadership on climate adaptation is missing (Canosa et al., 2020). Additionally, regulatory and infrastructural barriers seem to cause climate adaptation efforts to remain in their infancy in the context of the Arctic (Ford et al., 2014). Meanwhile, logistics and infrastructure have been the common barrier in both Northern and Southern polar regions (Convey and Peck, 2019; Ford et al., 2014). Despite continuing increase in the investigations of barriers to climate adaptation, a small number of studies have reviewed the effects of climate change on cultural heritage in polar regions (Fenger-Nielsen et al., 2020; Hall et al., 2016).

The focus of climate adaptation of cultural heritage in the polar regions as in European-focused studies has been on the tangible heritage assets. However, the indigenous bio-cultural heritage, languages, and knowledge have been undermined not only in heritage preservation but also in climate adaptation efforts (Aktürk and Lerski, 2021; Canosa et al., 2020).

The systematic literature review on this theme explicitly focuses on the Arctic and Antarctic regions due to their own site-specific challenges. While the preservation of polar heritage has recently been receiving attention from scholars, it has been mostly included as part of comparative studies. Although scholars systematically reviewed the barriers to climate change adaptation (Adger, 2007; Measham et al., 2011) and also of heritage (Casey and Becker, 2019; Fatorić and Biesbroek, 2020; Fatoric and Seekamp, 2017b; Sesana et al., 2018), there is still a major gap to fill in the context of polar regions. Therefore, this paper provides an analysis of the main barriers to building climate adaptation of polar heritage by using content analysis. The findings will fill in the gap in the systematic understanding of barriers to climate adaptation of cultural and natural heritage sites (Aktürk and Dastgerdi, 2021) and therefore serve as evidence in the use of policy-making (Collins et al., 2019).

The results reveal that there are some convergences and differences in certain types of barriers that are being identified in the literature. In climate adaptation policy, some barriers such as funding are considered to be more significant for relevant stakeholders (Waters et al., 2014) than the results of the analysis of the barriers in the literature. The frequency of different barriers and their interconnection can inform policy-makers on the priorities for integrating cultural and natural heritage resources of polar regions into climate adaptation efforts.

Having established an overview of the literature on barriers, the paper first identifies the characteristics of the selected publications in the existing literature based on a clearly formulated questionnaire of four questions: (1) what is the number of the publications and those with funding acknowledgements by year, (2) what is the name of the publication source, (3) what is the geographical location of the selected publications, and (4) what are the types of cultural and natural heritage assets mentioned in the selected publications? It then asks the main research question: (5) what are the main barriers, constraints, and limitations in building climate adaptation in cultural and natural heritage sites in polar regions? The first four questions provide the identification of characteristics of the extent and nature of the existing literature, while the last question focuses on the question of what the main barriers, obstacles, and constraints are in building climate adaptation of cultural and natural heritage assets in the polar regions. Lastly, it discusses the interrelationships and convergences of these barriers and the policy implications of these results.

2. Materials and Methods

A systematic literature review is undertaken to identify and critically analyze the barriers, constraints, challenges, and limits in building climate adaptation of cultural and natural heritage in polar sites. A systematic literature review is conducted to identify, analyze, categorize, and synthesize the findings of studies of a relevant specific research question to test a hypothesis or develop new theories (Xiao and Watson, 2017). This analysis reveals evidence of the pitfalls, weaknesses, inconsistencies, and contradictions to guide policy-making (Xiao and Watson, 2017). This method has been widely used in the identification of the key barriers to reduce, tackle, and avoid them (Eisenack et al., 2014).

2.1. Literature Selection

The publications on polar heritage under the changing climate, that were published between 2002 and 2020 were analyzed by using the content analysis. Content analysis is a qualitative research tool to analyze the content of the text by identifying consistent notions, patterns, and relationships (Hsieh and Shannon, 2005). The three steps used in the content analysis are (1) coding, (2) categorizing, and (3) development of themes.

The key terms included a combination of the keywords: (("climat* chang*" OR "glob* warm*") AND "heritag* " AND ("Arctic" OR "Subarctic" OR "Antarctic" OR "Polar" OR "Circumpolar" OR "Alaska" OR "Denmark" OR "Greenland" OR "Iceland" OR "Norway" OR "Sweden" OR "Finland" OR "Scandinavia" OR "Russia" OR "Northwest Territories"))" to select the most relevant publications by purposive sampling. The researcher interprets the data based on his or her own judgment in this technique (Ames, Glenton, and Lewin, 2019). The keywords used in this review were selected based on the number of publications yielded from the search. In order to obtain enough literature, the selected geographical locations were expanded to include the southern pole. These keywords were searched using the internationally recognized electronic scientific database Web of Science Core Collection and Scopus in June 2021.

The search query initially retained a total number of 218 documents with the retrieval of 97 publications from the Web of Science and 121 from Scopus. During the screening phase, 69 papers were eliminated due to the duplicates from the initial review of these two databases. It yielded a preliminary list of 149 relevant publications, which were downloaded and screened according to eligibility criteria.

The inclusion criteria for these 149 publications consisted of documents which are written in English with a strong emphasis on cultural and natural heritage under changing climate. Among them, 30 documents were identified under the first exclusion criteria on the document type, including commentaries, abstracts, books, book chapters, perspectives, early access articles, and editorial materials. Furthermore, 7 publications, which were written in foreign languages, were removed. Due to the exclusion of non-English publications, some local evidence may be omitted in the analysis. For the scope of this review, 36 publications, which do not mention cultural/natural heritage and/or climate change and do not focus on the stated geographical regions, were also filtered out. The process of selection of publications for this systematic literature review is explained in Fig. 1.

A limitation of this study is that it does not include publications in foreign languages due to translation issues and limitations. It also excludes grey literature, white papers, and policy documents. As a result, a list of 76 publications (62 journal articles and 14 conference proceedings) was included in the final analysis as explained in Fig. 1. All citations including their titles, authors, and abstracts were imported into the Endnote X8 reference management software to manage bibliographies and references used in this systematic literature review.

2.2. Analyzing the literature

Data from 65 publications were first entered into the Microsoft Excel Spreadsheet to identify the general characteristics of the documents. After reviewing the full text of selected publications, content analysis is performed to identify the main barriers. The steps of content analysis involve (1) coding, (2) categorizing, and (3) generating themes (Erlingsson and Brysiewicz, 2017). The search of keywords such as "barriers," "challenges," "concern," "constraints," "limits," "lack," "need," "must," and "should" were used in the initial analysis (Gül Aktürk and Dastgerdi, 2021). The main barriers were categorized as regulations and organizations, educational, technical, behavioral, and financial generated from the literature (Aktürk and Dastgerdi, 2021; Fatorić and Biesbroek, 2020; Fatoric and Seekamp, 2017b). Following that, publications were examined both qualitatively by interpreting the content and quantitatively by giving the number (n) and percentages (%).

Another limitation is that this study only focuses on scientific publications excluding policy documents, white papers, magazines, newsletters, and working papers. A meta-analysis of the included publications was not carried out due to the heterogeneity of various topics and disciplines covered in this study.

2.3. General characteristics of the literature

There has been a growing body of research on the cultural and natural heritage in the polar regions under changing climates with various publications over the past eighteen years (Fig. 2). Interest in Arctic and Antarctic heritage under the effects of climate change did not grow until a decade ago. The number of publications fluctuates between 2002 and 2009. Between 2010 and 2012, the number of publications remains low with half of them acknowledging a funding body behind the studies. The number of studies without any support from funding resources has been the lowest in 2006, 2009, and 2013. Aligned with the number of publications, there has been a sharp linear rise in the number of funding sources between 2014 and 2018. Yet, the amount of research funding

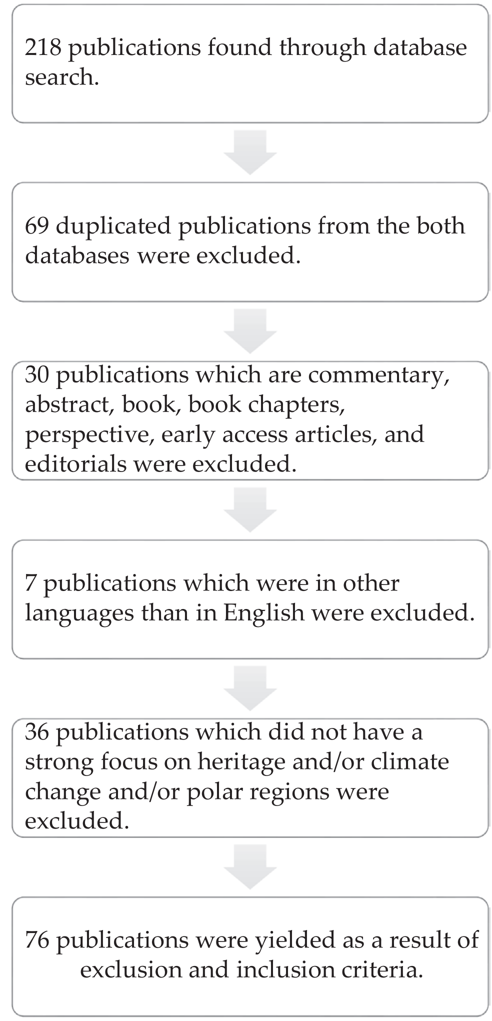

Fig. 1. The flow diagram of the selection process of publications includes the eligibility criteria of the systematic literature review.

received and acknowledged in mobilising academic interest has been inadequate to support the noticeable attention gained for the understudied polar regions in this period. 2020 is the year when most publications emerged in this field of research. The sharp rise in obtained funding sources reveals the reason behind the motivation of the studies. Despite the growth in the number of publications to 19, the number of funding has not reached beyond 15 in 2020. The progress made in the allocation of funds in polar studies is a promising sign in the light of future studies.

Evidence on funding acknowledgements in the reviewed publications reveals that there is a variety of acknowledged funding sources which partially support the publications. As this analysis implies, the funding policies of the EU commission i.e. Northern Periphery and Arctic Programme, 2014–, 2020 might have become the driving source behind these publications. One example of these funded projects "Adapt Northern Heritage" aims to develop an online tool to assess the vulnerabilities of heritage assets in nine case studies (Northern Periphery and Arctic Programme, 2014–, 2020).

The distribution of the number of a wide range of publication sources represents the heightened interest in polar regions and states, as observed in Table 1. The theme and geographical location concern various disciplines. The publication sources frequently appear are Geosciences and IOP Conf. Series: Earth and Environmental Science (n = 3, 4%). Moreover, the next recurrent publications which give geographical indication are Polar Record, Etudes Inuit Studies, Arctic

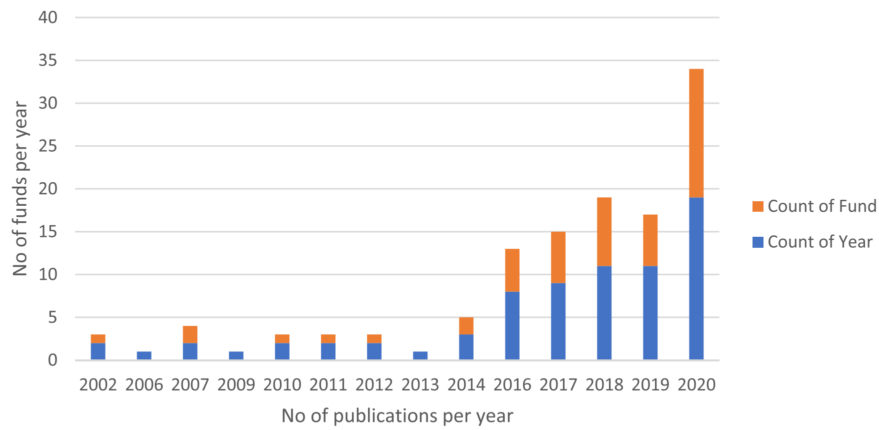

Fig. 2. The number of publications and fundings per year of the reviewed literature.

Institute of America, and Journal of Coastal Conservation (n = 2, 3%) in addition to Conservation and Management of Archaeological Sites and Archaeometry. The reviewed publications include different temporalities (past and present/future) of the effects of climate change on cultural and natural heritage. However, only five publications analyze past climate change (n = 5, 7%) in which the findings of some publications refer to future climate adaptation efforts such as community-based projects.

The publications from the polar regions include multiple cases from different Arctic states and the countries closely related to the Arctic, whereas some others include non-Arctic countries as a part of comparative analysis (Table 2) (E. Sesana et al., 2018). The highest number of studies were documented in Norway (n = 23, 26%) and following that, Russia, including Siberia (n = 12, 13%) was mentioned the most. Next most investigated were Antarctic (n = 9, 10%), Canada (n = 8, 9%), and Greenland (n = 7, 8%). USA and Sweden were equally investigated cases (n = 4, 4%). The studies identified in this period were Denmark (n = 3, 3%) with the least number recorded in Belarus, Finland, Curonian spit, Iceland, Kazakhstan, China, Mongolia, Republic of Karelia, and Northwest territory (n = 1, 1%). Overall, publications focus on the Arctic more than on the Antarctic.

Please note that some publications referred to multiple case studies. In some cases, polar regions were mentioned with other parts of the world as comparative studies. These countries outside the two polar regions are not included in the table. Also, conceptual analyses regarding Arctic regions are not included as they do not refer to specific cases.

In coding the categories of polar heritage sites in the reviewed publications, it is important to understand the concept of heritage is often problematic. As new concepts are introduced in heritage studies such as cultural landscapes and biocultural heritage, the identification and categorization of them became more difficult over the years. While this paper does not aim to discuss the terminologies in-depth, the concept of cultural landscapes is conceptualized as the interaction between cultural and natural heritage, represented in Fig. 3. Reviewed publications often refer to national parks as cultural landscapes. Biocultural Heritage (BCH) refers to the indigenous knowledge and practices and their biological sources (International Institute for Environment and Development) and as an integral part of their cultural landscapes, it is included in the subcategories of cultural landscapes.

The remaining ten publications refer to polar heritage broadly as cultural heritage and/ or natural heritage resources. The studies which mention these concepts broadly or in passing or give a brief explanation are not included in the analysis of the categories of polar heritage assets. According to the analysis in Fig. 4, tangible (n = 46,70 %) in combination with intangible heritage (n = 7,11 %) is overwhelmingly emphasized in comparison to other forms of heritage assets, including natural heritage (n = 8,12 %) and cultural landscapes (n = 5,8%).

Archaeological heritage sites (n = 24,36 %) by far are the most studied heritage asset in the polar regions (Fig. 4). Following, historic buildings (n = 13,20 %) such as timber structures (Haugen et al., 2018) are the second most reported heritage asset. As natural heritage assets, lakes, rivers and the water ecosystem surrounding them (n = 5,8%) are the next common heritage resources reported in the reviewed publications. National parks, language, and historical centers are represented equally in these studies (n = 4,6 %). Furthermore, regarding the tendencies towards indigenous knowledge systems and biodiversity around 5 % of the publications point out the narrowness of the two subcategories. Considering 4 million residing in the North Pole (National Snow and Ice Data Center, 2020) and the population ranging from 4000 in summer to 1000 in winter living in the South Pole (World Population Review. Antarctica Population, 2022), it is highly significant to recognize and study the vulnerabilities of the underrepresented indigenous communities along with their biocultural heritage. Similarly, the challenges of polar monuments (n = 1,2 %) are yet to be discovered under changing climate change and the preservation of them requires the cross-collaboration of nations (Barr, 2000). The movable heritage assets such as museum collections and artworks are other least reported subcategories (n = 1,2 %).

2.4. Barriers, limits, and constraints

In the context of the polar regions, there is a wide range of constraints, challenges, and barriers that hinder planning for climate adaptation of cultural and natural heritage. In the literature review, most of the publications (n = 50, 76%) acknowledged and analyzed a range of challenges to adaptation and preserving polar heritage. Initially, these barriers were coded as “policy” and “practice” (Aktürk and Dastgerdi, 2021; Fatorić and Biesbroek, 2020). Then, axial coding is used to identify the five major barriers (i) technical, (ii) regulations and organizations, (iii) educational, (iv) financial, and (v) behavioral barriers. These themes were accompanied by eighteen subthemes (see Table 3) and each is explained with their implications in detail below.

3. Results

Most of the publications mention barriers (n = 60, 79 %) by referring to more than one. The findings reveal that the most mentioned theme is technical barriers (n = 67, 54 %). Regulations and organizations (n = 29, 19 %), educational (n = 22, 16 %), financial barriers (n = 9, 7 %), and behavioral barriers (n = 4, 4 %) are reported most often after technical barriers (Fig. 5).

The analysis of the barriers per heritage category uncovered that all the barriers clustered around the archaeological sites with the highest number of times mentioned except behavioral barriers. This category of heritage asset is followed by historical buildings on each barrier. As has

Table 1
The titles, numbers, and percentages of the publication sources.

The Titles of Publication Sources	Number	Percentages
Geosciences	3	4%
IOP Conf. Series: Earth and Environmental Science	3	4%
Conservation and Management of Archaeological Sites	2	3%
Archaeometry	2	3%
Polar Record	2	3%
Journal of Coastal Conservation	2	3%
Arctic Institute of North America	2	3%
Etudes Inuit Studies	2	3%
Oceanologia	1	1%
Journal of Contemporary Water Research & Education	1	1%
Wood Material Science & Engineering	1	1%
Journal of Heritage Tourism	1	1%
Proceedings of the National Academy of Sciences	1	1%
Environmental Research Letters	1	1%
Antiquity	1	1%
Archaeological Dialogues	1	1%
New Zealand Geographical Society Inc.	1	1%
Sustainability	1	1%
Ocean & Coastal Management	1	1%
Energy Strategy Reviews	1	1%
Quaternary International	1	1%
Journal of computer applications in archaeology	1	1%
Estuaries And Coasts	1	1%
Open Archaeology	1	1%
Quaternary Science Reviews	1	1%
Climate Services	1	1%
Climate	1	1%
International Journal of Building Pathology and Adaptation	1	1%
Arctic Anthropology	1	1%
Society of Ethnobiology	1	1%
National Recreation and Park Association	1	1%
Third Text	1	1%
Climate Risk Management	1	1%
International Journal of Climate Change Strategies and Management	1	1%
Journal of Rural Studies	1	1%
Public Library of Science	1	1%
Alternative-An International Journal of Indigenous People	1	1%
World Archaeology	1	1%
Hydrological Processes	1	1%
Remote Sensing	1	1%
Water	1	1%
Landscape Research	1	1%
Australian Journal of International Affairs	1	1%
Nature	1	1%
Advances In Archaeological Practice	1	1%
Marine Policy	1	1%
Cambridge University Press	1	1%
Ecological Management & Restoration	1	1%
The Anthropocene Review	1	1%
European Countryside	1	1%
Energy and Buildings	1	1%
Arctic	1	1%
12th Nordic Building Physics Conference NSB 2020	1	1%
Transdisciplinary Multispectral Modeling and Cooperation for the Preservation of Cultural Heritage	1	1%
Integr Environ Assess Manag	1	1%
International Multidisciplinary Scientific Geoconference	1	1%
IOP Conference Series: Materials Science and Engineering	1	1%
Proceedings of the 8th International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation	1	1%
Systematics and Biodiversity	1	1%
Hydrology Research	1	1%
Regional Environmental Chang	1	1%
Aquatic Ecosystem Health & Management	1	1%
Journal of Architectural Conservation	1	1%

Table 2
The geographical focus of the selected publications grouped by country.

Location	Publication number	Percentages
Canada	8	9 %
Norway	23	26 %
Greenland	7	8 %
USA	4	4 %
Antarctic	9	10 %
Sweden	4	4 %
Denmark	3	3 %
Russia	12	13 %
Belarus	1	1 %
Finland	1	1 %
Curonian spit	1	1 %
Iceland	1	1 %
Kazakhstan	1	1 %
China	1	1 %
Mongolia	1	1 %
Republic of Karelia	1	1 %
Northwest territory	1	1 %
Total	89	100 %

been illustrated in Fig. 6, technical barriers and regulations and organizations appear in the majority of heritage assets. The least common barrier seen is behavioral which is a cluster around archaeological sites, historical centers, buildings, and biocultural heritage. Only museum collections were not correlated with any barriers as the publication has not referred to any barriers.

3.1. Technical barriers

The analysis demonstrated that more than half of the identified barriers are technical barriers (n = 67, 54 %). Technical barriers include (1) data and inventories, (2) facilities and tools, (3) accessibility and infrastructure, (4) risk assessments, (5) monitoring and evaluating, (6) staff and expertise, (7) documentation, and (8) scales.

With 64 mentions, *data and inventories* (n = 15, 11 %) was the most mentioned determinant of the technical barriers. The barrier of *data and inventories* refers the inaccurate, lacking, or missing data and inventories. For instance, limited data on permafrost has hindered an attempt to develop a coastal vulnerability index for Alaska (Jensen, 2020). The lack of comprehensive stability analysis is also highlighted for the Antarctic Ice Sheet in the context of changing global temperatures (Garbe, Albrecht, Levermann, Donges, and Winkelmann, 2020).

There is a need for more detailed and high-quality data (Haugen et al., 2018) on maritime heritage resources (B. W. Barr, 2017) in comparative monitoring studies (Walker et al., 2016) as a majority of these records remain uninvestigated, particularly in Alaska (Hillerdal, Knecht, and Jones, 2019). The need for complete inventories (Fenger-Nielsen et al., 2020) for the mapping and inventory of archaeological sites (Bourgeois et al., 2007) and the built environment is emphasized at the local level (Ronkko and Aarrevaara, 2017). Research in environmental art requires both qualitative and quantitative methods as these two disciplines are complementary (Michałowska, 2020).

In the case of the Herschel island in Yukon territory in Canada, the use of high-quality data is required in the analysis of coastal hazards in the context of obtaining vertical aerial photographs (Radosavljevic et al., 2016). In freshwater ecosystems such as in a World Heritage Site, the South Nahanni River Basin in Canada, the lack of water chemistry data and baseline information on biota limit the understanding of the ecosystems and the occurrence of the new species (Bowman, Spencer, Dubé, and West, 2010). A combination of cultural, environmental and economic concerns should be embedded within seasonal activities for high-quality data capture, especially in the preservation of

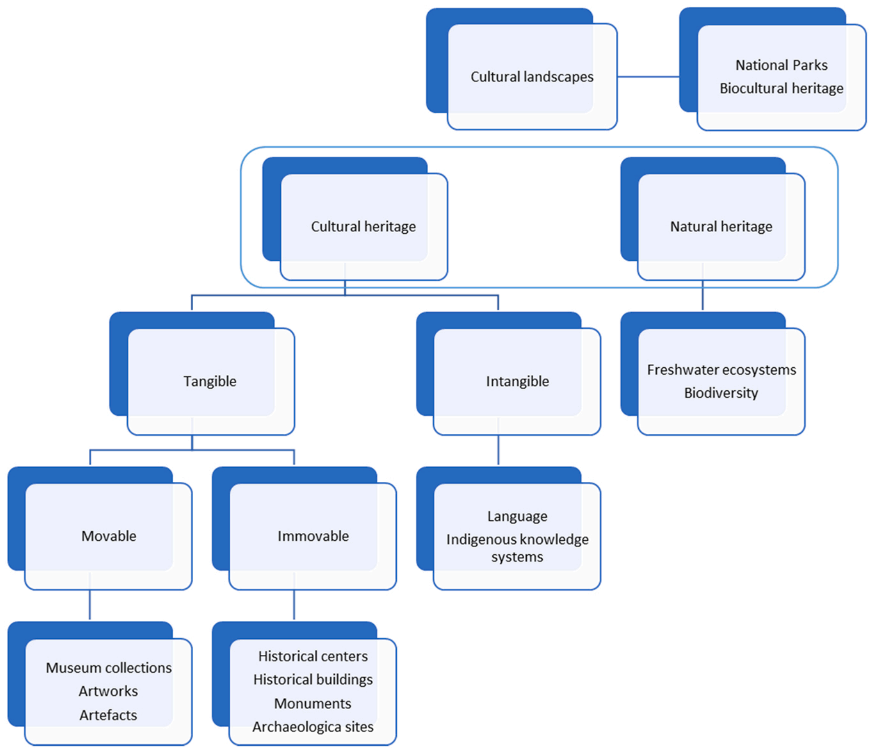

Fig. 3. Note that sometimes the concept is used as colonial heritage and agricultural and cultural heritage without discussing in more detail how it is defined. Only the terms that are specifically referring to a certain category are included in the analysis.
The types of polar heritage assets mentioned in the reviewed publications fall under the categories adapted from UNESCO (Petti, Trillo, and Makore, 2020).

archaeological assets in West Greenland (Harmsen et al., 2018a). However, in the use of remote sensing technologies, the quality of early surveys is questioned due to low and unsuitable spatial resolution (Carmen et al., 2020).

Strong concerns were raised regarding the determinant of *facilities and tools* (n = 13, 10 %), which refers to the lack of methodologies, technologies, instrumentations, and tools (Kaspersen and Halsnæs, 2017) used in climate adaptation of cultural heritage (Sesana et al., 2018). There is a requirement for comparable approaches in survey methods and samplings (Cannone, Convey, and Malfasi, 2018). Given its effectiveness, remote sensing is widely used as a tool to identify and monitor Arctic vegetation (Walker et al., 2016). Similarly in Siberia, classic archaeological methods were found to be inefficient in studying prehistoric stone objects hence causing the loss of heritage (Marsadolov, Paranina, Grigoryev, and Sukhorukov, 2019).

Inadequate samplings (Rebecca et al., 2018), inaccurate climate change projections, and models (Roburn, 2012) were raised as a technological concerns. In fieldwork, limited facilities may pose challenges in the processing and analysis of the data (Knecht and Jones, 2020). Managing archaeological sites under the risk of decay requires more attention to developing methods for mitigation (Hollesen et al., 2018). These limitations in tools and methods along with other barriers, such as costs, can cause difficulties in conducting integrated geophysical surveys (Carmen et al., 2020).

Accessibility and infrastructure (n = 11, 8%) is a major constraint in the Arctic and Antarctic contexts due to their remoteness and harsh environmental conditions. The influence of a challenging environment is quoted in building the connections between cultural heritage narratives and environmental concerns (Powell et al., 2016). The remoteness of polar heritage sites limits the opportunities for visitor experiences (Dawson and Levy, 2016). Specifically, access and logistics become a challenge in archaeological sites in the High Arctic (Walls et al., 2020). Even the sites that are easier to reach, it is difficult to move staff and collections (Jensen, 2020). Especially, touristic infrastructure needs to be improved in order to allow access to the archaeological sites (Grigoryev et al., 2020).

Along with harsh climate in high altitudes, limited infrastructure can interfere with the disaster emergency response (Kontar et al., 2018). In addition, it is expensive to access data and in remote areas data is used in the management of vegetation and analysis of vegetation change at various scales in the Arctic (Walker et al., 2016). Geographical limitations are a barrier to a multistressor approach to the understanding of the vulnerability of Arctic ecosystems and landscapes (Kittel et al., 2011).

Risk assessments (n = 9, 7 %) have been an important determinant in the identification of the climate change risks on cultural heritage sites to prepare for climate action (Aktürk and Hauser, 2021). The assessment and management of archaeological sites should consider a set of various challenges derived from atmospheric, coastal, and biochemical phenomena (Harmsen et al., 2018a). Most importantly, there are inadequate assessments of sites including the parameters for erosion, permafrost thaw, vegetation increase, and human access (Hollesen et al., 2018). This overshadows the understanding of the extension of the damage on the sites. In the case of biodiversity in Antarctica, a lack of overall assessment of the region is found to be particularly urgent (Cannone et al., 2018).

It is challenging to differentiate "normal" deterioration that results from extreme weather events (Austigard and Mattsson, 2019). The lack of consideration given to the climate risk, vulnerability assessments, and water management plans is a barrier to building climate adaptation (Scott et al., 2020). In this aspect, inadequate risk assessment in combination with a lack of emergency training in the Arctic may hinder the process of disaster response (Kontar et al., 2018).

Monitoring and evaluating (n = 7, 5%) is reported relatively low, although it is critical for long-term planning of climate adaptation of cultural and natural heritage. There is little known about the current state of heritage sites in the polar regions; therefore, there is an increasing emphasis on the need to monitor the impacts of climate

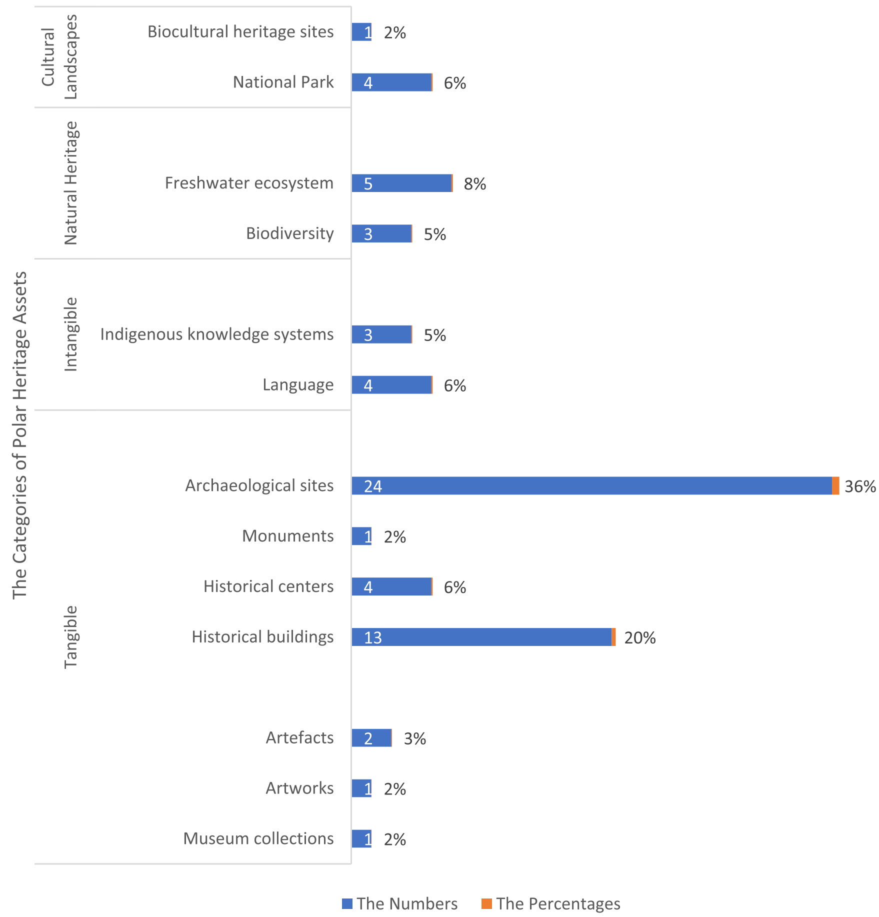

Fig. 4. The types of polar heritage assets mentioned in the reviewed publications are given with the number and percentages. 66 publications out of 76 refer to a certain type of heritage asset.

change on cultural heritage sites (Hollesen et al., 2018). Existing studies on the investigation of the degradation of archaeological sites are insufficient, for example in the case of the surrounding Kuibyshev reservoir (Nicu et al., 2019). The ArcGIS analysis revealed that 85% of the cultural heritage around the site is exposed to the increasing water levels, erosion from water, water level oscillations, and the mechanical action of waves (Nicu et al., 2019). Further investigation is needed in order to better understand the destruction of the excavation sites and archaeological remains (Boethius et al., 2020). Budget constraints go hand in hand with the development of tools for monitoring and investigating Arctic heritage sites and assessment of the level of threat to them (Hodgetts and Eastaugh, 2017). Often, a lack of monitoring, especially of changes in land use, cause the loss of archaeological remnants as artefacts (Marsadolov et al., 2019). For the sustainable management of cultural heritage, there is an urgent need for continued monitoring of coastal sites (Nicu et al., 2020).

Few publications have examined the determinant of *staff and expertise* (n = 5, 4 %). Lack of specific expertise together with the limited amount of staff and funding can impede the preservation of archaeological sites, which are at the risk of disappearing due to climate change (Barr, 2017). Recognizing the need for scientific expertise (Cannone et al., 2018) and experts, particularly archaeologists in the case of Arctic heritage sites (Hollesen et al., 2018), is a step towards future action. The unavailability of the tools, funds, logistics support, and trained personnel could interfere with the implementation of integrated geophysical surveys (Carmen et al., 2020). There is a need for the support of academic partners with the necessary tools and expertise to conduct research and project (Hillerdal et al., 2019).

Documentation (n = 5, 4 %) is crucial for the preservation of cultural heritage sites and yet it is not considered as a major determinant of technical barriers. Northern communities are struggling to document at-risk sites (Hodgetts and Eastaugh, 2017). Documentation should consider the site's significance in addition to the degree that which it is affected by climate change (Hodgetts and Eastaugh, 2017). Equally, the lack of a prior systematic survey of the archaeological site in the High Arctic challenges the conservation efforts (Walls et al., 2020). Lack of well-documentation proved to cause the loss of significant cultural heritage buildings due to misunderstanding of the cause of the damage by rot fungi (Flyen et al., 2020).

Scales (n = 2, 2%) is the least mentioned obstacle among technical barriers. Scale differences in climate change and cultural heritage studies are often disregarded. Building climate adaptation of cultural heritage sites requires efforts at smaller scales (Haugen and Mattsson, 2011). The scale issue appeared not only in buildings and sites but also in surrounding landscapes. There is a need for information on vegetation and its change at all scales to better understand and manage it (Walker et al., 2016). As is observed in Fig. 5, the most common investigated scale is at local and building levels, whereas landscape scale adaptation efforts are relatively low.

3.2. Regulations and Organizations

Organizational barriers (n = 22,%16) are the second most common theme. They consist of (1) communication and collaboration, (2) prioritization, (3) policy and regulations, and (4) management and practices.

Many authors mention *communication and collaboration* (n = 11,%8) as one of the discrepancies in regulatory and organizational barriers.

Table 3
The themes and sub-themes of the barriers are explained with exemplary quotations.

Themes of the Barriers	Sub-themes of the Barriers	Exemplary References
Technical	Documentation of heritage	"Very few of these sites have been investigated and we know little about their current state of preservation" (Hollesen et al., 2018).
	Prioritization	"It may be necessary for the cultural heritage management to choose between sites" (Vandrup Martens, Bergersen, Vorenhout, Utigard Sandvik, and Hollesen, 2016).
	Facilities and tools	"The need to accurately locate and delimit such sites is therefore imperative both from a research and management point of view" (Rebecca, Lars, Monica, & Erich, 2018).
	Access and infrastructure	"Archaeological work in the High Arctic involves unique challenges in terms of access and logistics" (Walls et al., 2020).
	Monitoring and evaluating	"However, a more thorough process of monitoring and evaluating the present state of cultural heritage is needed" (Nicu, Usmanov, Gainullin, and Galimova, 2019).
	Risk assessments	"It is challenging but crucial to distinguish "normal" deterioration of building materials from deterioration caused by climate changes" (Austigard and Mattsson, 2019).
	Data and inventories	"For the purpose of inventory, accurate maps are needed to locate all archaeological structures precisely" (Bourgeois, De Wulf, Goossens, and Gheyle, 2007).
	Scales	"Since possibilities to reduce exposure due to climate change are generally lacking at wider scales, it will often be necessary to improve the climatic shelter of the cultural heritage at smaller site scales" (Haugen and Mattsson, 2011).
	Staff and expertise	"Low-resolution and over-interpreted data, as well as a lack of trained personnel, has also played a role" (Carmen et al., 2020).
Regulations and Organizations	Policy and regulations	"There may be competing interests pursuing these opportunities, and political pressure to streamline review processes to ensure economic opportunities are not lost as a result of satisfying regulatory requirements" (Barr, 2017).
	Prioritization	"In addition, sites can be protected by law though in reality very few are" (Milner, 2012).
	Management and practice	"National parties involved in the survey and study of cultural sites in the South Shetlands (Chile, Argentina, Britain and the USA in particular) should be encouraged to continue that work, and provide feedback to improve guidance for the informed visits by tourist and national parties, and to improve management planning for APSAs" (Pearson, Stehberg, Zarankín, Senatore, and Gatica, 2010).
	Communication and collaboration	"In this phase, a close communication with the institution that is managing the historic buildings is needed" (Haugen et al., 2018).
Educational	Awareness of polar heritage	"We hope that the modelling aspect of the project will help to generate interest in the preservation of archaeological heritage in Greenland, and throughout the Arctic, while also raising awareness of the pressing need to preserve that archaeological heritage before it is lost" (Walsh et al., 2020).
	Knowledge of the climate change effects	"However, in the Selenga River delta and many other deltas of the world, there is a lack of knowledge regarding impacts of potential shifts in the flow regime (e.g., due to climate change and other anthropogenic impacts) on sedimentation processes, including sediment exchanges between deltaic channels and adjacent wetlands" (Pietroń et al., 2018).
Financial	Funds	"Aside from finances, logistics are a challenge in the Arctic" (Jensen, 2020).
Behavioral	Changing narratives	"This interplay between old narratives and the need to, at least partially, revise them or shift to new ones may be a common challenge for many cities worldwide" (Scott et al., 2020).
	Psychology	"Where we recognize the significant cognitive and psychological barriers that limit climate change risk awareness and impede behavioural choices that facilitate adaptation, mitigation, and environmental sustainability (see Gifford 2011)" (Britton and Hillerdal, 2019).

Note that some of the barriers were mentioned more than once.

More communication and collaboration are needed between research and management (Vandrup Martens et al., 2016) and the diverse institutions that are responsible for historic building management (Haugen et al., 2018).

Effective communication and collaboration also mean the inclusion of public opinion in the decision-making progress to achieve sustainable livelihoods in northern communities (Kaltenborn et al., 2017). Through mutual work, tribal nations, researchers, and educators can overcome these barriers (Fillmore et al., 2018). A bottom-up approach is encouraged to pave the way for collaborative projects between indigenous and local communities and archaeologists (Hillerdal et al., 2019). Public access to governmental and academic reports, workshops, and other findings is found to be limited, particularly in the case of Tr'ondëk Hwëch of Yukon Territory (Roburn, 2012). The documentation and digitization of traditional knowledge of climate change often face challenges due to the limited facilities of Tr'ondëk Hwëch Heritage Department and the long process of transcription of narratives and following steps such as receiving consent from elders some of whom have passed away or moved to another community (Roburn, 2012). The completion of these archives with the support from the government and project partners of the "Documenting Traditional Knowledge in Relation to Climate Change" can allow access to the local environmental knowledge of the past to tackle the present issues (Roburn, 2012).

One of the challenges is found to be the networking process, which refers to an agreement, involvement, and collaboration among different stakeholders (Vistad et al., 2016). To give an example, inadequate flood risk governance and management is a result of a lack of communication and trust between relevant stakeholders (Kontar et al., 2018). Participatory approaches and alliances are encouraged between businesses, governments, and civil society in response to the needs of rural localities (Ronkko and Aarrevaara, 2017). Although tools such as mapping can be efficient in risk assessments, city planners and building owners should be brought together to develop guidelines (Venvik et al., 2019). The dissemination of scientific research outcomes by the managers of cultural heritage is important in climate adaptation of cultural heritage (Sesana et al., 2019).

Prioritization (n = 8,%6) is one of the determinants of regulatory and organizational barriers. It refers to the selection of some heritage sites over others. In the Arctic and Antarctic context, many heritage sites remain legally unprotected (Milner, 2012).

The management of archaeological sites under environmental challenges as stated in several charters failed in practice mainly due to differences in designations and protections of sites (Harmsen et al., 2018a). As the degree of degradation of the site differs greatly, there is a need to identify and rank vulnerable sites to help focus the use of resources on these prioritized sites (Fenger-Nielsen et al., 2020; Hollesen et al., 2018). Considering the lack of documentation and monitoring of the threatened sites, it may be necessary for heritage managers to prioritize certain sites

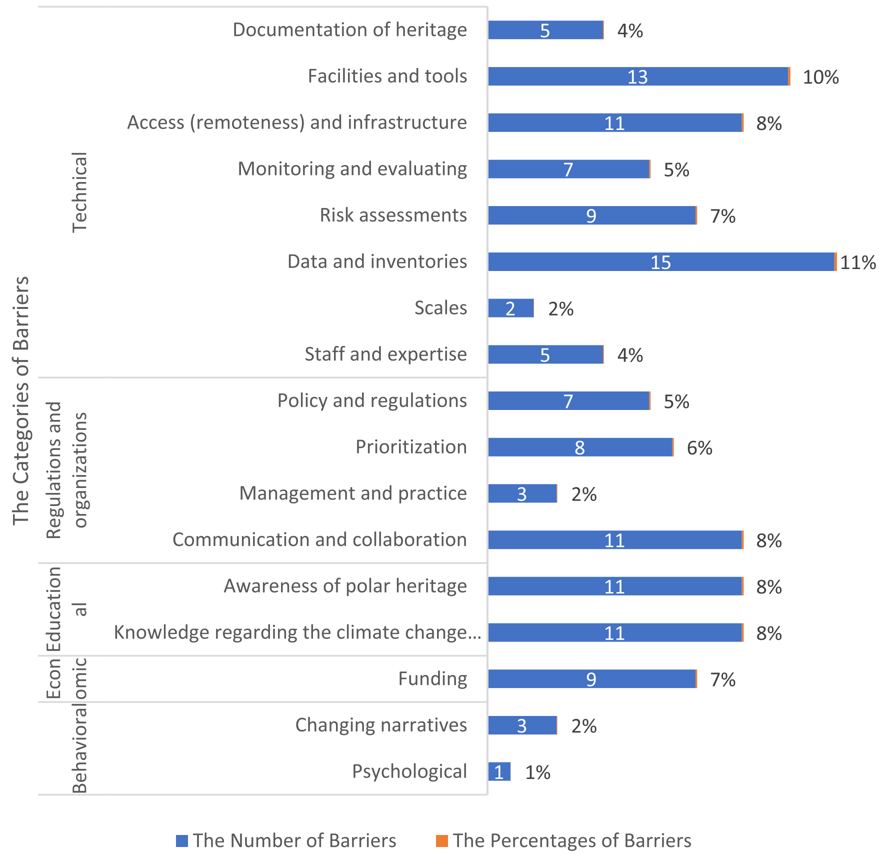

Fig. 5. The number and percentages of each barrier per category. The total amount of times that the barriers are counted among selected publications is 131.

(Hodgetts and Eastaugh, 2017; Vandrup Martens et al., 2016). As part of conservation practices, prioritizing the archaeological artifacts is important due to limited facilities and analysis (Knecht and Jones, 2020). Similarly, in the renovation of historic houses, cultural values must be considered along with economic profit (Abdul Hamid et al., 2020).

Policy and regulation (n = 7,%5) includes the failures, deficiencies, inconsistencies, late and/or inadequate enforcements in taking protective actions (Barr, 2017; Ronkko and Aarrevaara, 2017). The lack of legislation and regulations was found to be a constraining factor in climate change mitigation of cultural heritage and the adoption of energy efficient solutions (Sesana et al., 2019). In accordance with energy policies, renovation of historic buildings, especially those which have poor insulation, should be included in designing future policies (Legnér and Femenias, 2020).

In the context of flood risks, absence of flood risk governance, policies, and measures lead to inability to reduce impacts (Kontar et al., 2018). The root of the problem lies in the regulations on the management of heritage sites by regulating tourism in Antarctica (Bray, 2016). However, in the Canadian Arctic, the policy enforcements are needed in giving permission cruise tourism to unlock socio-cultural and economic developments (Dawson et al., 2017). Arctic Ocean in terms of protection of biodiversity can benefit from a clearer understanding of both biophysical and socioeconomic systems in policy processes (Berkman,

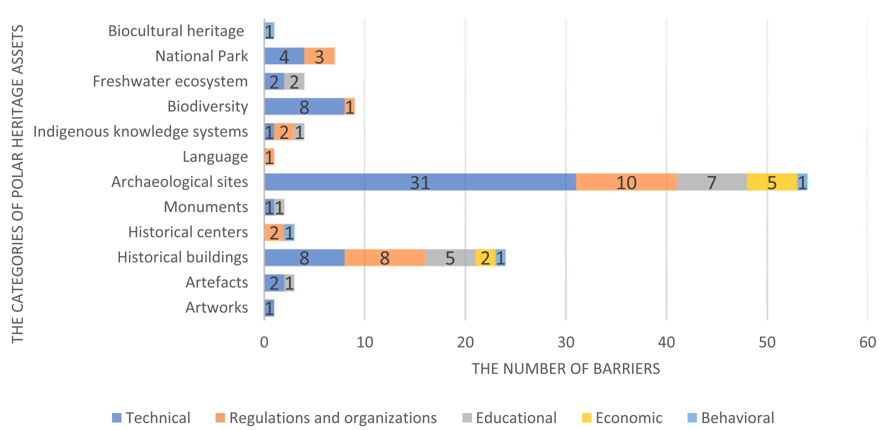

Fig. 6. The number of barriers mentioned per category of heritage. The total amount of 51 publications presents both heritage categorization and the barriers.

2010). The conflicts between the interests in heritage preservation versus development appeared to favor the latter even in times of climate change.

In a few instances, *management and practices* (n = 3,%2) is mentioned as a barrier to the climate adaptation of cultural heritage sites. National parties of the Antarctic Special Protected Areas (ASPAs) should provide feedback for the improvement of the management plans of these sites (Pearson et al., 2010). Lack of maintenance and incorrect indoor climate management may lead to the biodeterioration of built heritage (Austigard and Mattsson, 2019). In relation to dune management, the activities of forestation, husbandry, and grazing should be included as part of the plans for the conservation of coastal dunes (Armaitiene et al., 2007). It is suggested that the hydrological field investigations along with risk assessments are needed to come up with the best management practices in historic city centers such as Bergen in Norway where flooding and subsidence cause issues (Venvik et al., 2019).

3.3. Educational barriers

Educational barriers (n = 22,%16) emerge relatively as important as organizational barriers. These barriers comprise the two following determinants: (1) Awareness of polar heritage and (2) knowledge regarding the effects of climate change.

Awareness of polar heritage (n = 11,%8) is relevant in understanding and appreciating polar heritage to address the societal challenges of climate change. Strong concerns are raised by interviewees of limited understanding of the values, integrity, and authenticity of tangible and intangible heritage assets in building climate change adaptation (Sesana et al., 2018). Prehistoric stone objects and structures, though important touristic resources, are largely understudied and are therefore less likely to be protected (Grigoryev et al., 2020).

The research community showed little attention to the discovery of archaeological sites in the Russian Arctic (Hollesen et al., 2018). This suggests the need for awareness programs, including training about the site's presence, significance, value, and protection by national parties to reach a wider audience (Pearson et al., 2010). As physical visits are limited, modelling of archaeological sites in Greenland (Walsh et al., 2020) and virtual exhibits can convey the message of significance for polar heritage throughout Arctic and Antarctic regions (Dawson and Levy, 2016). With the eroding of sites and artifacts, younger members of indigenous communities learn less about their cultural heritage sites, traditions, and preservation of them (Hillerdal et al., 2019; Knecht and Jones, 2020). In the context of the renovation of historic buildings, the knowledge transfer for the use of modern materials and techniques is needed that is compatible with the traditional behaviors of these buildings to mitigate climate change in the built heritage sector (Sesana et al., 2019).

Another significant determinant of educational barriers is *knowledge regarding climate change effects* (n = 11,%8). Given environmental uncertainty, there is a need for integrated knowledge of changing climatic conditions and deterioration processes (Fenger-Nielsen et al., 2020). For instance, the lack of understanding of deterioration caused by a fungal attack on wooden constructions is the largest knowledge gap in cultural heritage management in the case of Svalbard (Flyen et al., 2020). Sometimes, these projections remain inaccurate or limited (Roburn, 2012). The experience and knowledge about the indicators of climate change effects are limited, as well as the consequences of it on sites (Haugen and Mattsson, 2011). Increasing awareness should be ensured in the multifaceted conflicts over environmental management (Kaltenborn et al., 2017; Kittel et al., 2011). The role of new knowledge and skills is emphasized for the preservation of cultural heritage to tackle climate change (Sesana et al., 2018).

In line with climate-induced risks, disaster response in the Arctic requires emergency training (Kontar et al., 2018). The lack of knowledge is stated in flow regimes of The Selenga River delta in southern Siberia due to climate change or anthropogenic influences on sedimentation processes (Pietroń et al., 2018). The sedimentation patterns and processes and contaminants in deltaic storage are important in understanding hydroclimatic change (Pietroń et al., 2018). Similarly, the characteristics of the soil and hydrology of a given site should be considered along with its vegetation in the assessment of climate change effects (Hollesen, Matthiesen, and Elberling, 2017). The establishment of the difference between biodeterioration causes can be challenging (Austigard and Mattsson, 2019).

3.4. Financial barriers

Financial barriers (n = 9,%7) are the second to the least common barrier. *Funding* (n = 9,%7) appears to be the only determinant in this main theme. It reflects economic constraints (Novikau, 2019), which constrain climate adaptation efforts of cultural heritage (Sesana et al., 2018).

The inverse proportion between high conservation costs and limited government funds makes it difficult to support preservation projects in the polar regions (Dawson and Levy, 2016). The agencies which carry out these projects are often underfunded (Carmen et al., 2020) and understaffed (Barr, 2017).

Economic factors are perceived as an important barrier to mitigating climate change considering the expensive cost of restoration, especially when retrofitting historic buildings (Sesana et al., 2019). The estimated service life of a historic building relies on parameters such as the allocated budget (Loli et al., 2020). Difficulties arise from obtaining sufficient funding to conduct projects on a tight deadline (Jensen, 2020). Incentives are needed for the enforcement of collaborative projects between archaeologists, communities, and indigenous people for safeguarding archaeological sites that are vanishing (Hillerdal et al., 2019).

3.5. Behavioral barriers

Behavioral barriers (n = 4,%4) have not been as influential as other barriers to climate adaptation of polar heritage. These barriers are categorized as changing narratives and psychology.

Changing narratives (n = 3,%2) has gained little acceptance in reviewed publications despite its widespread recognition in indigenous studies. It refers to the changing narratives, stories, tales, and experiences of individuals and communities facing the impacts of climate change (Aktürk, 2020; Aktürk and Fluck, 2022). Specifically, the interpretation of historic sites requires the construction of cultural heritage narratives and environmental concerns due to the harsh environment of Antarctica (Powell et al., 2016). However, the construction of cultural heritage narratives is sometimes impeded by language barriers. To give an example, the circle dance of *ohuokhai* which is practiced by Sakha, Turkic speaking people in northeastern Siberia in Russia, is threatened by a steadily declining language in industrialization, globalization, and climate change in the future (Susan, 2019). The weakening of communication can be also seen among the young and elder generations (Aktürk, 2020) of indigenous communities in the transmission of hunting and gathering practices (Reo et al., 2019).

The old traditions of surface water management are shifting with the future predictions of climate change. The existing way of managing water systems should change by taking future climate risks into account (Scott et al., 2020).

Psychology (n = 1,%1) has gained little attention in the reviewed publications. Dislocated from their lands, indigenous people are distanced from their lands, cultural practices, and heritage. The psychological barrier refers to this distance, which limits climate change action, mitigation, and adaptation (Britton and Hillerdal, 2019).

4. Conclusion and policy implications

The barriers to climate adaptation are rarely examined particularly in the context of cultural and natural heritage resources in the polar regions. This article detected and analyzed the main barriers to building climate adaptation of cultural and natural heritage sites in the polar regions by conducting a systematic literature review.

The various contributions from all disciplines are invaluable in polar studies and their publication should be encouraged. Polar heritage does not only concern cultural heritage, including archaeological sites, but also natural heritage, such as water resources and national parks as well as intangible heritage such as indigenous languages and cultural landscapes. Despite growing interest in these regions in recent years, studies on climate adaptation of polar heritage are insufficient considering the particular vulnerabilities the poles have to climate change.

The majority of these studies are published in journals with specific geographical interests. While some studies are focused on developed countries, studies on developing countries are not represented outside of their national boundaries, in the international arena. For the transparency and global propagation of their results, it is recommended for studies to reach a wider community.

Through content analysis, key barriers were identified and analyzed including technical, regulations and organizations, educational, financial, and behavioral barriers. Among all barriers, technical barriers (n = 67, 54 %) are the most encountered constraint while the mentioning of regulations and organizations (n = 29, 19 %) consist of less than half of technical barriers. *Data and inventories* (n = 15, 11 %) is noted as the greatest barrier technical barrier among all barriers. Among these given barriers, *psychology* as a behavioral barrier is the least noticeable barrier, as it was only mentioned in one publication.

These barriers are often interconnected and influence each other. To give an example, *data and inventories* (n = 15, 11 %) cannot be isolated from *facilities and tools* (n = 13, 10%) as they refer to the technologies to implement them. This is why they occur together as key technological constraints. The third common technological barrier is *access and infrastructure* (n = 11, 8 %) is found to have similar weight in the number and frequency with the subcategories of educational barriers, including *awareness of polar heritage* and *knowledge regarding the effects of climate change* and regulations and organizations, including *communication and collaboration*. In "The International Co-Sponsored Meeting on Culture, Heritage, and Climate Change" (ICSM CHC), the experts advised that the translation of the theory of indigenous knowledge systems into scientific research is as crucial and scientific research to complement them (ICOMOS: Culture Heritage and Climate Change, 2021). Better communication and collaboration are the key, particularly in the polar regions between academics, indigenous communities, and government officials.

The next common barrier of regulations and organizations (n = 29, 19%), which is slightly more reported than educational barriers (n = 22, 16 %), highlights the emphasis on the need for better *communication and collaboration* (n = 11, 8 %). The regulatory process can take time to catch the technological advancements and innovations in the scientific community, which is why regulatory agencies should be informed by these developments through the dissemination of scientific research findings.

Prioritization of polar heritage sites relies on the understanding of their cultural and historical significance. Thus, it is significant to interpret the interconnection between these challenges to overcome barriers and enable climate adaptation of polar heritage. Prioritization may be the most conflicting component of the barriers due to the cross-national heritage assets of various indigenous communities in the Arctic and the protection of artefacts, structures, and biodiversity in the Antarctic. Putting indigenous knowledge systems at the forefront of adaptation strategies, issues in whose languages, biocultural heritage, and traditional knowledge need to be protected are likely to arise in times of climate migration in the future. Hence, the allocated funding for polar heritage protection should be carefully used by involving indigenous communities in decision making.

Although *funding* is significant in enabling project owners and participants to access data and inventories, facilities and tools, and other technological services, it is not consistently reported. This may be due to the fact that some of these publications are a part of broader work, which have been funded.

The level at which barriers were discussed across the Arctic and Antarctic explore mostly countries located in the Northern polar. The dominance of Arctic studies over polar regions acknowledge the imbalance between the two polar regions. Although there has been no indigenous communities in Antarctic, the continent has been hosting heritage assets, including temporary settlements, huts, abandoned military bases, and whale oil production plants. Under a Heritage List established by the Antarctic Treaty, there is a list of ninety two monuments and sites, scattered throughout the different parts of the continent. The conservation of these sites are relying on the initiatives such as the Antarctic Heritage Trusts and ICOMOS International Polar Heritage Committee. In conclusion, the representation of polar regions is expected to rise in the future policies concerning climate change adaptation of cultural and natural heritage.

Author Agreement Statement

I the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. I confirm that the manuscript has been read and approved by the author and that there are no other persons who satisfied the criteria for authorship but are not listed. I understand that the Corresponding Author is the sole contact for the Editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. Signed by the author as follows: Gül Aktürk.

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