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Understanding the Impacts of Arctic Climate Change Through the Lens of Political Ecology

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ABSTRACT

Climate change is a critical global issue with far-reaching implications for the environment, society, and economy. Political ecology examines the relationship between political systems, social inequalities, and ecological concerns in relation to climate change. It focuses on how power dynamics, resource allocation, and political decisions influence vulnerability, adaptation, and mitigation efforts, highlighting the intersectionality between politics, ecology, and climate change impacts. Climate change in the Arctic is having profound geopolitical, environmental, and socioeconomic impacts on Indigenous Peoples. However, few, if any, studies have examined these interactions from a political ecology standpoint. Herein, we review and analyze the complex relationships and power dynamics that shape and are shaped by climate change in the Arctic through a political ecology lens, developing an understanding of how political, economic, and social factors interact to drive climate change impacts and responses. We introduce the term Arctic Political Ecology to understand these dynamics. The paper examines the significance of Indigenous knowledge, environmental governance, and Indigenous Peoples' sovereignty in control over productive resources, promoting sustainable practices, and addressing the challenges posed by climate change. We highlight the need for a comprehensive approach that considers the political ecology of climate change in the Arctic to understand the interplay of capitalism, colonialism, and resource exploitation.

1 | Introduction

Climate change is one of the most pressing global challenges of our time, with overarching consequences for ecosystems, societies, and economies (IPCC 2023). The vulnerability (and resilience) of ecosystems and people to climate change varies across and within regions due to factors such as socioeconomic development, unsustainable ocean and land use, inequity, marginalization, historical and ongoing patterns of inequity such as colonization, and governance, especially for Indigenous Peoples (IPCC 2022). Climate change impacts represent a complex problem that requires a comprehensive understanding of their socioeconomic, political, and cultural contexts, and acknowledgement of broader heterogeneity and connections of agents, communities, and environments that comprise them (Gunderson and Holling 2002; Liu et al. 2007; Naylor et al. 2020). Disparities in vulnerability and exposure emerge because of social, economic, historical, and political factors operating at multiple scales (Thomas et al. 2019; Malik and Ford 2024a). These disparities contribute to varying levels of risks associated with climate change (IPCC 2023).

The Arctic is home to about four million people, with diverse populations consisting of settlers, more recent arrivals, city dwellers, and Indigenous Peoples, including Alaska Natives, First Nations, Inuit, and Metis in Canada, Inuit in Greenland,

and Sámi in Sweden, Norway, Finland, and Russia, speaking over 40 languages and representing more than 40 ethnic groups, with Russia having a diversity of Indigenous Peoples like Aleuts, Enets, and Nenets too from many different groups (AMAP 2021; Arctic Council 2024). Diverse knowledge systems provide pathways for knowing and understanding different aspects of life in the Arctic, including the spiritual, cultural, and ecologically interconnected ways that support the environment and human relationships with the lands, waters, air, plants, and animals (Yua et al. 2022; Eerkes-Medrano and Huntington 2021; Watt-Cloutier 2018). However, the Arctic is facing several issues: diminishing snow cover is threatening wildlife; wildfires are surging in many regions; permafrost is thawing; coastlines are eroding rapidly; communities are experiencing food shortages and risks to their livelihoods and culture; traditional travel routes are becoming unsafe, limiting access to harvesting sites; economic development is exacerbating climate pressures; global and imperial powers are threatening security; and neocolonialism and increased industrial and extractive activities are posing challenges to ecosystems and communities (IPCC 2019; Sakib 2022; Bogdanova et al. 2021; Hossain, Raheem, and Cormier 2018).

The Arctic is at the forefront of climate change, warming nearly four times faster than the globe (Rantanen et al. 2022), with potentially wide-ranging consequences for both the region and globally. It is experiencing amplified climate impacts while also coping with the effects of a growing global rush for resources (e.g., oil, gas, and minerals), the opening of new shipping routes, and associated opportunities (Cohen et al. 2020). Summer sea ice is disappearing at a rate of 12.2% per decade (NASA 2023), with projections indicating potential ice-free summers by the 2030s if global warming exceeds 1.5°C, which would have detrimental effects on rising sea levels (Hoegh-Guldberg et al. 2018). Some studies indicate that the first sea ice-free September will occur as early as the 2030s–2050s, irrespective of emission scenarios (Kim et al. 2023). The reduction of Arctic sea ice has resulted in an upsurge of human activities, with economic, environmental, and cultural implications (Mudryk et al. 2021).

The Russian invasion of Ukraine has had significant repercussions on the geopolitical landscape of the circumpolar north (O'Rourke et al. 2023). The shifting Arctic geopolitical direction is increasingly bifurcating into a "Russian-Asian" and a "Western" sphere (Andreeva et al. 2024), with all seven of the non-Russian Arctic states now members of NATO (Rees and Buentgen 2024). As half of the Arctic and a large portion of the world's permafrost zone lie within Russian territory, the geopolitical tensions have affected scientific collaboration, causing increasingly large data gaps in Arctic research (Rees and Buentgen 2024). "What happens in the Arctic doesn't stay in the Arctic" emphasizes the importance of global concern for issues such as the decline of sea ice, permafrost thawing, melting ice caps, geopolitical posturing, cultural health, and various other interconnected aspects (Huntington 2022).

There is significant geopolitical interest in the Arctic due to its natural resources, strategic location, and climate change (Lebel and Nilsson 2024). This has led to increased interest in commercial shipping and energy resources, the risks and trade-offs of development activities, and resource development (McDowell and Ford 2014). As the ice melts, it creates new navigational paths, facilitating access to valuable minerals and fossil fuels (Alvarez, Yumashev, and Whiteman 2020). Countries with Arctic territories, including Russia, Canada, the United States, Denmark through Greenland, and Nordic nations, are competing to gain control over these resources, asserting their sovereignty and territorial claims, and enhancing their military presence (Kornhuber et al. 2023; Østhagen 2024). This rush for resources mirrors colonial patterns, resulting in the displacement of local communities and the disruption of traditional ways of life (Chi et al. 2024). Historically, the exploitation of resources has played a significant role in the colonization of the Arctic, and the colonial pursuit of valuable minerals, oil, and gas has influenced its history (Southcott et al. 2019; McCannon 2013).

Climate change facilitates the extraction of resources by melting ice and uncovering previously inaccessible areas through the exploitation of Arctic resources by external actors, often at the expense of Indigenous Peoples and their traditional ways of life (Mudryk et al. 2021; Green et al. 2021). The legacy of historical colonial ties intersects with present-day extractive practices. Colonial ties mediated by fossil fuels are linked to the increase in rare earth mineral mining (Hanacek, Kröger, and Martinez-Alier 2024). Arctic resource extraction not only benefits from but also exacerbates climate change by increasing carbon emissions and causing environmental degradation (Hanaček et al. 2022; Vincent 2020). Climate change accelerates these dynamics, making the Arctic a microcosm of global challenges.

Despite the Arctic's increasing significance in global affairs, and multifaceted challenges facing the region, there is a dearth of research that has used a political ecology lens to understand Arctic change as it affects Indigenous Peoples. This paper responds to this gap, using what we call an Arctic Political Ecology perspective to examine and understand the various processes across multiple spatial–temporal scales affecting how Indigenous Peoples experience, contest, and respond to climate change. We argue that political ecology offers a unique—yet largely overlooked in the Arctic—lens to examine the interactions between society, politics, and the environment, emphasizing how power dynamics and social inequalities shape environmental decision-making processes and resource distribution. It recognizes that environmental issues are deeply intertwined with political and economic factors, and emphasizes that climate change is not just a scientific issue but also a deeply political and social one.

Indigenous Peoples refer to communities that share intergenerational ancestry and cultural ties with the original pre-colonial inhabitants of ancestral lands in a specific region of the world (UNDRIP 2007) or those with historical ties to a region before colonization or annexation, who identify as Indigenous, are recognized by their community, and have strong connections to their territories, unique social and political systems, and distinct languages and cultures (UNPFII 2000). Their territories, which include both land and water, along with their spiritual environments, play a vital role in livelihoods, health, and well-being, which for many are closely connected to activities such as hunting, fishing, herding, foraging, small-scale farming, and sustainable land- and water-management practices that have developed

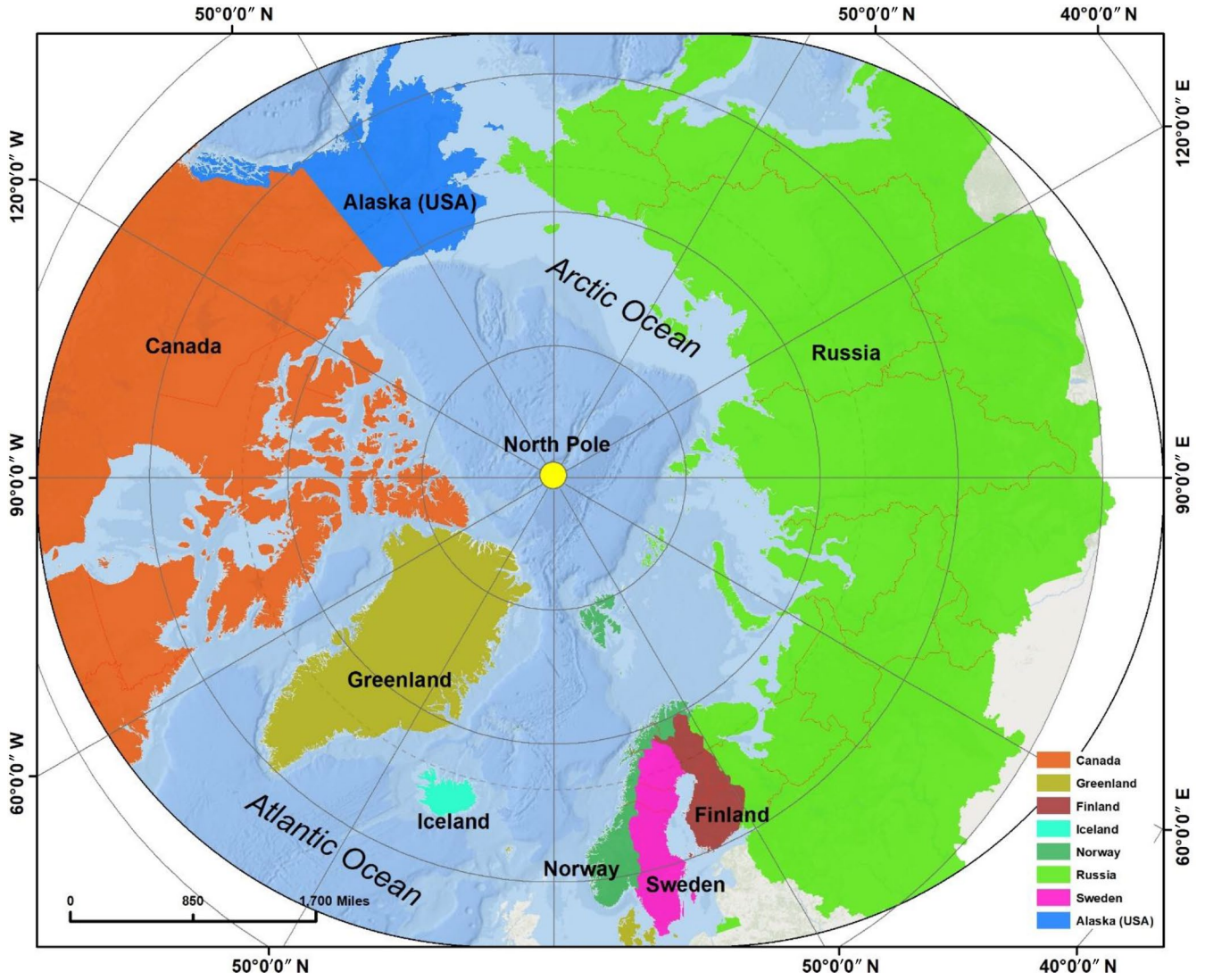

FIGURE 1 | The Arctic region.

over centuries (Ford et al. 2020). The Arctic (Figure 1) is a polar region situated in the northernmost part of the globe, consisting of the Arctic Ocean, including the North Pole, and the northern parts of eight Arctic states, that is, Russia, Canada, Norway, Alaska (United States), Greenland (Denmark), Iceland, Finland, and Sweden (Han, Kim, and Yi 2020).

We begin the paper by reviewing the concept of political ecology and how it has been used in different contexts and then we discuss why a political ecology approach is needed to study Arctic climate change. We then analyze the causes and impacts of climate change in the Arctic and discuss Indigenous Peoples knowledge, resilience, and adaptation strategies. Finally, we examine the interplay of political ecology and Arctic change and how climate change in the Arctic can be understood in a broad context.

2 | What Is Political Ecology?

Political ecology is an epistemologically plural field of scientific inquiry (Tetreault 2017) defined as the study of unequal distribution and control over natural resources, frequently reinforced by ideologies of individual rights and property, at the intersection of ecologically rooted social science and political economy (Peet and Watts 2004; Martinez-Alier 2003). It combines ecological concerns with a broad understanding of political economy and analyzes the dynamic interactions between society, resources, and various social groups and classes within society (Blaikie and Brookfield 1987). Political ecology emphasizes the intersection of political economy and ecology, highlighting the ways in which capitalist processes shape and transform both nature and society (Harvey 2002). It analyzes how and why structural forces and power relations drive environmental change and its impacts in an increasingly interconnected world (Robbins 2019; Biersack and Greenberg 2006; Blaikie and Brookfield 1987). It examines the fundamental linkages between the deterioration of the environment and the marginalization of social groups, the underlying factors and dynamics of resource access and control, and the intrinsic interconnections between geographical locations and individual identity (Robbins 2019). It analyzes the role-played by external forces such as global development and economic modernization in the reconfiguration of local lives and environments (Roberts 2020).

As an analytical framework, political ecology examines the process of politicization of environmental concerns and how global and local power dynamics, and unequal exchanges contribute to varying consequences for different actors due to environmental change (Acheampong 2020). It focuses on analyzing how political and economic power is used to marginalize and dispossess people of their land, resources, and livelihoods, and how this emerges and plays out over time (Gallardo et al. 2017). It examines how humans interact with nature and focuses on the environmental challenges faced by vulnerable communities worldwide, including the unequal effects of climate change, health issues caused by environmental toxins, corporate environmental crimes, deforestation, resource conflicts, land grabbing, and environmental injustices (Batterbury 2018). It helps explain these phenomena by examining the social and political inequalities that contribute to them and analyzing the political sources, conditions, and ramifications of environmental change (Bryant 2015). Political ecology recognizes multiple and contested knowledges, challenges the notion of a single, objective truth, and acknowledges that different actors and communities have diverse ways of understanding and interacting with the environment (Tornel 2023; Tetreault 2017).

Political ecology is an interdisciplinary and global field that primarily emerged and developed within colonial or settler colonial contexts and examines environment–society relations and struggles over access to natural resources (Sultana 2021). It is effective in uncovering the roots of environmental degradation and different forms of injustice (Batterbury 2015) and changes occurring in the lives of people due to socioeconomic and environmental transformations, including the transformation of Indigenous systems (Bassett 1988). Political ecology is thus a field of study that examines the relationships between political, economic, and social factors and their impact on the environment, as well as how power dynamics, policies, and institutions shape environmental issues and resource management and control.

2.1 | Political Ecology as Used in Different Contexts

In the context of climate change, political ecology has been used in research on mitigation, mineral extraction, vulnerability, adaptation, and governance of climate-induced migration (Andreucci and Zografos 2022). It explores the concept of "othering" in connection with the production of the current climate crisis, shedding light on the neoliberal and colonial structures of domination that bear significant responsibility for our present predicament (Klein 2016). Political ecology has been applied in the realms of colonialism and subaltern studies (Spivak 1985), the coloniality of climate change governance and climate refugees (Andreucci and Zografos 2022), green grabbing (Avila Calero 2017), solar colonialism (de Souza et al. 2018), and development studies (Escobar 2011). It assesses the creation of extractivism through various forms of physical and structural violence (Camargo and Ojeda 2017) and examines the connections between extractivism, climate change, and social change; the effects of the commodity boom on the environment, social structures, elite formation, and cultural politics; the effects of resource extraction on the relationships between space and power; and the ways in which the extraction industry has frequently not facilitated effective participation but rather served to open up new extractive frontiers, socioecological harm, violence, and injustice (Bebbington 2015; Schilling et al. 2021; Brock 2023).

Political ecology is used by disaster anthropologists to understand social patterns of vulnerability and resilience (Hoffman and Oliver-Smith 2002). Studies of political ecology have significantly contributed to the understanding of politics, territories, alternative environmental rationality, ecological redistribution conflicts, and resistance based on ecology and culture (Escobar 2008; Leff 2004; Martinez-Alier 2003; Alimonda 2002; Boff 1997; Svampa and Viale 2014). The application of political ecology has been so wide that it led to the creation of several new subfields that include feminist political ecology (Rocheleau, Thomas-Slayter, and Wangari 2013; Sultana 2021), urban political ecology (Zimmer 2010; Neo and Pow 2015), and materialist political ecology (Cederlöf 2015; Hayes-Conroy and Hayes-Conroy 2015), as well as an Indigenous decolonial political ecology (Mignolo and Escobar 2013; Middleton 2015).

Political ecology examines the resistance of Indigenous communities to encroachment, exploitation, and mining operations on their lands and advocates that these movements represent forms of translocal resistance based on the local political ecologies of communities (Banerjee, Maher, and Krämer 2023; Fent 2020). It asserts that resource extraction and conflicts over natural resources are global phenomena and that Indigenous communities are affected by these dynamics as their cultural practices and livelihoods are intertwined with the local ecology (Kumar 2023). Political ecology analyzes how conflict in Indigenous territories is intertwined with state development projects and capitalist interventions. It examines the history of these projects and the associated issues of territorialization, dispossession, accumulation, and marginalization, which communities have been fighting against for decades (Chamie Gandur 2018; Kumar 2023). It examines the impacts of ecological transformation and everyday resistance on the livelihoods and cultural practices of Indigenous Peoples (Kumar 2023; Vaz-Jones 2018).

Political ecology examines the overarching structural processes driving socioecological transformations, while also providing a thorough understanding of the impacts and responses to such changes in local contexts (Roberts 2020). It examines the production of local conditions through interaction with the global political economy, emphasizing that local environmental issues are often influenced by global economic and political processes (McCann 2018). It asserts that power imbalances play a crucial role in shaping the dynamics of environmental conflicts, with a specific focus on the exacerbation of marginalization of vulnerable communities (Bryant 1998). It focuses on the politics of environmental explanation to analyze structural connections of capitalism and environmental degradation (Forsyth 2008). The key themes in political ecology are degradation and marginalization; conservation and control; environmental conflict and exclusion; environmental subjects and identity; and political objects and actors. These theses indicate that environmental degradation has long been blamed on marginalized people but should be shown in a larger political and economic context and that political and economic systems are affected by the non-human

actors with whom they are connected (Robbins 2012, 2019; Malik and Ford 2024b; Malik and Hashmi 2022).

This discussion shows that political ecology stands out as a distinct field of inquiry by integrating the intricacies of political economy with ecological issues, focusing on how power relations and socioeconomic structures shape environmental outcomes. It considers historical processes, such as colonization and development, to understand present ecological conditions and inequalities (Andreucci and Zografos 2022). Concerned with social justice, it emphasizes the unequal distribution of environmental benefits and burdens, especially for marginalized communities. Employing interdisciplinary methods, it critiques dominant environmental narratives and advocates for inclusive, context-sensitive approaches (Robbins 2019). By linking local and global scales, political ecology reveals the interconnectedness of environmental issues and emphasizes local communities' agency, resistance, and adaptation, offering a comprehensive framework for understanding and addressing environmental challenges and political-economic pressures (Roberts 2019). This emphasis on grassroots movements and local resilience offers valuable insights into sustainable and equitable environmental practices. However, political ecology has not been widely used to examine environmental change in the Arctic.

2.2 | Why Do We Need a Political Ecology of Arctic Change?

Writing on the relevance of political ecology in analyzing current environmental issues, Paul Robbins (2012, 2019) notes that if political ecology is no longer relevant, no one bothered to tell the world. This is especially true in the Arctic, where relatively little attention has been given to political ecology (Benjaminsen et al. 2015; Cavanagh and Benjaminsen 2017; Benjaminsen and Robbins 2015; Benjaminsen 2015), but we propose that it is a key concept for understanding the changes occurring.

While scholars have discussed resource extraction, governance of marine resources, water governance, social and cultural impacts of resource development, resource extraction policies, maritime law, and governance in the Arctic (Bernauer 2019; Snook et al. 2022; Natcher, Felt, and Procter 2012; Procter 2020; Wilson 2019; White 2020; Bailey and Charles 2024; Chircop 2022), political ecology provides a broader theoretical and analytical framework that can deepen the understanding of how global and local power dynamics and neoliberalism intersect. It provides a more comprehensive critique of resource extraction practices and their socioenvironmental and political impacts. It advocates for Indigenous Peoples' sovereignty, resistance, activism, ownership, and control over productive resources, and environmental governance to promote Indigenous self-determination and resist environmental colonialism, under which Indigenous Peoples are separated from their lands and waters in the name of environmental protection (Clark, Fisher, and Macpherson 2024). Political ecology examines the process of development policies and projects shaping and restructuring the resource-rich ecology in the Indigenous territories and addresses the interrelated issues of development-induced dispossession, ecological transformation, governance, illegalities, state-building, and resistance (Kumar 2023). It analyzes the impact of development initiatives on Indigenous Peoples and explores the factors that contribute to their resistance and negotiation.

We argue for applying a political ecology approach in the context of climate change to understand changes and risks and generate new narratives that are embedded in the complex Arctic physical and cultural environment. We suggest that political ecology is particularly important in the Arctic because of the region's susceptibility to climate change and its associated impacts. It enables an exploration of how Indigenous communities, who have traditionally relied on the Arctic's resources, are often marginalized in decision-making processes and face barriers in asserting their rights and interests. By proposing what we call an Arctic Political Ecology perspective, we provide insights into the complex interactions between society, politics, and the environment in Arctic regions, developing understanding on the drivers of vulnerability, adaptation, resilience, sovereignty, resistance, and other dynamics at play.

We define Arctic Political Ecology as the application of political ecology to critically examine the intricate social, political, and environmental transformations in the Arctic to understand and analyze vulnerability, adaptation, resilience, and sovereignty of Arctic communities. It delves into the historical and ongoing impacts of colonialism and neocolonialism, scrutinizing how these processes, along with the forces of capitalism and neoliberalism, perpetuate environmental degradation, inequity, exploitation, and marginalization of Indigenous Peoples and local populations. By analyzing the interplay between political decisions, power dynamics, cultural influences, and environmental factors, Arctic Political Ecology reveals the complex interactions that shape the lived experiences and ecological landscapes of the Arctic. It suggests that the changes in the Arctic should be understood within the broader context of global socioeconomic and environmental impacts. It advocates decolonization by promoting equitable governance that respects Indigenous knowledge, leadership, and rights, emphasizing Indigenous agency and resilience, and supporting self-determination, cultural preservation, and control over productive resources. It focuses on the amplification of Indigenous voices and the incorporation of Indigenous concerns, priorities, and methodologies in research processes.

Arctic Political Ecology is helpful in examining the political and economic factors driving various activities and changes in the Arctic. It would help in examining the social and environmental consequences of these activities, particularly in relation to local communities and Indigenous Peoples who rely on the Arctic for their traditional livelihoods. The implications of these developments extend far beyond the Arctic region, affecting global climate patterns, international relations, and human rights.

Political ecology suggests that the relationship between humans and their environment through subsistence labor exerts a significant impact on social order (Robbins 2019). Steward (1955) argues that the fundamental elements intimately tied to subsistence practices and economic structures represent the “culture core” of a given society. In the Arctic, a significant proportion of Indigenous Peoples engage in subsistence harvesting (AHDR 2015), thereby shaping the fabric of social order and interpersonal dynamics within communities. Political ecology

lens is relevant to examine the negative impacts of colonialism on Indigenous communities, which extend to the deterioration of food culture and culture-carrying subsistence activities. The traditional economic pursuits within Arctic communities hold substantial social and cultural importance, effectively constituting their culture cores. Applying political ecology is crucial in understanding the impacts of global capitalism and neocolonialism on Arctic Indigenous communities and how these forces have engendered the commodification and exploitation of natural resources, the displacement of Indigenous communities, the erosion of traditional livelihoods, and the degradation of the environment, creating widespread inequalities and injustice.

3 | Climate Change in the Arctic: Causes and Impacts

The Arctic is warming due to anthropogenic climate change (Meredith et al. 2019), which is amplified because the diminishing Arctic sea ice cover intensifies the warming effect in the region (Dai et al. 2019). The region has also been heavily impacted by anthropogenic activities that take place elsewhere such as the release of pollutants (Pechsiri et al. 2010) and greenhouse gas (GHG) emissions (Moritz, Bitz, and Steig 2002), resulting in significant changes. Global warming caused by anthropogenic GHG emissions is leading to a significant reduction in Arctic's sea ice (Stroeve et al. 2012). Climate change is not an isolated phenomenon but rather an integral part of the global climate system. It is both influenced by and impacts global climate change, which can be understood by political ecology as it analyzes the interconnectedness of global impacts and the influence of global phenomena on local contexts. The increase in wildfire seasons in the Arctic has made forest fires more intense and destructive (Senande-Rivera, Insua-Costa, and Miguez-Macho 2022), resulting in deforestation and loss of forest cover (Van Wees et al. 2021) due to a combination of climate and nonclimatic factors (IPCC 2021). In conjunction with the effects of climate change, various other human-induced stressors such as air and water pollution, overfishing, depletion of the ozone layer, habitat modification and pollution resulting from resource extraction, and the escalating pressure on land and resources concurrently affect life in the Arctic (Davis et al. 2022; AHDR 2015).

Global environmental change is contributing to an increase in extractive activities in the Arctic by opening new shipping routes (Landrum and Holland 2020). Natural resource extraction, particularly iron ore extraction, is increasing, also contributing to more shipping. The sailing distance of bulk carriers has increased by 160% between 2013 and 2019 (PAME 2020). One of the richest iron ore deposits ever discovered, opened in 2014 in Nunavut, Canada, called the Mary River Mine, involves the seasonal shipping of approximately 3.5 million metric tonnes of iron ore during the open water season (PAME 2020). Ship traffic in the Canadian Arctic has nearly tripled over the past decade (Dawson et al. 2020). Lasserre (2019) documented a 30% increase in recorded sailings in Greenland between 2004 and 2013. Li and Otsuka (2019) found that the annual number of ships transiting through the Northern Sea Route (NSR) increased from 228 in 2013 to 301 in 2017, reaching a peak of 317 in 2016. The shipping activity in the Arctic experienced a growth of 25% from 2013 to 2019, and the distance sailed by all the vessels increased by 75% (PAME 2020). Shipping activities have impacted biogeophysical systems, including the atmosphere and the ocean. In the atmosphere, shipping contributes to GHG emissions and the release of black carbon, which accelerates ice melting (IMO 2021). In the ocean, shipping causes pollution, overharvesting of marine resources, disturbances to marine species, underwater noise pollution, and the introduction of invasive species (Stafford 2021). These impacts pose risks to the environment and society, particularly for Indigenous Peoples who rely on these systems (Berkman et al. 2022; McDowell and Ford 2014).

The Arctic is believed to hold up to 13% of the world's undiscovered oil, 30% of the world's undiscovered natural gas, and 20% of the world's undiscovered natural gas liquids, and approximately 84% of the estimated resources are expected to be found offshore (USGS 2008). With the melting of Arctic ice, there is increased exploration and production of fossil fuels in the area, further leading to climate change. Siberia alone is believed to have petroleum reserves equivalent to those in the Middle East (Chalecki 2007). As temperatures rise, permafrost melting could cause landslides, erosion, subsidence, and ground displacement that would impact the infrastructure buildings, pumps, pipelines, and worker housing that are already built on permafrost (Hjort et al. 2018). The sectors most likely to be affected are institutional buildings, electric power infrastructure, and transportation engineering infrastructure (Debortoli, Pearce, and Ford 2023). The reduction of sea ice extent in the Arctic Ocean has been observed in all months and nearly all regions during the past three decades, resulting in a significant decline of approximately 75% in ice volume since the 1980s (Gerland et al. 2019; Screen and Francis 2016).

Indigenous Peoples of the Arctic are facing threats to their livelihoods due to industrial development. This includes the destruction of caribou pastures and ecosystem degradation caused by industrial infrastructure, pollution, and sea ice loss (Normann 2021; Cunsolo et al. 2020). High *Rangifer tarandus* mortality has serious implications for the future of Arctic nomadism (Forbes et al. 2016, 2022). The construction of hydroelectric power dams has led to the flooding of valuable subsistence areas and increased pollutants in the Arctic (Schartup et al. 2015). Forest fires are becoming more frequent in some regions due to factors like poaching, increased recreational activities near industrial areas, climate change, lightning, fuel conditions, and human activity (Rein and Huang 2021; McCarty et al. 2021). The early-season fires and fires on permafrost are becoming more severe. These fires, including "zombie fires" that smolder underground, have significant local and global impacts, including the acceleration of thawing permafrost and increased carbon emissions (McCarty, Smith, and Turetsky 2020).

The historical legacy of colonization and climate change have contributed to the long-term infrastructural vulnerability in the Arctic (Povoroznyuk et al. 2022), and is linked to contemporary exposure to hazards and increased vulnerability (Marino 2012). For instance, in coastal Alaska and northern Canada, traditionally mobile groups were forcibly relocated

into fixed settlements, which are now susceptible to the rising sea levels caused by climate change and experiencing adaptation challenges (Magnan et al. 2022; Bronen and Chapin 2013). These examples highlight the complex interplay between climate change, nonclimatic factors, and historical processes in shaping vulnerability.

Indigenous knowledge holders' observations are important for understanding the impact of climate change on ecosystems and societies, and they have observed unprecedented temperature increases, altered precipitation patterns, and changed weather patterns in the Arctic, affecting both terrestrial and marine environments (Savo et al. 2016; Reyes-García et al. 2024). Arctic societies have shown resilience to climate change, but vulnerabilities are emerging due to changing environmental conditions and socioeconomic pressures (Ford et al. 2021). Radon, a leading cause of lung cancer, has higher death rates in Arctic communities (Glover and Blouin 2022). The thawing of permafrost due to climate change could expose a large Arctic population to dangerous levels of radon, leading to increased cancer cases. This would impact health services, building codes, and ventilation advice (Glover and Blouin 2022). Livelihoods and cultural activities linked to subsistence harvesting have been impacted by changes to wildlife, worsened by long-term land dispossession and landscape fragmentation (Ford et al. 2021). Snow cover duration in the Arctic has shortened by 2 to 4 days per decade, while sea ice extent and volume have decreased, contributing to global sea-level rise (Box et al. 2019). Higher temperatures and drier conditions have increased the risk of wildfires, disrupting the carbon cycle and affecting Arctic ecosystems (Romanovsky et al. 2017; Vihma et al. 2016).

Arctic communities are experiencing the effects of climate change due to their dependence on climate-sensitive resources and environments for livelihoods, such as wildlife and sea ice, and the cultural significance of harvesting, preparation, consumption, and sharing (Kenny et al. 2018). The increased activities in the Arctic have led to a range of environmental consequences impacting the sustainability and cultural considerations of inhabitants in states of Norway, Russia, USA/Alaska, Canada, and Greenland/Denmark. These changes have widespread consequences for local communities, affecting their livelihoods, well-being, and food security (Huntington et al. 2023; Osmundsen 2023; Richard et al. 2023). Arctic coasts are experiencing rapid change, particularly during the sea ice-free period. The erosion of permafrost coasts in Alaska, Canada, and Siberia has doubled since the early 2000s due to anthropogenic warming (Irrgang et al. 2022). The livelihood, health, and cultural identity of Arctic communities are impacted, as are their access to food availability, herding, hunting, fishing, foraging, and gathering places (Meredith et al. 2019). Consequently, these communities have encountered compromised food security, escalating risks linked to traditional practices like hunting, fishing, and trapping, and constraints on hunting during specific periods (Ford and Pearce 2010; Harper et al. 2012). These circumstances have affected mental health and are linked to the occurrence of ecological grief due to ecological losses caused by environmental change (Cunsolo and Ellis 2018). The mental well-being of Arctic communities is affected by the rapid environmental changes resulting from climate change, which disrupts the relationship between people, places, livelihoods, and cultures (Middleton et al. 2020). The rapid reduction of the number and access to *Rangifer tarandus* for harvesting, as well as the subsequent impacts on food systems, cultural continuity, community relationships, and health and well-being in the circumpolar north, have been connected to ecological grief (Cunsolo et al. 2020; Borish et al. 2021).

Political ecology asserts that global capitalism expands and exploits natural resources, resulting in environmental degradation and social inequality, affecting nature and society (Harvey 2010). Capitalist practices such as land grabbing and privatization result in "accumulation by dispossession" and dispossess communities, creating environmental injustices (Harvey 2018), which is evident at several places in the Arctic (Medby 2019; Shaw 2017). Political ecology is useful to understand how Indigenous Peoples are disproportionately affected by climate change and how global environmental change and vulnerability are the result of the nexus of ideas, institutions, and interests that have combined to accumulate power at the expense of people and the planet (Robbins 2012; Barnett 2020). Arctic Political Ecology addresses climate change impacts by integrating diverse knowledge systems, examining power dynamics, advocating interdisciplinary research, and ensuring comprehensive and equitable climate policies. This approach emphasizes the importance of environmental and climate justice, incorporating local and Indigenous voices and governance frameworks to respond effectively to climate change.

4 | Indigenous Peoples' Knowledge, Resilience, and Adaptation in the Arctic

The Arctic encompasses approximately 500,000 Indigenous Peoples (10% of the total population in the Arctic) residing within the territories of Canada, Alaska, Greenland, Russia, Norway, Sweden, and Finland (Figure 2) (Ford, McDowell, and Pearce 2015; Young and Bjerregaard 2008; Coates and Holroyd 2020; Arctic Council 2024). Diverse Indigenous Peoples live in the Arctic and have developed rich cultures, knowledge systems, and governance over millennia (Yua et al. 2022). Many Indigenous Peoples practice domestic harvesting that helps to inform their relationships to the Arctic environment, as well as their approaches to environmental management and decision-making (Falardeau et al. 2022; Spring et al. 2023). Many Indigenous Peoples live in small coastal communities with economies dependent on waged employment and subsistence harvesting (AHDR 2015, Poppel et al. 2007).

Climate change has increased the vulnerabilities of Indigenous Peoples in the Arctic, which are linked to historical and ongoing colonialism, land dispossession, unequal recognition of Indigenous rights, fragmentation of landscapes, and the social and environmental impacts of industrial development (Kuokkanen 2023; Schmaus 2023). These patterns have introduced new risks and increased susceptibility to climate-related consequences by modifying human–environment relations like settlement patterns and land use, undermining historical resilience factors like knowledge generation and transfer, and affecting human rights (Naylor et al. 2020; Farrell et al. 2021; Cullen 2022; Kuokkanen 2023).

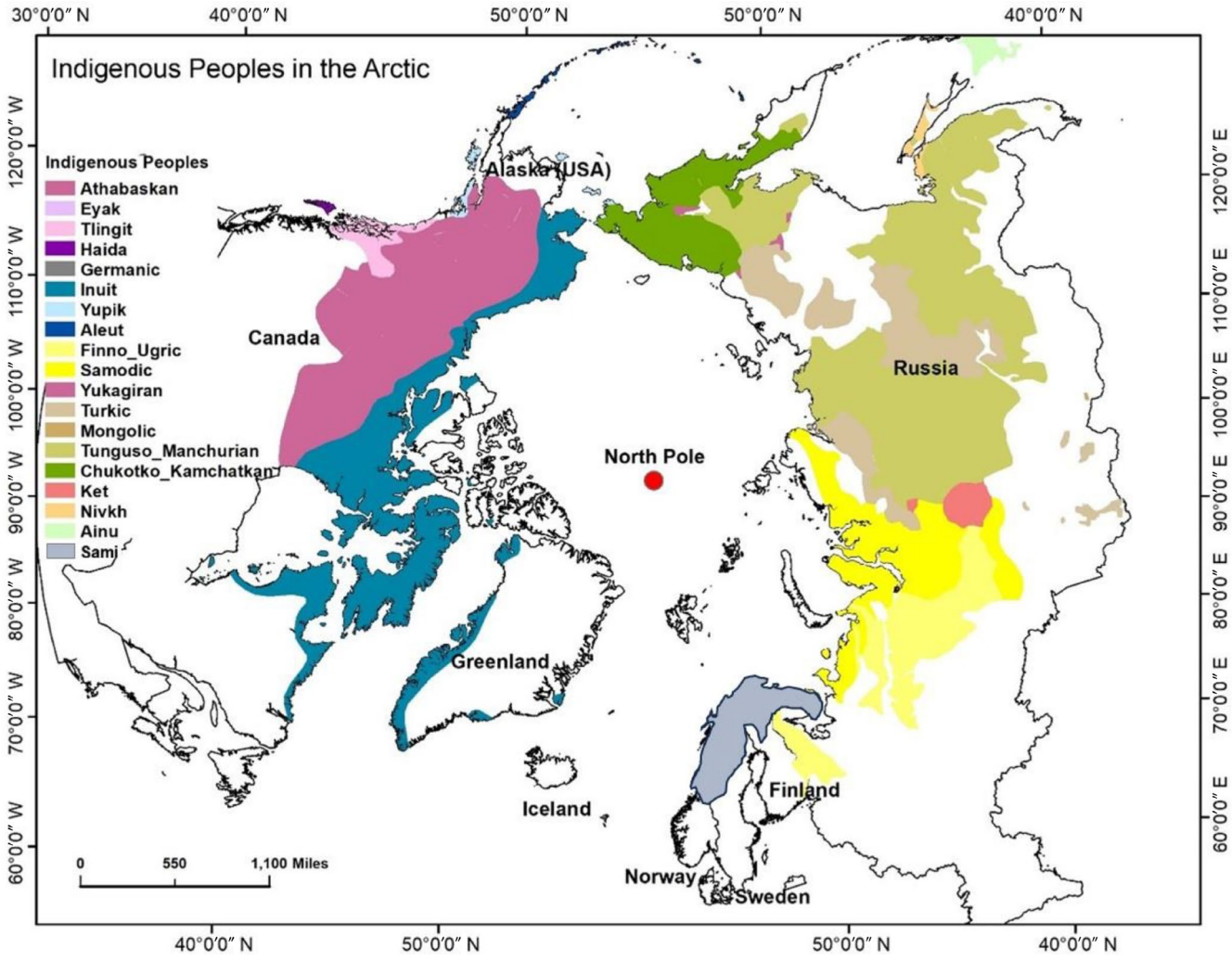

FIGURE 2 | Distribution of Indigenous Peoples in the Arctic.

Arctic Political Ecology holds significant importance for understanding the changes and adaptations of Indigenous Peoples in the Arctic. It reveals how preconceived solutions to environmental issues can undermine the knowledge and practices of Indigenous communities and philosophies, which embrace uncertainty and focus on flexibility and improvization and can be highly effective in knowing the Arctic environment (Jones 2008; Bates 2007). Research methodologies often assume a single characterization of time and sentience that applies to all Arctic residents, but emphasis should be placed on the importance of recognizing and respecting cultural differences in research methodologies (Natcher et al. 2007). Political ecology re-evaluates the temporal aspects of environmental research by emphasizing the historical resilience and adaptability of Indigenous resource management to enhance sustainability through resource management decisions (Snook et al. 2020). Vadjunec, Schmink, and Greiner (2011) argue that Indigenous concerns, which have emerged alongside neoliberal reforms, cannot be fully understood without considering the associated shifts in identity. This highlights the significance of emerging research that combines Indigenous knowledge with political ecology, enabling a cross-scale analysis that incorporates elements of identity, culture, and the environment.

Indigenous knowledge is vital in understanding Indigenous Peoples adaptation, and resilience and achieving long-term goals (Nakashima et al. 2012). Current practices often treat Indigenous knowledge as mere data to be aggregated and used in decision-making without recognizing Indigenous sovereignty and rights (Petzold et al. 2020; David-Chavez and Gavin 2018). There is a need for knowledge co-production in global environmental change research and a shift in the approach to knowledge co-production, moving away from integrating Indigenous knowledge into western science and instead giving Indigenous research leadership and respecting Indigenous governance of knowledge systems and Indigenous lands (Latulippe and Klenk 2020). The solutions-based research on climate change should not view it as a purely technical problem, but rather because of European and North American colonization. To effectively address climate change, the research process should be decolonized, and approaches should be transformed to include the knowledge systems of Indigenous Peoples and local communities (Orlove et al. 2023). Arctic Indigenous Peoples possess deep knowledge about the Arctic environment, which they use to forecast weather conditions and integrate into their daily lives, as well as traditional cultural practices and adaptations to climate change (Gearheard et al. 2010; Weatherhead, Gearheard, and

Barry 2010; Eerkes-Medrano and Huntington 2021). Indigenous observations and interpretations of meteorological phenomena have long been instrumental in guiding the seasonal and interannual activities of local communities for thousands of years (Nakashima et al. 2012).

Indigenous communities have developed sustainable hunting, fishing, and gathering practices that have allowed them to thrive in the Arctic environment for generations (Krupnik et al. 2010; Gladun et al. 2021). Their knowledge of seasonal variations, migratory patterns, and ice conditions can inform sustainable resource management and help mitigate the impacts of climate change on traditional livelihoods (Gladun et al. 2021; Nuttall et al. 2005). Indigenous knowledge systems include ecological insights, weather forecasting techniques, and agricultural practices that are proven to be adapted to local conditions, extreme weather conditions, changing patterns, and the delicate balance of Arctic flora and fauna (Petzold et al. 2020; Hosen, Nakamura, and Hamzah 2020). These knowledge systems are not only factual but also embedded in cultural and spiritual beliefs, values, and practices. They emphasize the importance of sustainable resource management, harmony with the environment, and respectful coexistence with flora and fauna (Mazzocchi 2020). Indigenous communities deeply respect and value the intricate relationships between plants, animals, and the overall ecosystem, understanding that any disruptions to this balance can have far-reaching consequences (Domínguez and Luoma 2020). Sharing knowledge is a core principle, with insights passed down through generations via oral traditions, storytelling, and community practices. This sharing extends beyond Indigenous communities to neighboring groups and wider society, promoting the exchange and preservation of wisdom (Johnson et al. 2016; Mazzocchi 2020).

Traditional Ecological Knowledge (TEK) plays an important role in Arctic Indigenous Peoples' adaptation to climate change. Indigenous knowledge of the environment, hunting practices, and emergency preparedness contribute to adaptation to changes in subsistence hunting (Pearce et al. 2015). Indigenous knowledge and knowledge-based practices serve as the fundamental pillars of resilience. For instance, despite shifting ice conditions due to climate change, Inuit knowledge of sea ice patterns enables safer travel and hunting (Forsythe 2023). Sami are using traditional knowledge to locate and sustainably harvest herbs like *Angelica archangelica*, which is crucial for health and well-being, supporting community health, and fostering resilience by maintaining biodiversity and ensuring access to natural remedies (Rautio, Linkowski, and Östlund 2016). Despite the susceptibility of Indigenous Peoples to environmental, social, economic, and technological changes, they have exhibited proactive responses to changing climatic conditions and have showcased resourcefulness, resilience, and high adaptive capacity (Huntington et al. 2021; Robards et al. 2018; Ford et al. 2021). Factors such as attachment, place, agency, institutions, valuing the environment, collective action, community relationships, support systems, cultural continuity, Indigenous knowledge, and learning are important for Indigenous Peoples resilience and strength in the face of generations of change and violence derived from extensive historical colonization and oppression (Bailey 2020; Huntington et al. 2018; Ford et al. 2020; Kral et al. 2014). Indigenous communities in the Arctic have rich cultural traditions and practices that provide a sense of identity, connection to the land, and social support (Nuttall 2019). Despite pressures from climate change, resilience is a living testimony of their strength that helps maintain their way of life and strengthens coping mechanisms against disasters (Desjardins, Friesen, and Jordan 2020; Reid 2019). Their resilience stands as a testament to their strength and adaptability to the challenges posed by climate change, drawing upon their rich cultural heritage, traditional ecological knowledge, and diverse livelihoods to navigate shifting landscapes (Jungsberg and Wendt-Lucas 2023; Ford et al. 2020). Their advocacy efforts for land rights, adaptation funding, and consultation are important not only to the Arctic but also to global climate resilience.

Through Indigenous knowledge, community resilience, and health emergency preparedness, the challenges faced by Indigenous Peoples and the strategies they have used to respond to these crises include the use of natural resources, traditional agricultural practices, and community cohesion (Zavaleta-Cortijo et al. 2023). Arctic communities have used different ways to adapt to the changing climate conditions. The Yupik community on St. Lawrence Island in Alaska, for instance, has implemented a winter whaling season (Noongwook, Huntington, and George 2007). Similarly, various Indigenous groups such as the Evenki, Sakha, Yamal-Nenets, Khanty, and caribou herders in Siberia have diversified their livelihoods by engaging in ethno-tourism, producing traditional arts and crafts for sale (Huntington et al. 2019). The Inughuit community residing in northern Greenland has initiated a commercial halibut fishery (Berthelsen 2014), and the communities of Clyde River in Nunavut, Canada have successfully established a research center that primarily focuses on conducting Inuit-led research projects (Ittaq 2019).

The historical trajectory of human habitation in the Arctic is characterized as a continuum of adaptive strategies and resilience, wherein cultural mechanisms have progressively evolved to effectively address the unique attributes of the local environment (Krupnik 2002; McGhee 2006). The social–ecological resilience required to effectively cope with heightened variability, unpredictability, and adapt to change is facilitated by diverse knowledge systems, community-based institutions, effective social networks, diversification, and adaptive co-management (Galappaththi et al. 2021). The presence of traditional governance systems and social networks further enhances the collective capacity to effectively respond to environmental transformations, thereby augmenting overall resilience (Nakashima et al. 2012).

Indigenous Peoples experience marginalization in climate change through disproportionate climate impacts threatening their livelihoods and cultural practices, which have close connections to land, water, and ecosystems, and systemic discrimination and exclusion from political and economic power (Redvers et al. 2023; United Nations 2009). They are impacted first, facing the impacts of climate change adaptation efforts more strongly and unequally, which is akin to the last straw, compounding disadvantages and inequalities (Friedrich 2023; Hernandez and Spencer 2020; Kaijser and Kronsell 2014). However, they significantly contribute toward the development of global solutions (Nitah 2021). For example,

Indigenous Peoples cover at least one-quarter of Earth's terrestrial area and manage nearly 40% of the world's protected lands and areas rich in biodiversity (O'Bryan et al. 2021; Fa et al. 2020). In Canada, Indigenous Peoples have provided valuable data on ice melt, wildlife migration patterns, and climate change and are leading the biggest and most ambitious proposals for protecting lands and waters (Nitah 2021). This underscores the imperative for a multidimensional approach that encompasses justice at the local, subnational, and national levels. The matters pertaining to procedural and recognition justice frequently revolve around critical concerns, such as ensuring equitable participation of states in negotiations and acknowledging the status of Indigenous Peoples within these deliberations (Coggins et al. 2021). Indigenous Peoples' adaptation solutions can inform broader strategies, and their participation in negotiations is crucial for safeguarding human rights, including the right to self-determination (Comberti, Thornton, and Korodimou 2016). Indigenous communities have persistently advocated for recognition and respect of their knowledge systems as part of their struggles for self-determination (Orlove et al. 2023), which is important for recognition of their rights and sovereignty as advocated by Arctic Political Ecology.

5 | Arctic Political Ecology: Interplay of Political Ecology and Arctic Changes

The interplay between political ecology and Arctic changes (Figure 3) offers insights into the socioenvironmental dynamics of the region. By applying Arctic Political Ecology perspective in the Arctic, we can gain valuable insights into the socioeconomic complexities of the region. This understanding enables us to understand climate change, resource exploitation, and geopolitical rivalries and work toward equity, sustainable development, respect for Indigenous rights, and collaborative governance approaches, ensuring the long-term well-being of the Arctic and its inhabitants.

Colonization has had detrimental effects on Indigenous communities, resulting in extensive disruptions and devastation. This has been primarily manifested through the dispossession of land, forced resettlement, and the fragmentation of landscapes, which have collectively impeded and, in certain cases, severed the essential connections Indigenous Peoples have with their ancestral territories (Ford et al. 2020). The Arctic has experienced colonization in the past and continues to be partially colonized because of the expansion of new

FIGURE 3 | Elements to be considered in an Arctic Political Ecology analytic.

commodity frontiers (Hanaček et al. 2022), and the region is viewed as a semi-colonial resource and commodity frontier (Engerman 2003; Körber, MacKenzie, and Stenport 2017). Climate change is only one of many drivers of change. Its effects cannot be isolated from the social, political, economic, and environmental changes confronting present-day Indigenous and marginalized communities. These impacts interact together and induce exacerbating and cascading effects (Nakashima et al. 2012; Naylor et al. 2020). Displacement and fragmentation of the land challenge Indigenous knowledge systems and institutions, exacerbated by environmental change. These vulnerabilities are linked to colonization, globalization, and development patterns, highlighting the need to address structural challenges (Ford et al. 2020). The impacts of climate change bear a profound connection to colonial assumptions and practices, necessitating a comprehensive evaluation of these assumptions and exclusions. It is crucial to recognize the wider colonial and political–economic backdrop within which Indigenous Peoples experience the impacts of climate change (Cameron 2012).

The dislocation of Indigenous communities from their ancestral lands has had significant implications for their resilience and knowledge systems. Younger generations are becoming less connected to traditional knowledge due to land dispossession, which affects their ability to understand and respond to environmental conditions (Ford et al. 2020). Young Indigenous People today spend less time involved in subsistence activities, resulting in fewer opportunities to learn necessary skills for safe travel and hunting in changing climatic conditions (Pearce et al. 2015). Arctic Indigenous Peoples, like Inuit in Canada, have been severely affected by colonization, capitalism, and economic, industrial, and military drivers behind anthropogenic climate change, resulting in climate-related risks, loss of language, tradition, knowledge, and traditional practices, as well as impacts on health and economic sustainability (Whyte 2019; Friedrich 2023; Mustonen 2013). Arctic Political Ecology analyzes these issues to uncover and understand the historically rooted power dynamics and social implications associated with exploitation and climate change. It provides a thorough examination of historical factors, cosmological beliefs, and management strategies to gain insight into how these communities perceive and adapt to environmental changes and how the ramifications of the historical factors create the current vulnerability.

Arctic Indigenous Peoples have experienced significant social change imposed by external influences such as explorers, settlers, missionaries, and governments (Hanrahan 2012), linking Arctic changes with broader context of political ecology. The resilience and vulnerability to environmental change are socially constructed and linked to issues of sovereignty, power, social justice, development, and history. In the Arctic, this involves recognizing and protecting Indigenous sovereignty and rights, which can include measures like political devolution, resolving land claims, acknowledging customary regulations and institutions, protecting Indigenous lands and resources, and incorporating Indigenous knowledge and institutions into resource management (Ford et al. 2020). Failure to address root causes and political dynamics can lead to governance traps and harm Indigenous Peoples (Morrison et al. 2020; Whyte 2020; Eriksen et al. 2021).

Political ecology suggests that the connection between climate change and economic interests in the Arctic is inseparable from the ongoing local struggles against historically unjust and disproportionately adverse socioenvironmental consequences in territories primarily inhabited by Indigenous Peoples (Avango and Roberts 2017; Cameron 2012). The extraction of commodities such as gold, oil, and natural gas has historically incurred, and continues to incur, significant social and environmental costs (McDowell and Ford 2014; Shadian 2018). The extensive extraction activities, coupled with the current climate change, pose substantial threats to the livelihoods, socioenvironmental conditions, and cultural well-being of communities (Alvarez, Yumashev, and Whiteman 2020). These threats manifest in various ways, including restricted access to their land, loss of territorial rights, negative impacts on health, biodiversity depletion, and the erosion of culture and identity associated with alterations in their surrounding icescapes (Herrmann and Heinämäki 2017; Malik et al. 2024). The Arctic has experienced significant extraction activities on both Indigenous and non-Indigenous lands, prompting local communities and others to resist these activities (Kröger 2019). People are demanding greater participation in addressing issues of physical exploitation and climate change in the region (Nuttall 2013), which pose challenges to extractive industries, states, and other entities with economic interests that endanger the environment and the traditional way of life of local communities (Dwyer and Istomin 2009; Kröger 2019; Bendixen et al. 2022). Consequently, political ecology is useful to conduct an analysis of socioenvironmental conflicts in the Arctic that goes beyond specific countries and commodities to assess the impact of economic extraction of natural resources on the traditional ways of life and survival of affected Arctic communities (Alvarez, Yumashev, and Whiteman 2020; Lassila 2021).

Indigenous governance, sovereignty, and control over lands emerged as important features of independence, resource management, decision-making, and the right of Indigenous Peoples to govern Indigenous lands and celebrate and preserve Indigenous cultures in the Arctic (Liboiron et al. 2021; Bernauer 2019; Cadman et al. 2023; Snook et al. 2022). Indigenous sovereignty over their lands has played an important role in countering capitalism and the violent enactment of colonial land relations that claim access to Indigenous lands (Bankes 2020; Liboiron 2021; Snook et al. 2019). Political ecology looks at how power dynamics affect the distribution and exploitation of resources such as fisheries, minerals, oil, and gas and evaluates external pressures from governments, corporations, and global markets seeking to exploit these resources (Brock 2023; Malik 2024; Robbins 2019). By examining power dynamics in the Arctic, Arctic Political Ecology can offer insights on who bears the costs and benefits from resource extraction. Arctic Political Ecology places a strong emphasis on environmental justice, advocating for the equitable distribution of environmental benefits and burdens. In the Arctic, this means recognizing Indigenous rights to self-determination, cultural preservation, and access to resources, and control over productive resources. The advocacy of Arctic Political Ecology for Indigenous sovereignty, self-determination, and territorial autonomy aligns with human rights principles, including the right to participate in decisions affecting their lands.

The Arctic is experiencing increased accessibility to resources due to climate change, but this has led to negative consequences

for the environment and Indigenous communities (Landrum and Holland 2020; Bennett 2016). Extractive economies primarily benefit a limited number of stakeholders and foreign investors, while Indigenous communities, pastoralists, and fishermen bear the effects (Moore 2018; Cameron 2012). Traditional land-use and territorial rights of Indigenous Peoples are being undermined by extractive and industrial activities, resulting in the displacement of common lands and traditional ways of life. Consequently, the extensive extraction and utilization of resources are causing irreversible socioenvironmental damage and fueling intense conflict in the region (Herrmann and Heinämäki 2017; Naykanchina 2012; Keil 2014). The introduction of wind power (characterized as green colonialism) is perceived by some Arctic Indigenous Peoples (e.g., the Sami of the Norwegian Arctic) as a continuation of historical processes of dispossession and colonialism, which disrupt reindeer herding practices (Soili, Tanja, and Ilari 2021; Normann 2021). The ecological evidence supporting the dominant narrative and associated policy about the Arctic pastoral landscape overlooks alternative scientific evidence, interpretations aligned with nonequilibrium ecology, and Indigenous knowledge of reindeer herders. Consequently, these alternative perspectives are often ignored by government institutions regulating caribou management (Benjaminsen et al. 2015).

The importance of Arctic Political Ecology is strongly linked to the impacts of global capitalism and colonialism on Arctic and Indigenous Peoples. The influences of global capitalism and colonialism on Arctic and Indigenous communities have had significant and wide-ranging consequences, resulting in the commodification and exploitation of natural resources, the displacement of Indigenous communities, the loss of traditional livelihoods, environmental degradation, the expropriation of homelands, and historical trauma affecting health and well-being (Hanaček et al. 2022; Owens 2018; Smallwood et al. 2021; Jalata 2011). Colonialism and capitalism have imposed foreign cultural norms and legal systems on Indigenous Peoples, eroding cultural identity and self-determination (Dodds and Smith 2023; Nuttall 2019). The impacts of global capitalism and colonialism intersect perpetuating power imbalances and marginalization. These influences have severe environmental implications, including pollution, climate change, and threats to traditional subsistence practices (Owens 2018; Hobart 2023). Indigenous Peoples bear disproportionate impacts from resource-intensive and resource-extractive industries (United Nations 2009).

Challenges remain in recognizing and implementing Indigenous Peoples' rights as they face risks and reprisals for defending their lands (UNDES 2021). The vulnerability of Indigenous Peoples caused by capitalism and colonialism continue to be significant challenges (Penados, Gahman, and Smith 2023; UNDES 2021). Indigenous Peoples face challenges in asserting their rights in sectors such as the extractive industry, agribusiness, infrastructure development, and conservation, which are connected to global capitalism (Bainton 2020; UNDES 2021). Despite these challenges, Indigenous communities in the Arctic have shown resilience and resistance through political activism and cultural revitalization efforts, and addressing the injustices requires inclusive approaches that prioritize Indigenous rights, self-determination, and sustainable development (Bennett et al. 2023; Snelgrove, Dhamoon, and Corntassel 2014; Ford et al. 2020).

We contend that the application of Arctic Political Ecology is essential for understanding the intricate nature of global capitalism, colonialism, and climate change. By facilitating a dialogue between Indigenous knowledge and diverse knowledge systems and ontologies, political ecology, grounded in the decolonial approach, is useful in developing conceptual approaches and methodologies that are applicable to complex societies worldwide. By using the insights from Indigenous knowledge and incorporating Indigenous priorities, Arctic Political Ecology can bring a more comprehensive and practical understanding, capable of enhancing our knowledge of current and future changes, facilitating the implementation of adaptation measures, and preventing maladaptation. The rectification of prevailing misapprehensions regarding the scientific nature of Indigenous knowledge is of utmost significance. Instead, it is essential to accord Indigenous knowledge and research leadership on Indigenous lands the due recognition it deserves and applies it in policymaking. This necessitates the acknowledgment of knowledge sovereignty and the eradication of impediments to Indigenous knowledge. By doing so, Arctic Political Ecology can effectively analyze historical complexities and bridge them with present vulnerabilities on a larger scale, thereby contributing to a just transition of societies and promoting climate justice. This can be accomplished by adopting a holistic and interdisciplinary approach of Arctic Political Ecology, enabling a comprehensive understanding of global environmental change through the examination of localized changes. By prioritizing local communities as the focal point and subsequently expanding to subregional, regional, and ultimately global levels, Arctic Political Ecology can effectively explore the resilience of Indigenous Peoples. These communities, despite residing in complex environments with limited resources, have demonstrated remarkable adaptability and sustainability, providing valuable lessons for people worldwide.

6 | Conclusion

Arctic Political Ecology approach is essential for understanding the socioenvironmental dynamics of Arctic change. The approach allows for an examination of power relations, conflicts, and inequalities that shape environmental governance and resource management. The susceptibility of the Arctic to climate change and its associated impacts makes this approach particularly important in understanding the region. Power relations play a central role in shaping environmental governance, and political ecology highlights the unequal distribution of resources and decision-making authority. It also emphasizes the socioeconomic implications of resource extraction and the conflicts between economic development and environmental conservation. The approach recognizes the historical and cultural dimensions of environmental issues, particularly the disruption of Indigenous Peoples traditional practices and knowledge systems. It also acknowledges the influence of capitalism, colonialism, and transnational and global processes in shaping environmental governance in the Arctic. Arctic Political Ecology provides a valuable tool for analyzing the complexities of the Arctic's socioenvironmental

dynamics and advocating for Indigenous Peoples sovereignty and control over productive resources.

Author Contributions

Ishfaq Hussain Malik: conceptualization (equal), formal analysis (equal), methodology (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review and editing (equal). **James D. Ford:** conceptualization (equal), formal analysis (equal), methodology (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review and editing (equal).

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Related Wires Articles

The rapidly changing Arctic and its societal implications

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