Urban Planning
2024 • Volume 9 • Article 8349
https://doi.org/10.17645/up.8349

cogitatio

ARTICLE

Open Access Journal

Urban Sustainability in Arctic Cities: Challenges and Opportunities of Implementing the Sustainable Development Goals

Ava Soroudi, Agatino Rizzo, and Jing Ma

Department of Civil, Environmental and Natural Resources, Luleå University of Technology, Sweden

Correspondence: Ava Soroudi (ava.soroudi@ltu.se)

Submitted: 8 March 2024 **Accepted:** 2 July 2024 **Published:** 16 August 2024

Issue: This article is part of the issue "Planning and Managing Climate and Energy Transitions in Ordinary Cities" edited by Agatino Rizzo (Luleå University of Technology), Aileen Aseron Espiritu (UiT The Arctic University of Norway), Jing Ma (Luleå University of Technology), Jannes Willems (University of Amsterdam), and Daan Bossuyt (Utrecht University), fully open access at https://doi.org/10.17645/up.i346

Abstract

Arctic cities are at the forefront of climate change, experiencing distinctive obstacles in their endeavors to pursue green transitions and attain sustainability objectives. These cities are marked by high energy consumption, primarily driven by activities related to resource extraction and the demanding climate. Moreover, they rely heavily on natural resources for growth, have limited infrastructure, and experience significant external and internal remoteness. This article presents a comprehensive analysis of urban sustainability in Arctic cities, focusing on key themes, trends, and challenges. Through a systematic review of extant literature, this study examines current research on urban sustainability in the Arctic and identifies crucial gaps, delineating a path to sustainability. Using VOSviewer software, six thematic clusters were identified: climate change and environmental adaptation, SDGs and smart urban planning, sustainable development and urban governance, sustainable economic development, social sustainability, and green energy transition. These clusters provide valuable insights into the dominant themes and evolving discourse in Arctic sustainability research. The findings show that the literature focuses predominantly on Russian Arctic cities, signaling an imperative for a more inclusive strategy encompassing a broader spectrum of Arctic cities. Additionally, sustainability is inherently site-specific and necessitates a nuanced understanding that incorporates different stakeholders' perspectives and considers particular regional traits to create a more effective and meaningful approach to measuring and achieving sustainability in Arctic cities. This article contributes to the ongoing discourse on sustainability in Arctic cities by advocating for a comprehensive framework that accommodates unique challenges and opportunities of Arctic urban environments.

Keywords

Arctic cities; green transition; SDGs; sustainable development; urban sustainability

1. Introduction

Climate change is altering the way policymakers and planners intervene in urban areas. The Paris Agreement and the Sustainable Development Goals (SDGs) have established a set of indicators and targets that promise to transform our cities, making them more sustainable and adaptable to climate events. One area of the globe most affected by climate change is the Arctic (Chapman et al., 2018). According to various scenarios (Swedish Meteorological and Hydrological Institute, 2024), the Arctic is experiencing consistent temperature anomalies, increased precipitation, and melting ice, which are already impacting urban infrastructures built in the previous century. Arctic sustainability has become a growing concern both within the region and among stakeholders worldwide, given the ongoing transformation and development occurring in the polar region (Petrov et al., 2016; Rizzo & Sordi, 2020). Monitoring sustainability, which involves analyzing data on environmental, social, and economic factors, is crucial to combat the far-reaching impacts of climate change. It helps to understand the current sustainability status by providing real-time data and trends that direct future sustainability initiatives. This imperative evaluation helps in shaping strategies to achieve sustainability, identifying challenges, and implementing the necessary actions toward a more sustainable future. Arctic sustainability research is expanding as a significant contributor to global sustainability knowledge by examining unique environmental conditions and human–environment interactions in the Arctic (Petrov et al., 2016; Tornieri et al., 2024).

Arctic cities encounter specific challenges in achieving sustainability, including extreme climate, fragile ecosystems, and distinct social dynamics. To navigate this complex terrain, it is essential to scrutinize and adapt the global SDGs to align with the Arctic cities' specific needs and aspirations. Some efforts have been made to create a tailored monitoring framework for Arctic cities. For instance, Berman and Orttung (2020) conducted a thorough evaluation of the applicability of the ISO 37120 index for the Arctic urban context. They highlighted the unique challenges in the Arctic, arising from factors such as geographical remoteness, harsh climates, and reliance on resource-based economies, emphasizing the essential requirement for supplementary indicators that account for regional contexts and the presence of Indigenous populations (Berman & Orttung, 2020). Nilsson and Larsen (2020) examined the need for region-specific SDGs and indicators in the Arctic context, focusing on demographic factors, Indigenous rights, Arctic-specific economic measures, and local engagement, to ensure that sustainable development aligns with the unique challenges of the region. However, despite these insightful efforts, a crucial gap remains in the literature concerning a comprehensive measurement of sustainability tailored to the specific characteristics and challenges faced by Arctic cities.

This study seeks to review and assess the current state of knowledge about sustainability in Arctic cities by conducting a comprehensive systematic literature review. The main research questions are: (a) What are the emerging trends, patterns, and key themes within the literature? (b) What are the challenges and opportunities of implementing the SDGs in Arctic cities? This study highlights the key areas of focus for urban sustainability in the Arctic, allowing for the development of more accurate and relevant indicators tailored to the unique challenges and priorities of the region. The article begins by presenting the research methodology and data collection process (Section 2). Following this, Section 3 explores the literature by investigating how keywords appear together to understand connections and thematic clusters, track changes over time, and visualize thematic concentrations across the datasets. In Section 4, we analyze each key thematic cluster to elucidate the challenges and opportunities Arctic cities encounter in implementing

SDGs. We answer the research questions and discuss the results in the final section, highlighting existing gaps in the literature and identifying potential areas for future studies.

2. Material and Methods

A systematic literature review was conducted to achieve the article's objectives. According to Snyder (2019), adherence to rigorous steps is imperative to make the review credible and trustworthy. This methodology, renowned for its clarity in objectives, rigorous and reproducible procedures, and thorough search strategy, is effective in minimizing potential bias (Liberati et al., 2009). This article adheres to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as outlined by Moher et al. (2009).

The search query employed for this study is as follows:

> ("SDG*" OR "sustainable development goal*" OR "agenda 2030" OR "global goal*" OR "ISO 37120" OR "energy transition" OR "green transition" OR "urban sustainability" OR "Arctic sustainability" OR "sustainable urban development" OR "sustainability strategies*" OR "GHG emission*" OR "greenhouse gas*" OR "smart cit*") AND ("Arctic" OR "circumpolar" OR "Nordic" OR "Northern cit*")

The search query was strategically split into two main parts. The first part encompasses a spectrum of integrated sustainability concepts, including SDGs and urban sustainability, while the second part narrows the focus to the distinctive geographical context of the Arctic region. We filtered existing literature specifically relevant to urban dimensions of sustainability in the Arctic (excluding sub-Arctic), concentrating on its unique challenges and opportunities to reach sustainable development goals. This dual-part approach ensures a comprehensive understanding of urban sustainability concepts in the specific context of Arctic cities. Two major academic databases, Scopus and Web of Science (WOS), were selected to find relevant articles due to their extensive coverage of peer-reviewed and interdisciplinary journals. WOS was used to find publications published between 2002 and 2023, and Scopus was used to find articles published between 2000 and 2023. However, the first relevant paper was not published until 2014 (Figure 1).

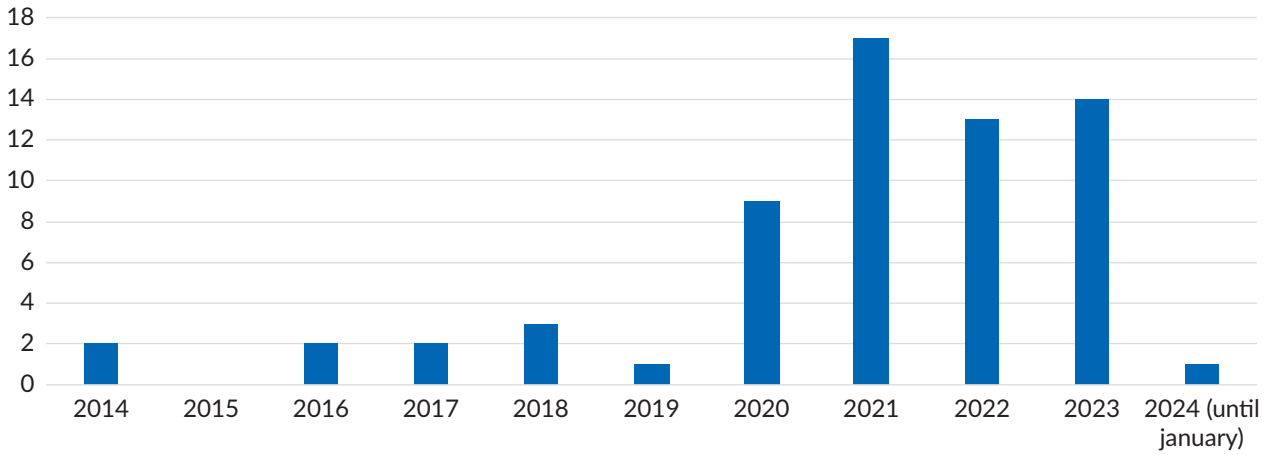

Figure 1. Number of relevant articles per year from Scopus and WOS.

For practical reasons, we limited our queries to English-language journal papers. Figure 2 illustrates the procedures employed for source selection. The initial search was conducted on December 20, 2023. After removing duplicate records, our dataset comprised 337 articles. Subsequent screening of titles and abstracts led to the exclusion of 187 records unrelated to sustainability in the Arctic, resulting in a selection of 150 articles for thorough examination. We further refined our selection by excluding articles focusing on different geographical regions or unrelated subjects concerning urban sustainability, SDGs, and energy transition in the Arctic. Ultimately, this process yielded a final set of 64 relevant articles for comprehensive analysis in our study.

A mixed-methods approach was used to analyze thematic content within the dataset. Initially, thematic clusters were identified using VOSviewer, a bibliometric analysis tool which facilitates the extraction of dominant themes based on co-occurrence patterns of words. Subsequently, a deductive analysis approach (Casula et al., 2021) was employed to extract and analyze text segments in the datasets corresponding to the identified themes.

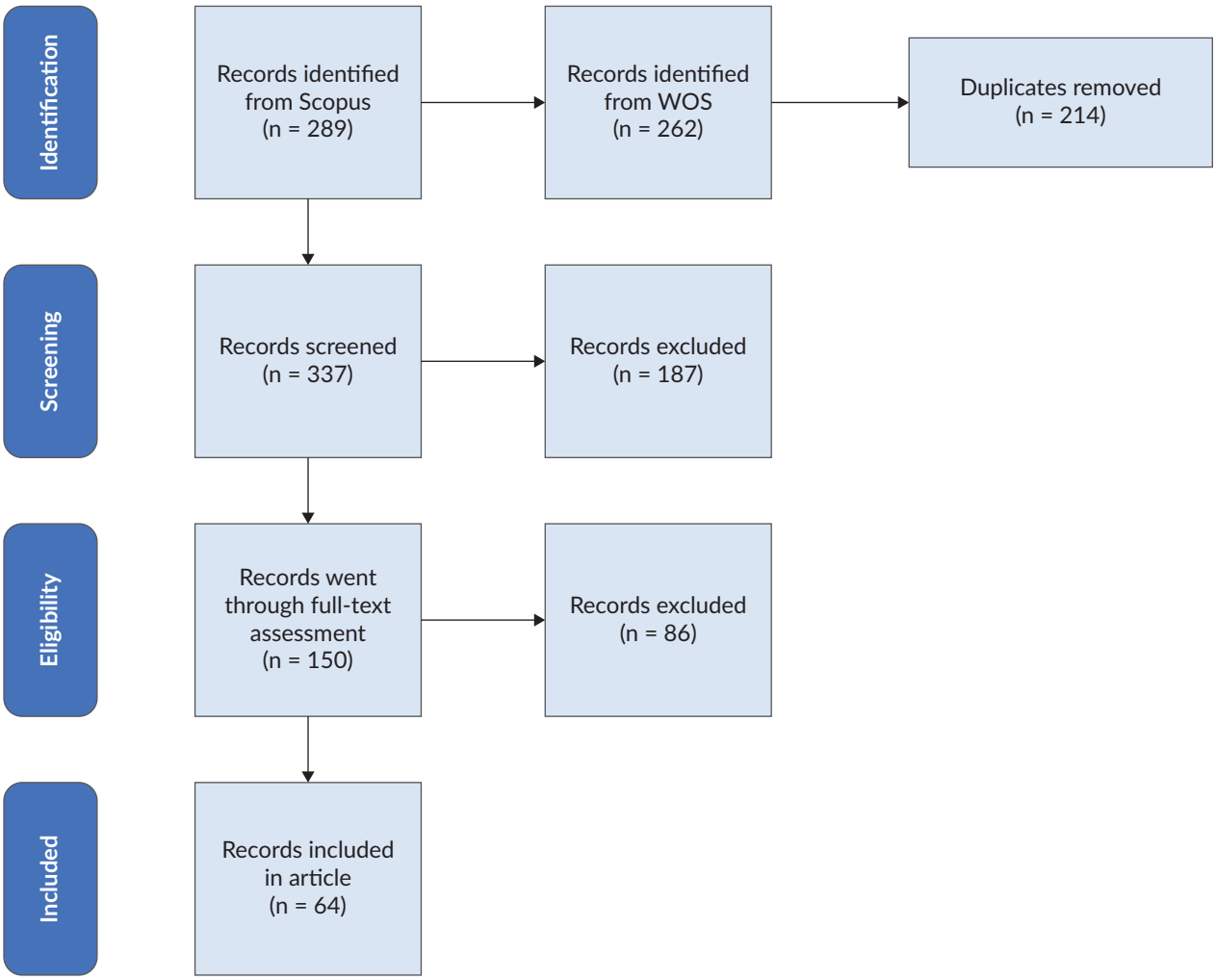

Figure 2. PRISMA flow diagram illustrating the selection of literature (Moher et al., 2009; Page et al., 2021).

3. Bibliographic Analysis

In this section, we conduct a comprehensive bibliographic analysis by examining the co-occurrence of keywords. We begin by identifying the interconnectedness of the keywords and the thematic clusters within the dataset. Then, we evaluate keyword co-occurrence over time to reveal shifting trends and emerging topics. Subsequently, we employ density visualization to understand thematic concentrations and dispersion across the dataset.

3.1. Analysis of Keywords Co-Occurrence

Keyword co-occurrence was analyzed using VOSviewer to identify prominent thematic clusters within the included papers. We applied an occurrence threshold of three instances per keyword to identify significant keyword associations in this study. This means that keywords appearing at least three times were considered. Additionally, we incorporated a manually created thesaurus file to merge keywords that were duplicates or closely related in meaning, ensuring greater consistency and avoiding redundancy. As a result, 27 keywords were identified. In VOSviewer, six main clusters emerged (Figure 3), each distinguished by a unique color and representing a sub-field of urban sustainability in the Arctic. We labeled these clusters by examining relevant datasets to understand their primary themes and focus. The clusters include Cluster 1: climate change

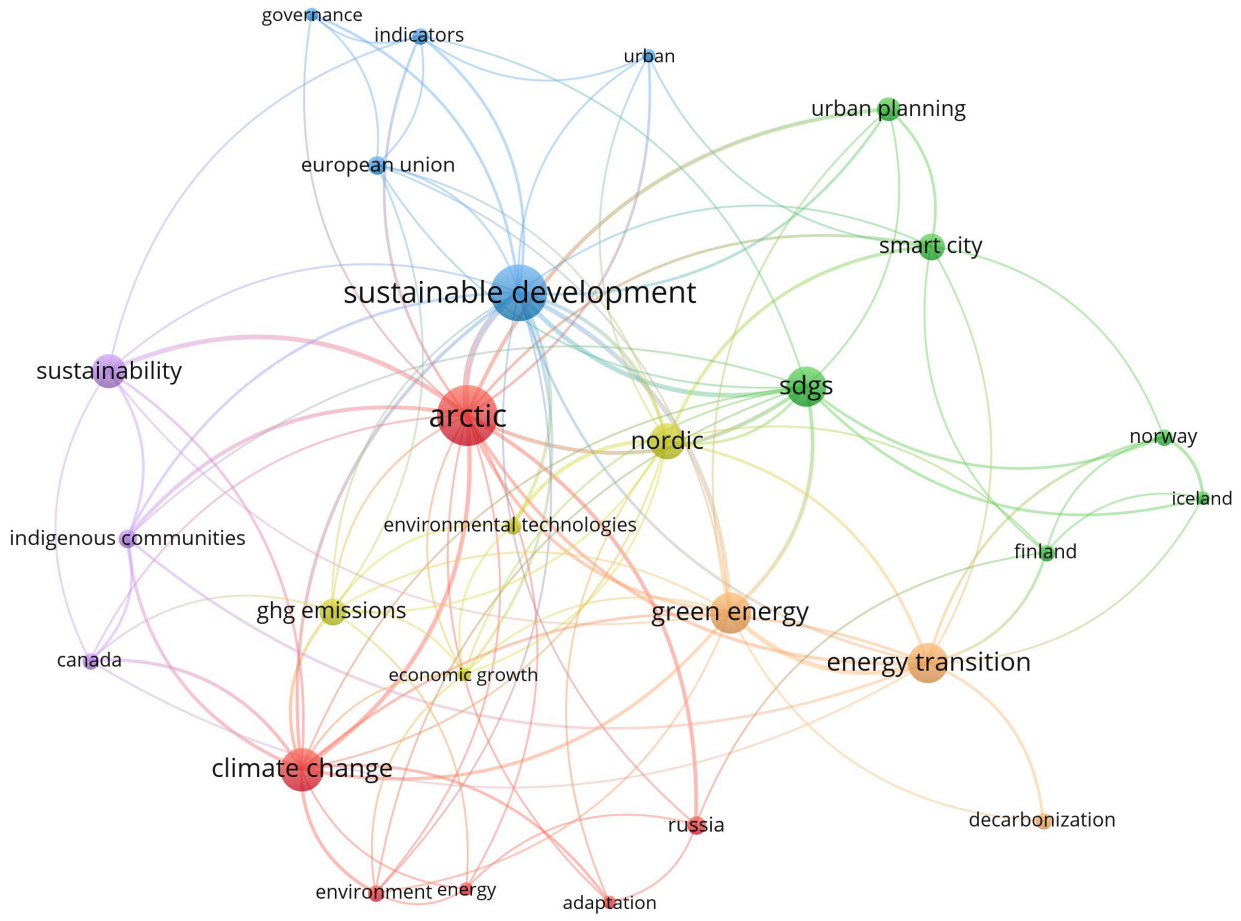

Figure 3. Co-occurrence keywords network map.

and environmental adaptation (red), Cluster 2: SDGs and smart urban planning (green), Cluster 3: sustainable development and urban governance (blue), Cluster 4: sustainable economic development (yellow), Cluster 5: social sustainability (purple), and Cluster 6: green energy transition (orange). The cluster map consists of texts, nodes, and lines, where the size of the texts and nodes corresponds to their weights, with larger sizes indicating higher weights (Jan van Eck & Waltman, 2017). Additionally, the lines denote the common co-occurrence of one keyword with another. The strength of the association between two items is represented by the thickness of the connecting line, with thicker lines indicating a stronger link (Jan van Eck & Waltman, 2017).

The keyword "Arctic" was connected and co-occurred with 19 other keywords, with the most frequent associations being with sustainable development (11), sustainability (6), climate change (5), SDGs (4), Indigenous communities (4), urban planning (4), and Russia (4). The total link strength, however, shows how frequently a specific keyword co-occurs with other keywords (Guo et al., 2019). Table 1 shows the keywords corresponding to each cluster. For instance, the total link strength of "Arctic" is 57, indicating that this keyword was associated with or occurred together with other keywords in a total of 57 publications within the dataset. The top six keywords with the highest total link strength and occurrence include Arctic, sustainable development, climate change, green energy, SDGs, and energy transition.

Table 1. Keyword metrics in clusters.

Ranking order	Keyword	Occurrences	Total link strength	Cluster number
1	Arctic	34	57	1
2	Sustainable development	30	52	3
3	Climate change	19	33	1
4	Green energy	18	29	6
5	SDGs	17	27	2
6	Energy transition	17	26	6
7	Nordic	14	22	4
8	Sustainability	13	14	5
9	GHG emissions	9	12	4
10	Smart city	9	12	2
11	Urban planning	7	10	2
12	European Union	5	7	3
13	Russia	5	8	1
14	Indigenous communities	5	16	5
15	Environment	4	9	1
16	Environmental technologies	4	9	4
17	Finland	4	7	2
18	Indicators	4	9	3
19	Norway	4	9	2
20	Canada	4	9	5
21	Decarbonization	4	3	6
22	Economic growth	3	10	4
23	Energy	3	5	1
24	Adaptation	3	5	1
25	Urban	3	6	3
26	Governance	3	5	3
27	Iceland	3	7	2

3.2. The Temporal Evaluation of Keyword Co-Occurrence

Figure 4 visualizes how the keywords have appeared together over time. The color of each circle in the map corresponds to the average publication year of the respective keyword (Zhang et al., 2021). For instance, "Arctic" was dominantly associated with other keywords in 2020, indicating its significant presence and frequent co-occurrence with other keywords in articles published during that year. This chronological map reveals a thematic evolution surrounding the keyword "Arctic" and its associations with various topics over time. The initial emphasis in Arctic-related discussions was on "governance" and "indicators." Then, the focus appears to shift towards "climate change," "environment," and "adaptation," emphasizing the environmental challenges and adaptive measures in the Arctic region. In 2021, the associations with "Arctic" extended to include keywords like "energy transition" and "sustainability," implying a growing consideration of energy-related aspects of sustainability. Moving from 2021, the connections diversified, encompassing broader sustainability themes with associations to "green energy," "urban planning," "Indigenous communities," "GHG emissions," and "sustainable development." This expansion suggests a nuanced investigation of environmental concerns and social and sustainable development aspects related to the Arctic. By 2022, "Arctic" formed associations with "smart city," "economic growth," and "SDGs." This shift indicates a more recent focus on technological advancements, economic considerations, and commitment to global sustainability goals in the Arctic. Based on our observations, by 2023, the themes broadened to include youth perspectives, justice, and stakeholder-driven solutions, indicating deeper attention to inclusivity and participatory methods in Arctic sustainable development.

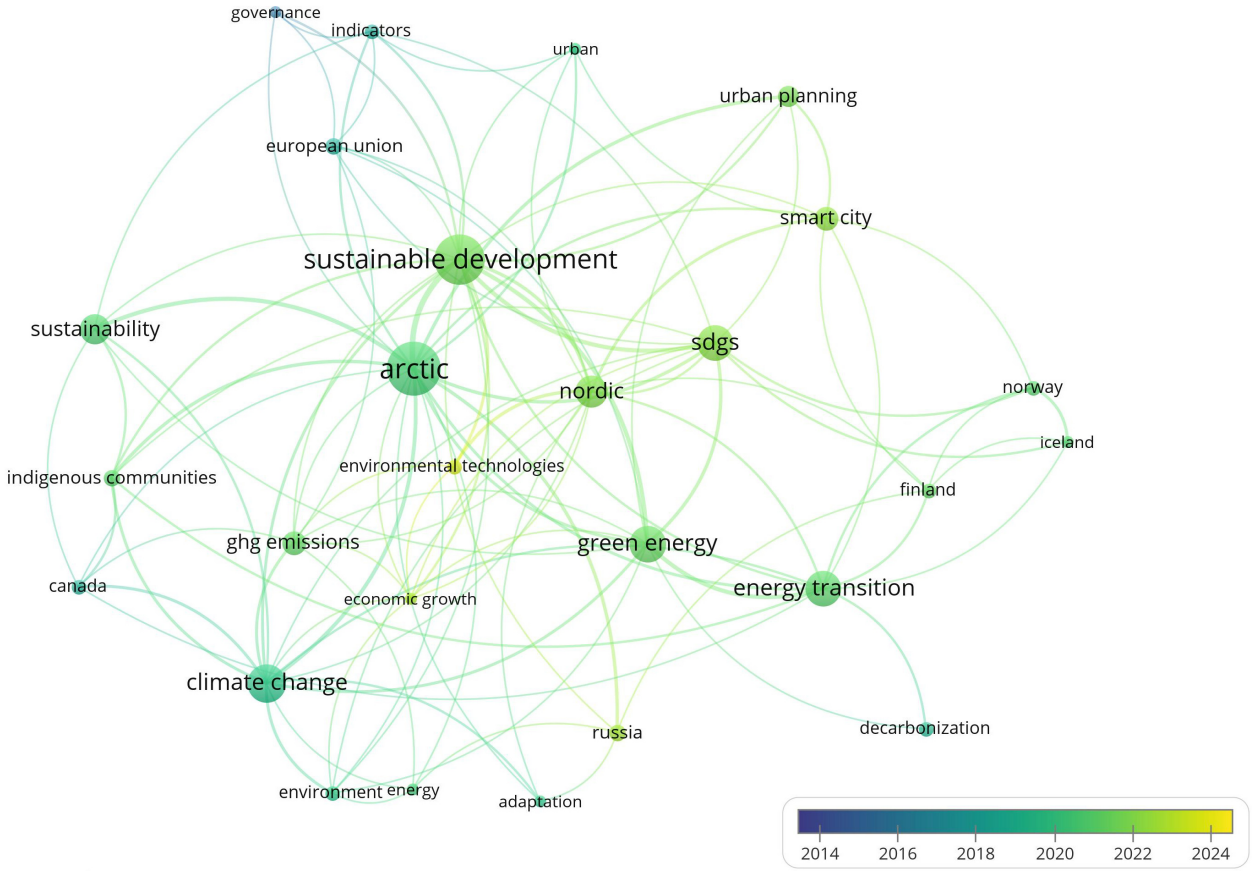

Figure 4. The temporal evaluation of keyword co-occurrence.

3.3. Density Visualization of Keywords Co-Occurrence

Based on color indications, we identified concentrated and dispersed topics in the dataset by showing item density visualization of keyword co-occurrence (Figure 5). Each point on the map corresponds to a keyword, and the color of each indicates the density of the related items. Points with higher item numbers and greater neighboring item weights appear closer to yellow, while those with fewer items and lower neighboring weights tend to lean toward blue (Jan van Eck & Waltman, 2017). Hotspot topics relevant to the Arctic are "sustainable development," "SDGs," "energy transition," "green energy," "sustainability," and "climate change," each demonstrating a high concentration of articles around these central themes.

3.4. Geographical Spread

A notable portion of scholarly articles within the dataset (23) focus on the Arctic region without specifying particular countries or cities (Figure 6). Following this, most case studies are in Russia (18), Canada (12), Norway (11), Greenland (9), and the USA (8). Fewer studies are dedicated to Finland (7), Iceland (6), and Sweden (6). The disparity between the total number of articles and the total number of case studies arises because some articles include more than one case study.

Most of the studies were conducted by authors from the USA (19), Russia (11), Finland (7), and Canada (6), indicating their prominent role in urban Arctic sustainability research (Figure 7). However, the country of

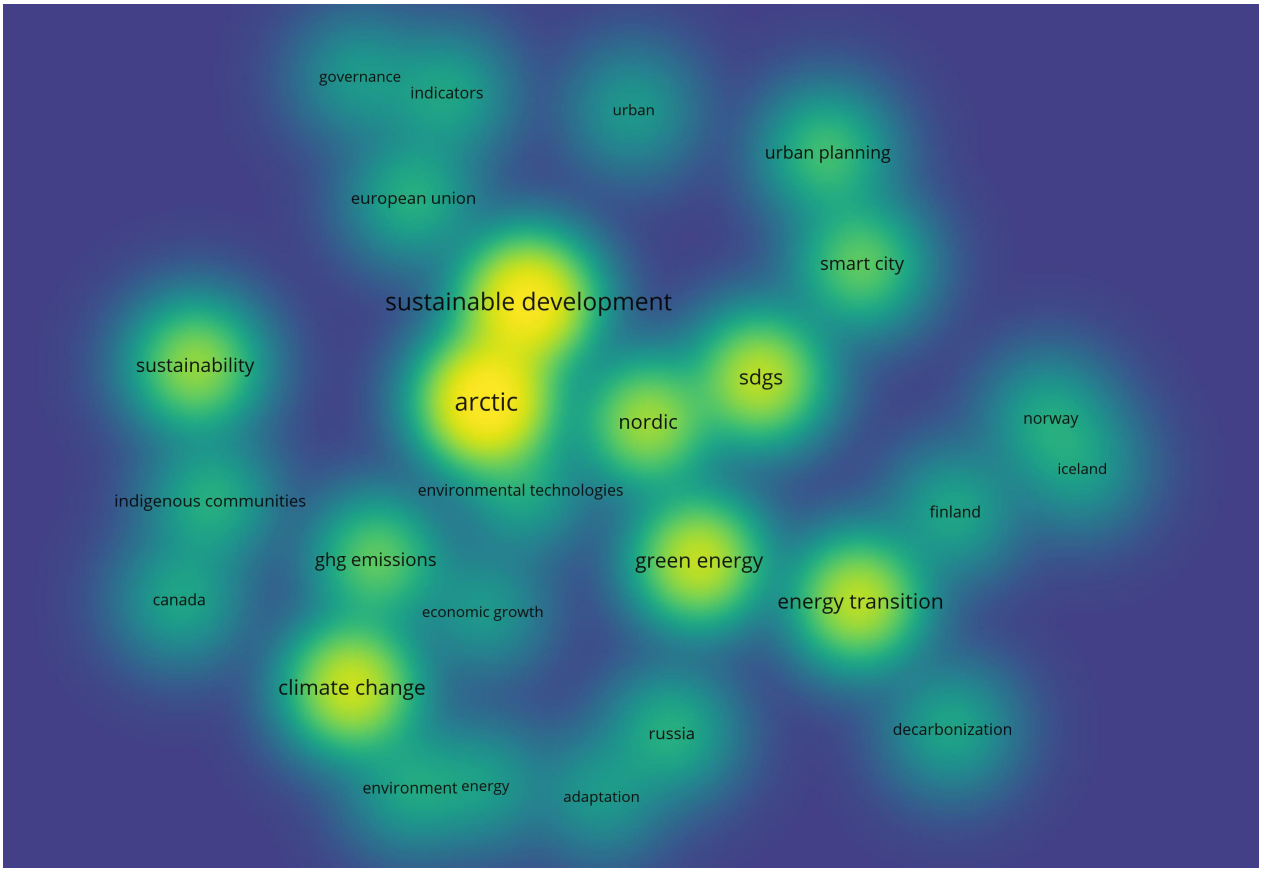

Figure 5. Density visualization of keywords co-occurrence.

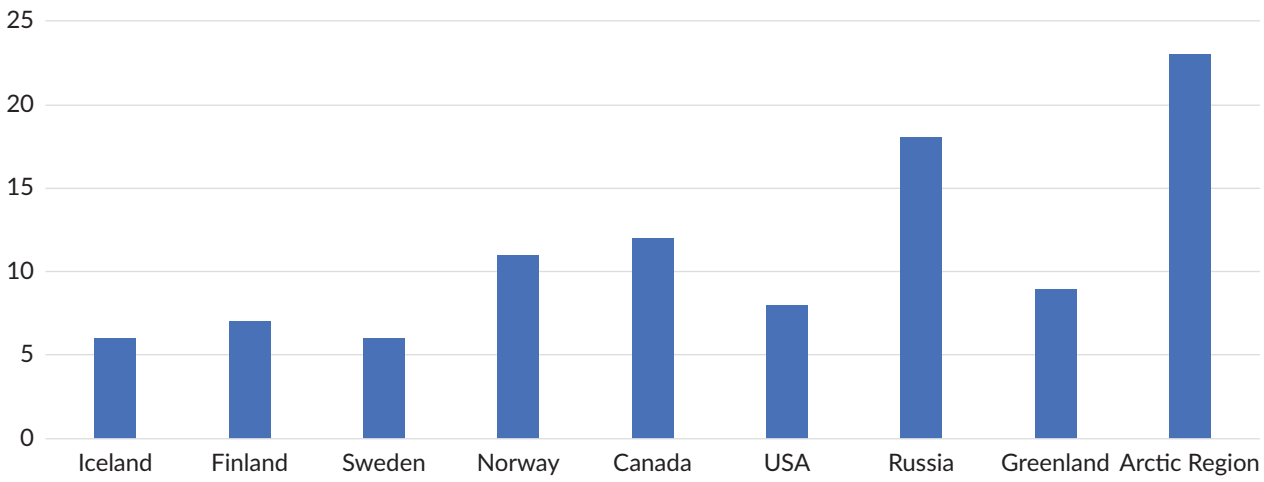

Figure 6. Case studies of the selected articles.

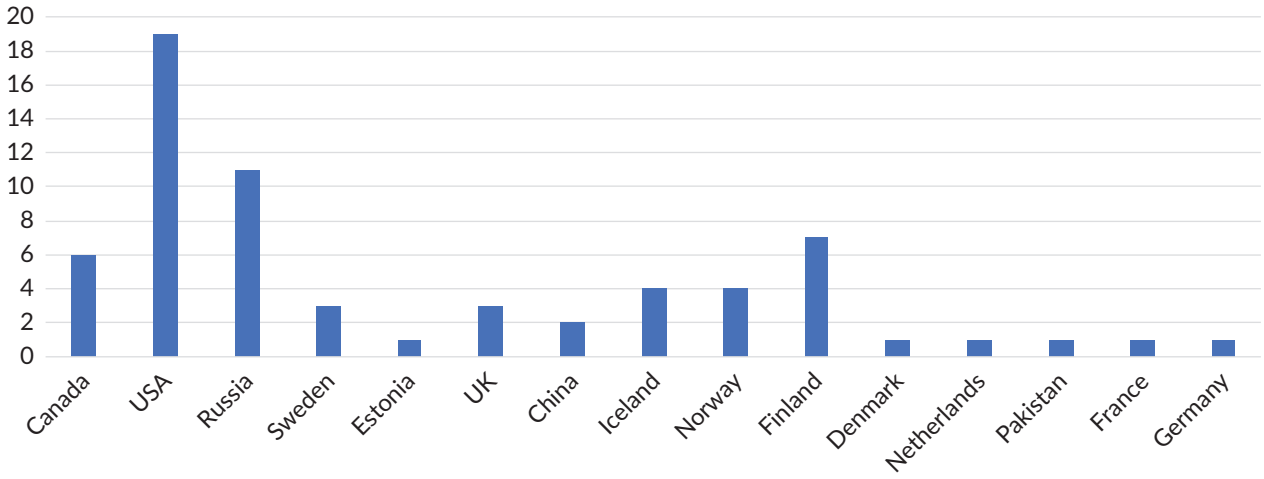

Figure 7. Country of the corresponding authors.

the main author and their case studies do not always align, indicating a broader international engagement with Arctic-related research beyond the geographical confines of the authors' home countries. Corresponding authors from smaller Arctic countries mostly had case studies within their home countries, while those from larger Arctic countries or outside the region tended to focus on the entire Arctic region.

Analyzing all contributing authors (Figure 8) shows that the USA (59), Russia (51), Finland (28), and Canada (23) constitute the primary sources of scholarly contributions. In the dataset, when a case study focuses on a specific country, there is always at least one author whose home country matches the case study.

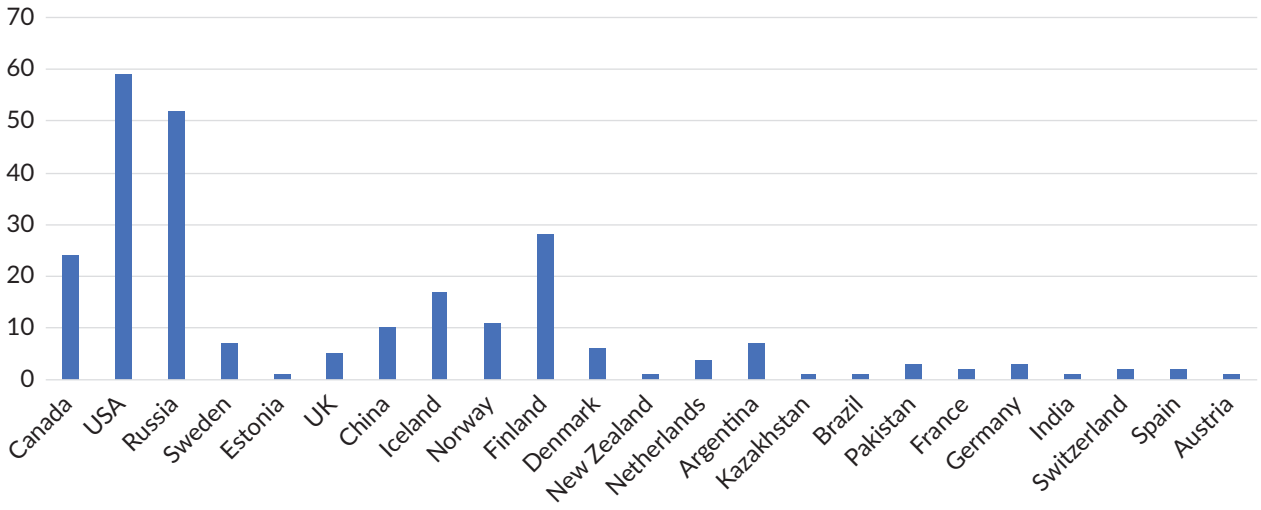

Figure 8. Country of all authors.

4. Text and Thematic Analysis

Arctic cities share some distinctive characteristics, although each one is unique in its own way (Nilsson & Larsen, 2020). Challenges in maintaining energy sustainability, coping with high transportation expenses, and grappling with constraints in infrastructure development are inherent to these relatively recently established cities (Berman & Orttung, 2020). In this section, we comprehensively examine each thematic cluster identified in this study to clarify Arctic cities' challenges and opportunities in reaching sustainability goals.

4.1. Climate Change and Adaptation

The Arctic regions are experiencing the most rapid increase in temperatures, causing profound and substantial changes in both the natural environment and the socio-economic dimensions within Arctic communities (Noe et al., 2022). This accelerated transformation highlights the urgent need for adaptation strategies. Fourteen articles within the dataset delve into specific topics spanning from waste management to climate adaptation policies and justice framework. These articles comprehensively explore various challenges and opportunities posed by climate change in the Arctic region, emphasizing collaboration efforts to mitigate impacts and promote sustainability and resilience (Baijnath-Rodino et al., 2021; Bressler & Hennessy, 2018; Cirkovic, 2021; Hansen-Magnusson & Gehrke, 2023; Kuokkanen, 2023; McCauley et al., 2022; Moe et al., 2023; Natali et al., 2022; Nicu & Fatorić, 2023; Orttung & Reisser, 2014; Salonen, 2021; Sebastian & Louis, 2021; Stephen, 2018; Tiller et al., 2022). Given the crucial influence of the Arctic regions on global climate change and their role in shaping worldwide environmental dynamics (Noe et al., 2022), addressing these challenges is imperative for broader climate resilience efforts.

4.2. SDGs and Smart Urban Planning

Fostering global governance is essential to align the diverse perspectives and interests of Arctic communities and people from other regions, emphasizing the need for the SDGs to establish a framework that encourages inclusive decision-making for sustainability (Noe et al., 2022). The SDGs framework is designed like a pyramid, starting with a wide range of data, scientific knowledge, and empirical evidence (Noe et al.,

2022). Moving up toward the top of the pyramid, this vast data is narrowed down and structured, eventually leading to the formation of specific indicators and the defined 17 SDGs (Noe et al., 2022). The SDGs represent a holistic vision for sustainable development, addressing economic, social, and environmental aspects (Noe et al., 2022). However, Nilsson and Larsen (2020) highlight that the notion of sustainability varies across different contexts and geographical locations, making it challenging yet essential to customize the SDGs to fit the particular features of the Arctic, thereby addressing the region's distinct needs more effectively. Eighteen articles within our dataset underscore the need for region-specific indicators and approaches tailored to the unique environmental, social, and economic conditions of the Arctic (Berman & Orttung, 2020; Bie et al., 2023; Bohlmann & Koller, 2020; Brazovskaia et al., 2021; Bressler & Hennessy, 2018; Burns et al., 2021; Degai et al., 2021; Degai & Petrov, 2021; DiNapoli & Jull, 2020; Dmitrieva & Romasheva, 2020; Hansen-Magnusson & Gehrke, 2023; Kuklina et al., 2021; Nilsson & Larsen, 2020; Noe et al., 2022; Raspotnik et al., 2020; Rizzo et al., 2023; Shijin et al., 2023; Tiller et al., 2022). These studies use various methodologies, such as remote sensing, statistical analysis, and stakeholder engagement, to assess sustainability metrics and progress toward the SDGs. Indeed, region-specific adaptations are crucial for effectively addressing the distinct characteristics of the Arctic. According to Degai and Petrov (2021), to enhance the quality of life in Arctic communities, it is crucial to incorporate new goals into the SDGs that accurately capture the region's unique needs, while also reflecting the insights and desires of Indigenous people for sustainable progress. To achieve this, they introduced five additional goals to the SDGs, focusing on (a) recognizing and safeguarding Indigenous rights for sustainable governance; (b) preserving cultural heritage, enhancing community resilience, and maintaining traditional practices and livelihood; (c) monitoring changes in sea ice patterns and permafrost conditions through Indigenous knowledge; (d) ensuring that the community members benefit equitably from natural resources; and (e) preserving Indigenous culture, knowledge, and heritage among the younger generation (Degai & Petrov, 2021). Incorporating Indigenous perspectives and values into the SDGs in the Arctic region can make these goals more relevant, representative, and impactful (Degai & Petrov, 2021), ensuring sustainable development strategies are culturally sensitive and effective for Arctic communities. Degai and Petrov (2021) suggest that the Arctic Council, consisting of representatives from Arctic states and Indigenous and local communities, could serve as a key platform for developing a sustainable development framework specifically tailored to the Arctic's unique needs and challenges.

Alongside this, data availability is a major concern for future work on Arctic SDGs, emphasizing the critical need for improved data across the Arctic (Nilsson & Larsen, 2020). In pursuit of this objective, Noe et al. (2022) argue that the ICUPE (Integrative and Comprehensive Understanding on Polar Environments) project developed over 20 datasets during its lifetime by employing a combination of on-site (ground-based) and remote sensing observations (from space). This project demonstrates how the integration of different Arctic datasets can be effectively used for sustainable development (Noe et al., 2022). These datasets encompass a broad array of subjects, covering the anthropogenic influences on the Arctic environment and the natural processes and dynamics in the region (Noe et al., 2022). To organize the datasets and link each of them to SDGs, they were categorized based on where the essential variables are observed (Noe et al., 2022). Then, "data teasers" were created, which are concise summaries of each dataset to identify prospective beneficiaries (Noe et al., 2022). Finally, scientists initiated discussions with stakeholders, including local communities, organizations, and policymakers, enabling a deep understanding of their needs and concerns, and ensuring that the created datasets meet real-world requirements (Noe et al., 2022). Therefore, incorporating comprehensive datasets is crucial for enhancing the effectiveness of Arctic SDGs, as they

provide a robust foundation for sustainable development initiatives and policies tailored to the region's unique environmental and socioeconomic dynamics. Degai et al. (2021) also argue that the lack of comprehensive data in Russian Arctic cities poses challenges in accurately evaluating the effectiveness of initiatives, potentially resulting in a bureaucratic focus on meeting numerical targets rather than fully achieving sustainability objectives, especially when these targets are determined externally.

4.3. Sustainable Development and Urban Governance

Implementing SDGs necessitates actions at the local level, where municipalities play a crucial role. Establishing sustainability programs within municipalities not only helps to downscale SDGs to address local challenges but also ensures that initiatives are aligned with the specific needs and priorities of each municipality. Seventeen articles within our dataset explore Arctic sustainability and provide insights into addressing the challenges faced by the region through interdisciplinary collaboration, policy interventions, and community engagement (Burkhart et al., 2017; Cirkovic, 2021; Degai et al., 2021; Dmitrieva & Romasheva, 2020; Esau et al., 2021; Huhmarniemi & Jokela, 2020; Kapsar et al., 2022; Laruelle & Hohmann, 2017; Orttung & Reisser, 2014; Paquette, 2020; Perrin et al., 2021; Petrov et al., 2016; Raheem et al., 2022; Speca, 2023; Stammler et al., 2023; Trump et al., 2018; Vlasova & Volkov, 2016). In their study, Degai et al. (2021) investigate the execution of sustainable urban development in the Russian Arctic by scrutinizing the sustainability plans of two Russian cities. Through a comparative analysis of these plans, they gain valuable insights regarding the prioritized and commonly adapted strategies, enabling a comprehensive understanding of sustainable development efforts across the entire Russian Arctic region (Degai et al., 2021). The plans were crafted to address different aspects of sustainability, although they did not directly mention any sustainability framework (Degai et al., 2021). They encompass a wide range of initiatives aimed at protecting natural resources, improving quality of life, enhancing transportation systems, fostering economic diversity, promoting energy efficiency, fostering community engagement, ensuring public health and safety, addressing social equity concerns, supporting cultural heritage, and investing in education and human capital development (Degai et al., 2021). Even though these initiatives indirectly consider some aspects of SDGs, they lack explicit alignment with these goals, leading to inefficiencies in addressing key sustainability challenges (Degai et al., 2021). For instance, they predominantly concentrate on enhancing the effectiveness of road and bus systems to facilitate accessibility, overlooking targeted approaches for reducing CO2 emissions (Degai et al., 2021). The trade-offs between SDGs highlight the need for developing balanced strategies that can achieve multiple goals simultaneously. Besides, most of the plans operated in a top-down manner, with a predominant focus on addressing economic issues while giving relatively less consideration to social and environmental sustainability (Degai et al., 2021). The lack of explicit direction for adapting sustainable development principles to local contexts, coupled with limited opportunities for community involvement, leads to the fragmentation and ineffectiveness of these plans (Degai et al., 2021). By integrating these initiatives with SDGs, each city can formulate comprehensive strategies for sustainable urban development.

4.4. Sustainable Economic Development

Arctic regions are facing a critical challenge, necessitating a shift from a boom-bust cyclical pattern dependent on natural resources to more stable, diverse, and sustainable economies (Berman & Orttung, 2020; Petrov et al., 2016). This transition aims to move away from economic fluctuations and build resilience

by diversifying economic activities beyond resource extraction. However, to effectively gauge economic success in the Arctic, economic indicators must be formulated and tailored to the unique context of the region (Nilsson & Larsen, 2020). The existing SDGs lack considerations for the specificities of Arctic economies, including subsistence activities and resource economics (Nilsson & Larsen, 2020). To address this gap, it is essential to generate indicators that consider factors such as the sustainability of extraction-based economies, fair wealth distribution, and gender-related aspects of local economic activities (Nilsson & Larsen, 2020). This holistic approach goes beyond relying solely on metrics such as Gross Regional Product or per capita household income and captures the diverse and unique economic dynamics of the Arctic region (Nilsson & Larsen, 2020). Eight articles within our dataset seek to understand and address economic sustainability within the unique context of the Arctic region (Bohlmann & Koller, 2020; Garbis et al., 2023; Orttung & Reisser, 2014; Raheem et al., 2022; Tiller et al., 2022; Tishkov et al., 2022; Trump et al., 2018; Usman et al., 2022). Based on the study by Garbis et al. (2023), in northern Sweden, industrial actors and governments prioritize economic growth and consumption over environmental sustainability. Meanwhile, Sámi reindeer herders, youth climate advocates, and conservationists prioritize maintaining the natural environment and traditional ways of life (Garbis et al., 2023).

4.5. Social Sustainability

Considering social capital and institutions is crucial amid the Arctic region's rapid transformations (Nilsson & Larsen, 2020). Social dynamics play a pivotal role in the Arctic's sustainable development, as the existing SDGs inadequately address demographic trends, such as out-migration (Nilsson & Larsen, 2020) and the growing urbanization witnessed in the region (Berman & Orttung, 2020), including the movement of populations toward larger cities (Koffi et al., 2021). Urbanization is reshaping the Arctic as people migrate from smaller to larger settlements for better opportunities, potentially leading to population decline in smaller communities (Heleniak, 2020). This urbanization trend, accentuated by increased population concentration, is further increased by the emergence of "climigration," caused by climate-related factors, adding a unique dimension to these demographic shifts (Larsen & Fondahl, 2015). Seventeen articles within our dataset emphasize the importance of understanding local contexts, Indigenous perspectives, and community engagement for improving sustainability in the Arctic (Bogdanova et al., 2022; Degai & Petrov, 2021; Holdmann et al., 2022; Middleton, 2023; Naylor & Hunt, 2021; Noe et al., 2022; Orttung & Reisser, 2014; Paquette, 2020; Perrin et al., 2021; Rozanova-Smith, 2021; Schwoerer et al., 2020; Stephen, 2018; Stoyanov & Sakharova, 2023; Svartdal & Kristoffersen, 2023; Tiller et al., 2022; Tishkov et al., 2022; Vlasova & Volkov, 2016). Noe et al. (2022) suggested a mobile web application pilot service aimed at supporting the reindeer herding community in the Scandinavian Arctic. This initiative integrates scientific data sources with Indigenous knowledge to provide practical information for sustainable reindeer herding practices in the region (Noe et al., 2022). The incorporation of user feedback from the community, including traditional knowledge and experiences, not only enhances the service's relevance but also improves the capability to track progress towards the SDGs using relevant indicators (Noe et al., 2022). According to Noe et al. (2022), actively involving the insights and experiences of Indigenous communities in structuring observation systems ensures the accuracy and relevance of the collected data, making the services more effective and inclusive. Emphasizing the importance of grassroots involvement, Nilsson and Larsen (2020) underscore the necessity for initiatives that can facilitate bottom-up processes. These initiatives should enable local actors to identify indicators that align with their specific visions of sustainability, directly addressing the unique challenges and perspectives of the Arctic region (Nilsson & Larsen, 2020). Achieving SDGs in the Arctic

requires an inclusive dialogue with global and Arctic stakeholders (Degai & Petrov, 2021). Degai and Petrov (2021) acknowledge the importance of Indigenous knowledge in tailoring the goals to the region's distinctive needs. Thus, active and equitable participation of Indigenous people in decision-making processes is essential to achieve meaningful and effective outcomes (Degai & Petrov, 2021). Involving local communities and respecting their perspectives is imperative, as external entities have historically imposed their preferences and visions for the desired future of the region (Nilsson & Larsen, 2020). Such an approach actively engages Indigenous peoples, local communities, and citizens, thereby gathering their knowledge and perspectives (Nilsson & Larsen, 2020). This cohesive and contextually relevant framework appropriately reflects the subtleties of sustainable development in the Arctic, ensured by this cooperative and locally focused approach. Nilsson and Larsen (2020) highlight the significance of empowering Arctic residents and subnational decision-making processes to actively contribute to determining the future of their communities. Developing benchmarks to specifically address the economic challenges and assess economic success is necessary for a comprehensive approach to Arctic sustainability (Nilsson & Larsen, 2020).

4.6. Green Energy Transition

Transitioning from fossil fuels to renewable resources is highlighted by the urgent need to mitigate climate change effects, particularly in the Arctic, where accelerated warming and heavy dependence on oil exacerbate susceptibility to environmental impact and price fluctuations (Galimova et al., 2024). Confronting the trade-offs between protecting the environment, promoting economic growth, ensuring social fairness, and finding a balance among these factors is crucial for achieving sustainability (Garbis et al., 2023). Twenty-one articles within our dataset centered around energy transition and sustainable resources in the Arctic (Brazovskaia et al., 2021; Das & Canizares, 2019; de Witt et al., 2021a, 2021b, 2022; Dmitrieva & Solovyova, 2023; Galimova et al., 2024; Garbis et al., 2023; Holdmann et al., 2022; Kuokkanen, 2023; McCauley et al., 2022; Middleton, 2023; Morgunova, 2021; Pantaleo et al., 2022; Salonen, 2021; Schwoerer et al., 2020; Shafiei et al., 2014; Sovacool et al., 2022; Tishkov et al., 2022; Usman et al., 2022; Zhukovskiy et al., 2021). Although transitioning to clean energy sources brings undeniable benefits, it poses challenges such as biodiversity loss, disruption to the reindeer herding of Indigenous communities, and urban development pressures (Garbis et al., 2023). According to Tishkov et al. (2022), Arctic residents may have insufficient knowledge and abilities to adjust their behaviors for transitioning towards sustainable energy practices, necessitating effective energy policies to incorporate public awareness campaigns aimed at educating and involving citizens.

5. Discussion and Conclusion

Through a systematic literature review and bibliographic analysis, we identified six main thematic clusters: climate change and adaptation, SDGs and smart urban planning, sustainable development and urban governance, sustainable economic development, social sustainability, and green energy transition. This highlights the multidimensional nature of sustainability challenges in the Arctic. Most studies concentrated on the Arctic region holistically, without specific focus on individual countries or cities within it (Figure 9). SDG implementation is closely linked to smart urban planning (see Figure 3), emphasizing the integration of sustainable practices into urban development. According to the published literature (Figure 9), Arctic sustainability research is stronger in the areas of "SDGs and smart urban planning" and "green energy transition," which have been widely studied across various Arctic countries, especially Russia. However, a

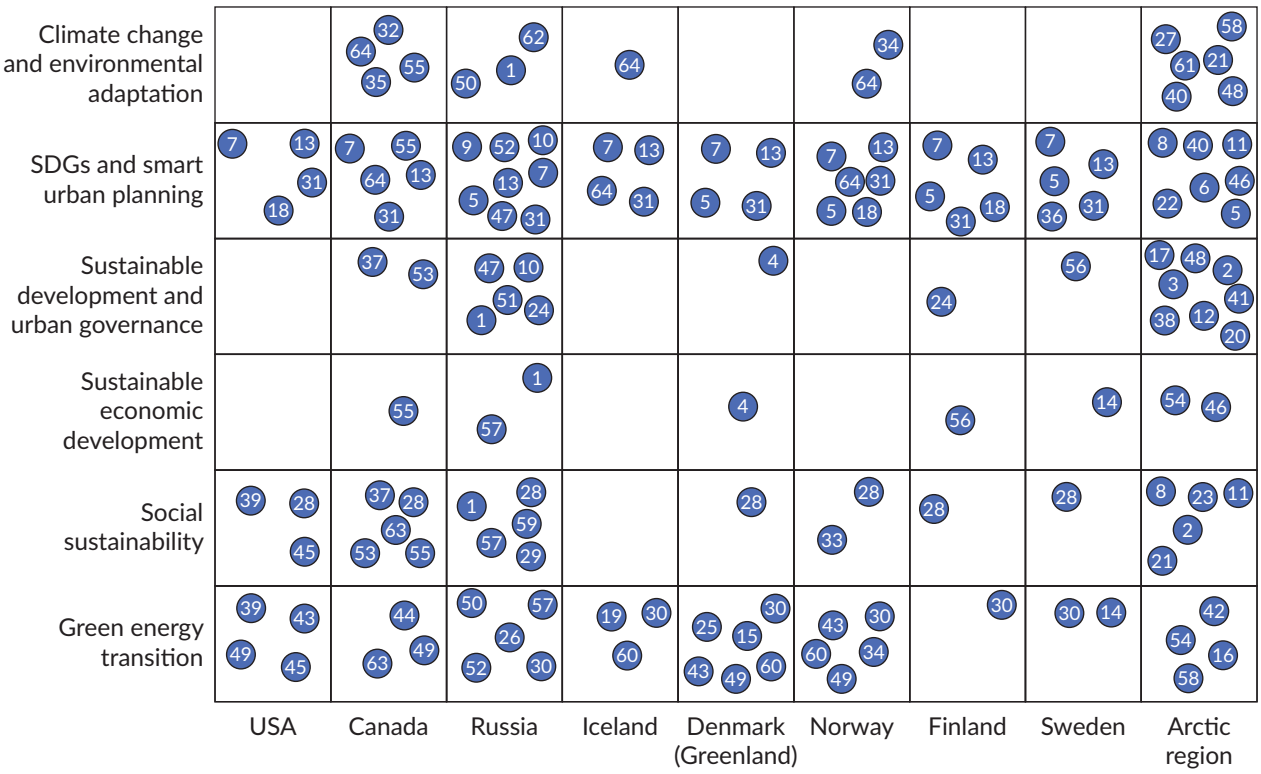

Figure 9. Article distribution based on recognized themes and geographical regions in the Arctic.

lack of research on the sustainability of Arctic cities in Nordic countries is evident, particularly concerning environmental adaptation, and social, economic, and governance sustainability.

Specific features in Arctic cities, such as limited population, geographical remoteness, intense seasonal fluctuations, and frigid weather, differentiate the sustainability measures from those in urban areas elsewhere (Berman & Orttung, 2020). It is imperative to identify SDGs tailored to the Arctic cities for monitoring progress and ensuring initiatives are suited to their distinctive conditions. This is supported by existing literature, such as Degai and Petrov (2021), which argues that to enhance the well-being of Arctic communities, redefining the SDGs is essential to establish additional objectives specifically for the Arctic. Efforts have been made to refine existing frameworks, such as SDGs or ISO 37120, for the Arctic context; however, these initiatives are limited to just a few studies. To improve a comprehensive framework tailored for Arctic cities, relevant indicators from the six identified clusters must be generated to accurately track progress toward sustainability goals, identify areas for improvement, and develop strategies. Arctic-specific indicators will also facilitate comparative analysis between different Arctic clusters. On the other hand, as the lack of data in the Arctic poses significant challenges in generating relevant indicators and targets, incorporating citizens in gathering data can address this problem to some extent.

We acknowledge that the decision to limit the search to English, peer-reviewed journal articles, and search engines in Scopus and WOS, might have excluded technical reports, books, and book chapters in English and other languages. Additionally, our broad search query, while synthesizing existing knowledge, may have generalized the findings and overlooked specific characteristics and disparities among different Arctic cities. Future research should investigate specific themes and contexts within the Arctic. Alongside this,

incorporating studies published in local languages will provide a richer understanding of urban sustainability in these areas.

To develop more holistic and culturally sensitive approaches in Arctic research, close collaboration with a wide range of stakeholders—including local people, Indigenous communities, and government agencies—and the incorporation of traditional knowledge held by local communities is necessary. Research should continuously focus on Indigenous communities; it is equally important to broaden the scope to include non-Indigenous people. This would ensure that a variety of perspectives, knowledge, and interests are considered, leading to more effective strategies that align better with the needs and values of Arctic residents. We conclude that a holistic approach is needed to consider diverse perspectives, subjective opinions, experiences, and contributions of both Indigenous and non-Indigenous populations to ensure inclusive and effective decision-making processes and policies.

Acknowledgments

The authors gratefully acknowledge funding from Arctic Five through the Arctic Chair in Architecture and Planning at Luleå University of Technology (2022–2024) and Region Norrbotten research project for the visualisation of SDGs indicators for regional planning.

Funding

Arctic Five Chairs.

Conflict of Interests

The authors declare no conflict of interests.

References

Baijnath-Rodino, J. A., Albizua, A., Sushama, L., Bennett, E., & Robinson, B. E. (2021). Determining freshwater lake communities' vulnerability to snowstorms in the northwest territories. *Water*, *13*(13), Article 1816. https://doi.org/10.3390/w13131816

Berman, M., & Orttung, R. W. (2020). Measuring progress toward urban sustainability: Do global measures work for Arctic cities? *Sustainability*, *12*(9), Article 3708. https://doi.org/10.3390/su12093708

Bie, Q., Wang, S., Qiang, W., Ma, X., Gu, Z., & Tian, N. (2023). Progress toward sustainable development goals and interlinkages between them in Arctic countries. *Heliyon*, *9*(2), Article e13306. https://doi.org/10.1016/j.heliyon.2023.e13306

Bogdanova, E., Filant, K., Ivanova, M., Romanenko, T., Voronina, L., Hossain, K., Filant, P., Andronov, S., & Lobanov, A. (2022). Strengthening collaboration of the Indigenous peoples in the Russian Arctic: Adaptation in the Covid-19 pandemic times. *Sustainability*, *14*(6), Article 3225. https://doi.org/10.3390/su14063225

Bohlmann, U. M., & Koller, V. F. (2020). ESA and the Arctic—The European Space Agency's contributions to a sustainable Arctic. *Acta Astronautica*, *176*, 33–39. https://doi.org/10.1016/j.actaastro.2020.05.030

Brazovskaia, V., Gutman, S., & Zaytsev, A. (2021). Potential impact of renewable energy on the sustainable development of Russian Arctic territories. *Energies*, *14*(12), Article 3691. https://doi.org/10.3390/en14123691

Bressler, J. M., & Hennessy, T. W. (2018). Results of an Arctic Council survey on water and sanitation services in the Arctic. *International Journal of Circumpolar Health*, *77*(1), Article 1421368. https://doi.org/10.1080/22423982.2017.1421368

Burkhart, K., McGrath-Horn, M. C., & Unterstell, N. (2017). Comparison of Arctic and Amazon regional governance mechanisms. *Polar Geography*, *40*(2), 144–161. https://doi.org/10.1080/1088937X.2017.1303755

Burns, C., Orttung, R. W., Shaiman, M., Silinsky, L., & Zhang, E. (2021). Solid waste management in the Arctic. *Waste Management*, *126*, 340–350. https://doi.org/10.1016/j.wasman.2021.03.021

Casula, M., Rangarajan, N., & Shields, P. (2021). The potential of working hypotheses for deductive exploratory research. *Quality & Quantity*, *55*(5), 1703–1725. https://doi.org/10.1007/s11135-020-01072-9

Chapman, D., Nilsson, K., Rizzo, A., & Larsson, A. (2018). Updating winter: The importance of climate-sensitive urban design for winter settlements. In L. Heininen & H. Exner-Pirot (Eds.), *The Arctic yearbook 2018* (pp. 86–105). Thematic Network on Geopolitics and Security of the University of the Arctic.

Cirkovic, E. (2021). The next generation of international law: Space, ice, and the cosmolegal proposal. *German Law Journal*, *22*(2), 147–167. https://doi.org/10.1017/glj.2021.4

Das, I., & Canizares, C. A. (2019). Renewable energy integration in diesel-based microgrids at the Canadian Arctic. *Proceedings of the IEEE*, *107*(9), 1838–1856. https://doi.org/10.1109/JPROC.2019.2932743

de Witt, M., Stefánsson, H., Valfells, Á., & Larsen, J. N. (2021a). Availability and feasibility of renewable resources for electricity generation in the Arctic: The cases of Longyearbyen, Maniitsoq and Kotzebue. *Sustainability*, *13*(16), Article 8708. https://doi.org/10.3390/su13168708

de Witt, M., Stefánsson, H., Valfells, Á., & Larsen, J. N. (2021b). Energy resources and electricity generation in Arctic areas. *Renewable Energy*, *169*, 144–156. https://doi.org/10.1016/j.renene.2021.01.025

de Witt, M., Valfells, Á., Larsen, J. N., & Stefánsson, H. (2022). Simulation of pathways toward low-carbon electricity generation in the Arctic. *Sustainability*, *14*(22). Article 15311. https://doi.org/10.3390/su142215311

Degai, T. S., Khortseva, N., Monakhova, M., & Petrov, A. N. (2021). Municipal programs and sustainable development in Russian northern cities: Case studies of Murmansk and Magadan. *Sustainability*, *13*(21), Article 12140. https://doi.org/10.3390/su132112140

Degai, T. S., & Petrov, A. N. (2021). Rethinking Arctic sustainable development agenda through indigenizing UN sustainable development goals. *International Journal of Sustainable Development & World Ecology*, *28*(6), 518–523. https://doi.org/10.1080/13504509.2020.1868608

DiNapoli, B., & Jull, M. (2020). Urban planning sustainability metrics for Arctic cities. *Environmental Research Letters*, *15*(12), Article 124023. https://doi.org/10.1088/1748-9326/abc37b

Dmitrieva, D., & Romasheva, N. (2020). Sustainable development of oil and gas potential of the Arctic and its shelf zone: The role of innovations. *Journal of Marine Science and Engineering*, *8*(12), Article 1003. https://doi.org/10.3390/jmse8121003

Dmitrieva, D., & Solovyova, V. (2023). Russian Arctic mineral resources sustainable development in the context of energy transition, ESG agenda and geopolitical tensions. *Energies*, *16*(13), Article 5145. https://doi.org/10.3390/EN16135145

Esau, I., Bobylev, L., Donchenko, V., Gnatiuk, N., Lappalainen, H. K., Konstantinov, P., Kulmala, M., Mahura, A., Makkonen, R., Manvelova, A., Miles, V., Petäjä, T., Poutanen, P., Fedorov, R., Varentsov, M., Wolf, T., Zilitinkevich, S., & Baklanov, A. (2021). An enhanced integrated approach to knowledgeable high-resolution environmental quality assessment. *Environmental Science & Policy*, *122*, 1–13. https://doi.org/10.1016/j.envsci.2021.03.020

Galimova, T., Satymov, R., Keiner, D., & Breyer, C. (2024). Sustainable energy transition of Greenland and its prospects as a potential Arctic e-fuel and e-chemical export hub for Europe and East Asia. *Energy*, *286*, Article 129605. https://doi.org/10.1016/j.energy.2023.129605

Garbis, Z., McCarthy, E., Orttung, R. W., Poelzer, G., Shaiman, M., & Tafrate, J. (2023). Governing the green economy in the Arctic. *Climatic Change*, *176*(4), Article 33. https://doi.org/10.1007/s10584-023-03506-3

Guo, Y. M., Huang, Z. L., Guo, J., Li, H., Guo, X. R., & Nkeli, M. J. (2019). Bibliometric analysis on smart cities research. *Sustainability*, *11*(13), Article 3606. https://doi.org/10.3390/su11133606

Hansen-Magnusson, H., & Gehrke, C. (2023). Navigating towards justice and sustainability? Syncretic encounters and stakeholder-sourced solutions in Arctic cruise tourism governance. *The Polar Journal*, *13*(2), 216–239. https://doi.org/10.1080/2154896X.2023.2251225

Heleniak, T. (2020). *Polar peoples in the future: Projections of the Arctic populations*. Nordregio. https://nordregio.org/publications/polar-peoples-in-the-future-projections-of-the-arctic-populations

Holdmann, G., Pride, D., Poelzer, G., Noble, B., & Walker, C. (2022). Critical pathways to renewable energy transitions in remote Alaska communities: A comparative analysis. *Energy Research & Social Science*, *91*, Article 102712. https://doi.org/10.1016/j.erss.2022.102712

Huhmarniemi, M., & Jokela, T. (2020). Arctic arts with pride: Discourses on arctic arts, culture and sustainability. *Sustainability*, *12*(2), Article 604. https://doi.org/10.3390/su12020604

Jan van Eck, N., & Waltman, L. (2017). *VOSviewer manual*. Universiteit Leiden; CWTS.

Kapsar, K., Frans, V. F., Brigham, L. W., & Liu, J. (2022). The metacoupled Arctic: Human–nature interactions across local to global scales as drivers of sustainability. *Ambio*, *51*, 2061–2078. https://doi.org/10.1007/s13280-022-01729-9

Koffi, B., Wilson, J., Ehrlich, D., Dubois, G., Mandrici, A., Vernaccini, l., & Delli, G. (2021). *Arctic populations dynamics and urbanisation*. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/4603d81a-ce4e-11eb-ac72-01aa75ed71a1/language-en/format-PDF/source-240974162

Kuklina, V., Sizov, O., & Fedorov, R. (2021). Green spaces as an indicator of urban sustainability in the Arctic cities: Case of Nadym. *Polar Science*, *29*, Article 100672. https://doi.org/10.1016/j.polar.2021.100672

Kuokkanen, R. (2023). Are reindeer the new buffalo? Climate change, the green shift, and manifest destiny in Sápmi. *Meridians*, *22*(1), 11–33. https://doi.org/10.1215/15366936-10220458

Larsen, J. N., & Fondahl, G. (Eds.). (2015). *Arctic human development report: Regional processes and global linkages*. Nordisk Ministerråd. https://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A788965&dswid=-553

Laruelle, M., & Hohmann, S. (2017). Biography of a polar city: Population flows and urban identity in Norilsk. *Polar Geography*, *40*(4), 306–323. https://doi.org/10.1080/1088937X.2017.1387822

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *Journal of Clinical Epidemiology*, *62*(10), e1–e34. https://doi.org/10.1016/j.jclinepi.2009.06.006

McCauley, D., Pettigrew, K. A., Bennett, M. M., Todd, I., & Wood-Donnelly, C. (2022). Which states will lead a just transition for the Arctic? A DeePeR analysis of global data on Arctic states and formal observer states. *Global Environmental Change*, *73*, Article 102480. https://doi.org/10.1016/j.gloenvcha.2022.102480

Middleton, A. (2023). Mapping the portrayal of small modular reactors in Canadian energy solutions. *The Polar Journal*, *13*(2), 264–287. https://doi.org/10.1080/2154896X.2023.2274264

Moe, A., Lamazhapov, E., & Anisimov, O. (2023). Russia's expanding adaptation agenda and its limitations. *Climate Policy*, *23*(2), 184–198. https://doi.org/10.1080/14693062.2022.2107981

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ*, *339*, Article b2535. https://doi.org/10.1136/bmj.b2535

Morgunova, M. (2021). The role of the socio-technical regime in the sustainable energy transition: A case of the Eurasian Arctic. *The Extractive Industries and Society*, *8*(3), Article 100939. https://doi.org/10.1016/j.exis.2021.100939

Natali, S. M., Bronen, R., Cochran, P., Holdren, J. P., Rogers, B. M., & Treharne, R. (2022). Incorporating permafrost into climate mitigation and adaptation policy. *Environmental Research Letters*, *17*(9), Article 091001. https://doi.org/10.1088/1748-9326/ac8c5a

Naylor, R. S., & Hunt, C. A. (2021). Tourism and livelihood sovereignty: A theoretical introduction and research agenda for arctic contexts. *Societies*, *11*(3), Article 105. https://doi.org/10.3390/soc11030105

Nicu, I. C., & Fatorić, S. (2023). Climate change impacts on immovable cultural heritage in polar regions: A systematic bibliometric review. *WIREs Climate Change*, *14*(3), Article e822. https://doi.org/10.1002/wcc.822

Nilsson, A. E., & Larsen, J. N. (2020). Making regional sense of global sustainable development indicators for the Arctic. *Sustainability*, *12*(3), Article 1027. https://doi.org/10.3390/su12031027

Noe, S. M., Tabakova, K., Mahura, A., Lappalainen, H. K., Kosmale, M., Heilimo, J., Salzano, R., Santoro, M., Salvatori, R., Spolaor, A., Cairns, W., Barbante, C., Pankratov, F., Humbert, A., Sonke, J. E., Law, K. S., Onishi, T., Paris, J. D., Skov, H., . . . Petäjä, T. (2022). Arctic observations and sustainable development goals—Contributions and examples from ERA-PLANET iCUPE data. *Environmental Science & Policy*, *132*, 323–336. https://doi.org/10.1016/j.envsci.2022.02.034

Orttung, R. W., & Reisser, C. (2014). Urban sustainability in Russia's Arctic: Lessons from a recent conference and areas for further investigations. *Polar Geography*, *37*(3), 193–214. https://doi.org/10.1080/1088937X.2014.919362

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, Article n71. https://doi.org/10.1136/bmj.n71

Pantaleo, A., Albert, M. R., Snyder, H. T., Doig, S., Oshima, T., & Hagelqvist, N. E. (2022). Modeling a sustainable energy transition in northern Greenland: Qaanaaq case study. *Sustainable Energy Technologies and Assessments*, *54*, Article 102774. https://doi.org/10.1016/j.seta.2022.102774

Paquette, T. (2020). The inhabitants of an imagined body: The crown's duty to consult and accommodate Indigenous communities in the Arctic adversely affected by climate change. *McGill Journal of Sustainable Development Law*, *15(2)*, 140–175.

Perrin, A. D., Ljubicic, G., & Ogden, A. (2021). Northern research policy contributions to Canadian Arctic sustainability. *Sustainability*, *13*(21), Article 12035. https://doi.org/10.3390/su132112035

Petrov, A. N., BurnSilver, S., Chapin, F. S., Fondahl, G., Graybill, J., Keil, K., Nilsson, A. E., Riedlsperger, R., & Schweitzer, P. (2016). Arctic sustainability research: Toward a new agenda. *Polar Geography*, *39*(3), 165–178. https://doi.org/10.1080/1088937X.2016.1217095

Raheem, D., Soltermann, A. T., Tamiozzo, L. V., Cogo, A., Favén, L., Punam, N. J., Sarmiento, C. R., Rainosalo, E., Picco, F., Morla, F., Nilson, A., & Stammler-Gossmann, A. (2022). Partnership for international development: Finland–Argentina conference on circular economy and bioeconomy with emphasis on food sovereignty and sustainability. *International Journal of Environmental Research and Public Health*, *19*(3), Article 1773. https://doi.org/10.3390/ijerph19031773

Raspotnik, A., Grønning, R., & Herrmann, V. (2020). A tale of three cities: The concept of smart sustainable cities for the Arctic. *Polar Geography*, *43*(1), 64–87. https://doi.org/10.1080/1088937X.2020.1713546

Rizzo, A., Sjöholm, J., & Luciani, A. (2023). Smart(en)ing the Arctic city? The cases of Kiruna and Malmberget in Sweden. *European Planning Studies*, *32*(1), 59–77. https://doi.org/10.1080/09654313.2023.2217850

Rizzo, A., & Sordi, J. (2020). Resources and urbanization in the global periphery: Perspectives from urban and landscape studies. *Cities*, *100*, Article 102647. https://doi.org/10.1016/j.cities.2020.102647

Rozanova-Smith, M. (2021). Stay or leave? Arctic youth prospects and sustainable futures of the Russian Arctic communities. *Sustainability*, *13*(21), Article 12058. https://doi.org/10.3390/su132112058

Salonen, H. (2021). All habits die hard: Exploring the path dependence and lock-ins of outdated energy systems in the Russian Arctic. *Energy Research & Social Science*, *78*, Article 102149. https://doi.org/10.1016/j.erss.2021.102149

Schwoerer, T., Schmidt, J. I., & Holen, D. (2020). Predicting the food-energy nexus of wild food systems: Informing energy transitions for isolated Indigenous communities. *Ecological Economics*, *176*, Article 106712. https://doi.org/10.1016/j.ecolecon.2020.106712

Sebastian, R. M., & Louis, J. (2021). Waste management in Northwest Territories, Canada: Current practices, opportunities, and challenges. *Journal of Environmental Chemical Engineering*, *10*(1), Article 106930. https://doi.org/10.1016/j.jece.2021.106930

Shafiei, E., Davidsdottir, B., Leaver, J., Stefansson, H., & Asgeirsson, E. I. (2014). Potential impact of transition to a low-carbon transport system in Iceland. *Energy Policy*, *69*, 127–142. https://doi.org/10.1016/j.enpol.2014.03.013

Shijin, W., Wenli, Q., & Qiaoxia, L. (2023). Key pathways to achieve sustainable development goals in three polar regions. *Sustainability*, *15*(2), Article 1735. https://doi.org/10.3390/SU15021735

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Sovacool, B. K., Upham, P., & Monyei, C. G. (2022). The "whole systems" energy sustainability of digitalization: Humanizing the community risks and benefits of Nordic datacenter development. *Energy Research & Social Science*, *88*, Article 102493. https://doi.org/10.1016/j.erss.2022.102493

Speca, A. (2023). Model Arctic Council for sustainable development. *Polar Geography*, *46*(1), 41–61. https://doi.org/10.1080/1088937X.2023.2210315

Stammler, F., Adams, R. M., & Ivanova, A. (2023). Rewiring remote urban futures? Youth well-being in northern industry towns. *Journal of Youth Studies*, *26*(10), 1257–1272. https://doi.org/10.1080/13676261.2022.2081493

Stephen, K. (2018). Societal impacts of a rapidly changing Arctic. *Current Climate Change Reports*, *4*(3), 223–237. https://doi.org/10.1007/s40641-018-0106-1

Stoyanov, A. D., & Sakharova, A. S. (2023). Accessibility of energy from renewable energy sources for inhabitants of Arctic cities. *Economy of Regions*, *19*(3), 860–869. https://doi.org/10.17059/ekon.reg.2023-3-18

Svartdal, I. H., & Kristoffersen, B. (2023). Why in my backyard (WIMBY): Forging the link to community futures when energy transition projects are met with indifference. *Energy Research & Social Science*, *101*, Article 103138. https://doi.org/10.1016/j.erss.2023.103138

Swedish Meteorological and Hydrological Institute. (2024). *Future climate*. https://www.smhi.se/en/climate/future-climate/future-climate

Tiller, S. J., Rhindress, A. P., Oguntola, I. O., Ülkü, M. A., Williams, K. A., & Sundararajan, B. (2022). Exploring the impact of climate change on Arctic shipping through the lenses of quadruple bottom line and sustainable development goals. *Sustainability*, *14*(4), Article 2193. https://doi.org/10.3390/su14042193

Tishkov, S., Tleppayev, A., Karginova-Gubinova, V., Volkov, A., & Shcherbak, A. (2022). Citizens' behavior as a

driver of energy transition and greening of the economy in the Russian Arctic: Findings of a sociological survey in the Murmansk region and Karelia. *Applied Sciences*, *12*(3), Article 1460. https://doi.org/10.3390/app12031460

Tornieri, S., Ma, J., & Rizzo, A. (2024). Which urban and landscape qualities make Arctic villages attractive? The Torne River villages in Sweden. *European Planning Studies*, *32*(8), 1731–1751. https://doi.org/10.1080/09654313.2024.2349753

Trump, B. D., Kadenic, M., & Linkov, I. (2018). A sustainable Arctic: Making hard decisions. *Arctic, Antarctic, and Alpine Research*, *50*(1), Article e1438345. https://doi.org/10.1080/15230430.2018.1438345

Usman, M., Jahanger, A., Makhdum, M. S. A., Balsalobre-Lorente, D., & Bashir, A. (2022). How do financial development, energy consumption, natural resources, and globalization affect Arctic countries' economic growth and environmental quality? An advanced panel data simulation. *Energy*, *241*, Article 122515. https://doi.org/10.1016/j.energy.2021.122515

Vlasova, T., & Volkov, S. (2016). Towards transdisciplinarity in Arctic sustainability knowledge co-production: Socially-oriented observations as a participatory integrated activity. *Polar Science*, *10*(3), 425–432. https://doi.org/10.1016/j.polar.2016.06.002

Zhang, X., Lai, H., Zhang, F., Wang, Y., Zhang, L., Yang, N., Wang, C., Liang, Z., Zeng, J., & Yang, J. (2021). Visualization and analysis in the field of pan-cancer studies and its application in breast cancer treatment. *Frontiers in Medicine*, *8*, Article 635035. https://doi.org/10.3389/fmed.2021.635035

Zhukovskiy, Y., Tsvetkov, P., Buldysko, A., Malkova, Y., Stoianova, A., & Koshenkova, A. (2021). Scenario modeling of sustainable development of energy supply in the Arctic. *Resources*, *10*(12), Article 124. https://doi.org/10.3390/resources10120124

About the Authors

Ava Soroudi is a PhD student in architecture at Luleå University of Technology (LTU) in Sweden. Her research focuses on green transition and implementing sustainable development goals (SDGs) in Arctic cities and towns. She explores the potential challenges and opportunities that Arctic municipalities may face when adopting green energy solutions and sustainable development practices. She aims to develop strategies to address these challenges, contributing to the creation of resilient and sustainable Arctic communities.

Agatino Rizzo is the chaired professor of architecture at Luleå University of Technology (LTU) in Sweden. In this university he leads a research group of 25 people focusing on the climate transition in cities, urban living labs, and climate-sensitive design/planning. His research has been funded by, among others, Qatar QNRF, EU Horizon, Swedish Energy Agency, Formas, and Vinnova.

Jing Ma (PhD) is an associate senior lecturer in architecture at Luleå University of Technology (LTU). Her work primarily revolves around the spatial analysis of public open spaces to improve human health and well-being. Currently, her research focuses on sustainable urban development in Arctic regions, addressing unique challenges and opportunities in these environments. Her contributions to the field are geared toward fostering healthier and more sustainable communities.