Exploring the Impact of Climate Change on Community Sustainability in Atlantic Canada: A Transdisciplinary Approach

Edmund Yirenkyi
PhD Candidate, Transdisciplinary Sustainability PhD
School of Science and Environment
Memorial University of Newfoundland
eeayirenkyi@mun.ca

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Abstract

This paper examines the significant impacts of climate change on community sustainability in Atlantic Canada, particularly for vulnerable populations. Rising temperatures and sea levels threaten livelihoods, infrastructure, and ecosystems, necessitating a transformative approach to avoid maladaptation. Current strategies primarily rooted in natural sciences and economic models lack the integration of social dimensions essential for effective sustainability assessments. The paper highlights the need for a holistic, transdisciplinary framework that encompasses environmental, economic, and social factors, recognizing diverse interpretations of sustainability across various disciplines. It highlights the importance of engaging local communities and Indigenous knowledge in developing context-specific solutions. Additionally, the paper addresses challenges such as differing epistemological perspectives and stakeholder negotiations, advocating for collaborative frameworks that facilitate meaningful dialogue and action. The paper emphasizes that balancing human well-being and ecological health contributes to a more resilient and equitable response to climate change in Atlantic Canada.

Introduction

Climate change has already caused widespread impacts on people's livelihoods and living conditions, especially among the poorest and most vulnerable. These effects will continue throughout the coming century and are expected to hamper development (Birkmann et al., 2022). According to Dietz and Arnold (2021), climate change is heightening risks in Atlantic Canada's coastal and flood-prone areas. From 1948 to 2016, temperatures rose by 0.7°C, and precipitation increased by 11%. While benefits like extended tourism and growing seasons may arise, negative impacts on fisheries, agriculture, and coastal infrastructure will increase. Lemmen et al. (2016) added that sea levels could rise by 75 to 100 cm by 2100, leading to more coastal flooding and infrastructure threats due to reduced winter sea ice and stronger storm waves. Hellin et al. (2022) suggested that the increasing seriousness of the climate crisis calls for a response that moves beyond incremental changes to one that is more fundamental, far-reaching, and radically transformative. Additionally, Hellin et al. (2022) noted that it is crucial to avoid maladaptation, where efforts to address climate risks unintentionally heighten vulnerability, exposure, and risk for certain segments of society.

However, Pereira et al. (2019) noted that present methods for investigating future solutions around biodiversity, ecosystem services, and their role in supporting human well-being are primarily rooted in the natural sciences. These approaches often consist of interconnected biophysical and economic models, similar to the integrated assessment models employed by the Intergovernmental Panel on Climate Change (IPCC). Over time, sustainability methodologies and indicators have gained traction at local, national, and global levels to track progress toward sustainable development (Lowery et al., 2020). Sala et al. (2015) observed that sustainability assessment (SA) is one of the most intricate evaluation methods, encompassing environmental, economic, and social dimensions and cultural and value-driven factors. Furthermore, SA serves as a tool to guide decision-makers and policymakers in determining which actions to pursue or avoid to steer society toward greater sustainability (Sala et al., 2015). Lowery et al. (2020) emphasized that initiatives such as Agenda 21, which urged collective action to address environmental and developmental challenges, and the more recent Sustainable Development Goals (SDGs) have helped popularize these evaluation methods and indicators.

Kopnina and Shoreman-Ouimet (2015) added that sustainability and sustainable development involve various dimensions—social, environmental, economic, cultural, and ethical—each presenting its own challenges and opportunities. Terms like social sustainability, environmental sustainability, sustainable development, and sustainable living highlight these diverse interpretations. Brandt et al. (2013) describe this as a social-ecological system facing unprecedented challenges, including ecosystem destruction, overexploitation of natural resources, the climate crisis, wealth inequality, and human conflict. With climate change, these aspects of sustainability are becoming increasingly interconnected. Rising sea levels, extreme weather events, and shifts in ecosystems are reshaping the sustainability landscape in Atlantic Canada. As communities confront these changes, they may struggle to maintain social cohesion, economic stability, and environmental health (Kopnina & Shoreman-Ouimet, 2015). Although these issues

are interconnected, each should be analyzed within the broader context of sustainability (Brandt et al., 2013).

In rural or urban settings, sustainable development occurs at the intersection of interconnected social, economic, ecological, and political systems. This requires a holistic approach to local development that accounts for multiple forms of capital while curbing unchecked economic growth that threatens ecosystems (Lowery et al., 2020). Sustainability, however, is a complex concept that differs significantly across various communities (Kopnina & Shoreman-Ouimet, 2015). Hence, in Atlantic Canada, its application would vary from one community to another. Du Pisani (2006) confirmed that "sustainable development" has become an overused buzzword. It is often used without a complete understanding of its meaning and consequences.

To fully understand sustainability in this context, there is a need for a transdisciplinary approach that bridges science and society (Sellberg et al., 2021), bringing together a variety of disciplinary and experiential knowledge needed to understand these challenges and to co-create effective solutions (Pineo et al., 2021). This connection is essential for tackling the complex social-ecological climate challenges in Atlantic Canada. A comprehensive perspective is needed to navigate climate change and build resilience in local communities, empowering them to adapt to and mitigate its impacts while striving for a sustainable future (Kopnina & Shoreman-Ouimet, 2015). Hence, this paper aims to examine the multifaceted impacts of climate change on community sustainability in Atlantic Canada, considering varying definitions of sustainability and diverse community contexts. Additionally, this research aims to evaluate the potential benefits and challenges of adopting a transdisciplinary approach to address the complex interplay between climate change and community resilience.

Methodology

This paper employs a conceptual analysis methodology to investigate the definition of sustainability and its implications for addressing climate change in Atlantic Canada, with a specific focus on the role of a transdisciplinary approach. Through a comprehensive review of scholarly literature, policy documents, and case studies, the paper aims to explore the diverse interpretations of sustainability across different contexts and examine how a transdisciplinary framework can enhance the development of climate change adaptation and mitigation strategies for coastal communities. The analysis is underpinned by three key theoretical frameworks:

The Brundtland Definition of Sustainability: This framework emphasizes the balance between meeting present needs without compromising the ability of future generations to meet their own needs, offering a foundational understanding of sustainability.

The Three Pillars of Sustainability: This model highlights the interconnectedness of the environmental, social, and economic dimensions of sustainability, providing a holistic lens for examining the challenges and opportunities of sustainable development.

Climate Change as a Contextual Factor: This framework recognizes climate change as a critical contextual factor influencing sustainability, particularly in regions like Atlantic Canada, where

communities are increasingly vulnerable to climate-related risks, including sea-level rise and extreme weather events.

A literature review was conducted to gather relevant sources that contribute to the understanding of sustainability within the context of climate change. This review involved searching academic databases such as Google Scholar, JSTOR, Scopus, and Web of Science, as well as manually reviewing key journals and publications. Keywords and phrases such as "sustainability," "climate change," "Atlantic Canada," "community resilience," "transdisciplinary approach," and "sustainable development" were used to identify a wide range of sources. The review focused on scholarly articles, policy documents, and case studies that explore the intersections of sustainability and climate change, ensuring that both theoretical and practical perspectives were considered. Given the vast amount of literature on sustainability and climate change, a purposive sampling approach was used to select relevant documents. Documents were chosen based on their direct alignment with the research questions, focusing on the intersection of sustainability, climate change, and transdisciplinary approaches. Each document was evaluated for its scholarly rigor, considering the credibility of the authors, the robustness of the research methods, and the strength of the evidence presented. Priority was given to peer-reviewed sources and authoritative publications to ensure high academic standards. Recent publications were prioritized to incorporate the latest research findings and perspectives in the field. Initially, the first ten documents retrieved from each database search were considered. However, the final selection was made after a more thorough review, emphasizing the relevance and quality of the materials, with some documents being excluded based on these criteria.

The collected literature was analyzed using **thematic analysis**, a method that facilitates the identification of key themes and patterns across the literature. The analysis focused on several areas:

Definitions of Sustainability: The review explored how sustainability is defined across various disciplines and contexts, with a particular focus on the evolving interpretations of sustainability in response to climate change.

Impacts of Climate Change on Atlantic Canadian Communities: The literature was examined for insights into how climate change is affecting the environment, economy, and social fabric of coastal communities in Atlantic Canada, emphasizing the role of local resilience and adaptive capacity.

Transdisciplinary Approaches to Climate Change: The study analyzed the role of transdisciplinary research in addressing complex climate challenges, identifying both the opportunities and limitations of integrating multiple disciplines in sustainability research.

Each theme was categorized to identify patterns, contradictions, and gaps in the literature. This process enabled a nuanced understanding of the diverse perspectives on sustainability and climate change. Additionally, the analysis examined the effectiveness of existing approaches and identified areas where further research is needed. Through the analysis of the literature, the study aimed to uncover the complexities of defining and applying sustainability in the face of climate change,

with a particular focus on the role of community resilience and transdisciplinary research in addressing these challenges.

Defining Sustainability:

Understanding sustainability and the transition to sustainable development is complex due to the diverse bodies of knowledge and often conflicting normative goals and values across various disciplines and contexts. Du Pisani (2006) emphasized that recognizing the historical context of sustainability is essential for guiding current efforts to tackle modern challenges such as climate change and resource scarcity. He stated that sustainability has been a concern for centuries, tracing back to ancient civilizations and evolving significantly during the Industrial Revolution. Key themes include responsible resource management, intergenerational equity, and the need to balance economic development with minimal environmental impact. Hence, different fields and contexts interpret sustainability in unique ways, leading to varied evaluations by societal actors based on their backgrounds and decision-making levels. This complexity is further heightened by wicked, multi-dimensional problems that complicate efforts to achieve sustainable outcomes (Karrasch et al., 2022).

Du Pisani (2006) further showed that sustainability, as it is used today, stems from historical concerns about resource depletion and environmental harm. Kopnina and Shoreman-Ouimet (2015) agreed that the concept of sustainability, as commonly understood today, emerged in the 1960s in response to growing concerns about environmental degradation. This period marked a shift towards recognizing the need for responsible resource management to protect both the environment and future generations. According to Du Pisani (2006), the term originated in the 18th century with Hans Carl von Carlowitz, who focused on responsible resource use to ensure future availability. This idea acknowledges that human activities like agriculture and industrialization can threaten the environment. Thinkers such as John Stuart Mill and Thomas Malthus warned about the dangers of unchecked population growth and resource exploitation, highlighting the need to balance economic progress with ecological health. As industrialization grew in the 19th century, worries about finite resources like coal and oil led to calls for more sustainable practices. The German term “Nachhaltigkeit” and the French “durabilité” reflect similar ideas about responsible resource management, emphasizing long-term viability for both people and the planet (Du Pisani, 2006, p. 84). Johnson et al. (2016) asserted that today, science endeavors to examine the insights that arise from the scholarly study of human–nature interactions. These interactions involve social and environmental justice issues and more profound metaphysical questions about connection and meaning. Consequently, they lead to important discussions on human rights, Indigenous wisdom, environmental justice, community resilience, and sustainable cities (Johnson et al., 2016). Each of these topics must be understood within its specific context to develop effective and appropriate solutions.

Siegenfeld and Bar-Yam (2020) described sustainability as a complex system that considers the interplay between physical, biological, and social components. Unlike traditional science, which focuses on individual parts, complex systems science prioritizes understanding their interactions, helping us grasp ecological balance and societal well-being. Sustainability can encompass multiple parts, including environmental health, economic stability, and social well-being. Paterson et al. (2020) suggested that people’s learning styles and knowledge generation are shaped by their

experiences, perspectives, and cultures. This diversity influences their responses and willingness to change behaviors, ultimately affecting how they define sustainability. Kopnina and Shoreman-Ouimet (2015) asserted that the term 'sustainability' is used in various contexts, giving rise to concepts like social sustainability, environmental sustainability, sustainable development, sustainable living, and sustainable future. For instance, Sellberg et al. (2021) explain place-based sustainability as an approach that examines the intricate connections between ecological and social systems in specific locations by looking at how these systems interact, delving into the relationship between our natural surroundings and human communities, and identifying the factors that influence change—directly and indirectly. Therefore, the place-based sustainability approach aims to create strategies and solutions that foster meaningful transformations toward a more sustainable future.

Hadorna et al. (2006) stated that sustainability gained widespread recognition following the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 (Weiss, 1992). This concept builds on the definition provided in the 1987 report "Our Common Future" by the World Commission on Environment and Development (WCED, 1987), which highlights the importance of balancing human needs with the natural environment's limitations (Mebratu, 1998, p. 494). Sustainable development addresses present needs while ensuring that future generations can fulfill theirs (WCED, 1987; Weiss, 1992). Achieving this requires evaluating technology, social structures, and the environment's ability to sustain human activities (Mebratu, 1998). This concept was adapted because it acknowledges the interconnectedness of economic growth, environmental health, and social equity. The idea was to ensure that it represented a holistic approach that integrates ecological, economic, and social dimensions, aiming for a balance that ensures long-term viability for human societies and the natural world (Du Pisani, 2006). Though this definition is widely acceptable and has been invaluable in promoting a unified understanding of the challenges facing our planet, it lacks specificity, and sustainability is probably not a one-size-fits-all. Various disciplines emphasize different elements of sustainability, resulting in conflicting objectives and interpretations of "needs." Furthermore, the future is unpredictable, and sustainability encompasses intricate interactions among multiple factors. This complexity makes it challenging to create universal solutions that tackle all potential issues and promote equity between generations.

Sustainability is a versatile concept that varies across different fields and contexts (Kopnina & Shoreman-Ouimet, 2015). In environmental science, sustainability focuses on preserving and responsibly managing natural resources (Pärli, 2023). This includes maintaining biodiversity, reducing pollution, and ensuring the long-term health of ecosystems. By addressing these concerns, environmental scientists aim to create a balance that allows ecosystems to thrive (Klenk & Meehan, 2015). In ecology, sustainability means that biological systems stay diverse, strong, resilient, and productive over time, which is vital for the well-being of humans and other species. As environmental and social issues became more pressing, sustainability emerged as a common political goal, highlighting the importance of managing resources responsibly for everyone (Kopnina & Shoreman-Ouimet, 2015). In ecological economics, sustainability refers to practices that support long-term economic growth without depleting natural resources or harming the environment. This involves implementing sustainable business practices, promoting green technologies, and developing policies that foster economic stability and equity. By prioritizing

sustainability, economies can thrive while minimizing their environmental impact (Hadorn et al., 2006; Karrasch et al., 2022).

From a social sciences perspective, sustainability involves creating systems that support social well-being and equity. This includes ensuring access to basic needs such as education, healthcare, and employment while promoting social justice and community resilience. By addressing these social dimensions, sustainability seeks to uplift individuals and communities (Hoffmann-Riem et al., 2008). In urban planning, sustainability means designing environmentally friendly, economically viable, and socially inclusive cities. This includes creating green spaces, efficient public transportation systems, and buildings that reduce energy consumption. Such planning is essential for fostering livable cities that accommodate both people and nature (Gaziulusoy et al., 2016). On the other hand, sustainable agriculture focuses on farming practices that meet current food needs without compromising the ability of future generations to do the same. This involves soil conservation, effective water management, and reducing reliance on chemical fertilizers and pesticides. By prioritizing sustainability in agriculture, we can ensure food security for the future (Birkmann et al., 2022).

In the corporate sector, sustainability refers to practices that ensure a company's long-term viability and positive impact on society and the environment. This includes corporate social responsibility (CSR) initiatives, ethical supply chain management, and sustainable product development. Businesses that adopt sustainable practices contribute to their success and the well-being of their communities (Kuenkel et al., 2013; Lowery et al., 2020). Educational sustainability involves integrating sustainable practices into teaching and learning, ensuring that future generations are equipped with the knowledge and skills needed to address environmental, economic, and social challenges (Ibrahim et al., 2015). By fostering a culture of sustainability in education, we can empower individuals to make informed decisions (Gillis et al., 2017).

Klenk and Meehan (2015) speculated that human sustainability focuses on maintaining and improving people's quality of life. It ensures that individuals and communities can access basic needs like clean water, nutritious food, healthcare, and safe living conditions (Ives et al., 2020). Social equity, justice, and future generations' well-being are critical components of creating systems that allow humans to thrive (Kuenkel et al., 2013). In contrast, ecological sustainability is about maintaining the health and integrity of natural ecosystems. It involves protecting biodiversity, managing natural resources responsibly, and minimizing environmental degradation (Kopnina & Shoreman-Ouimet, 2015). The goal is to ensure that ecosystems can continue to provide essential services, such as clean air, water, and soil. Staffa et al. (2022) asserted that these two types of sustainability—human and ecological—are deeply interconnected. Human well-being is intrinsically linked to the health of the environment. Degraded ecosystems can lead to resource scarcity, loss of biodiversity, and adverse health impacts, affecting economic and social stability (Mebratu, 1998). Therefore, sustainable practices must address both human and ecological needs to ensure a balance that supports both in the long term. In the context of Atlantic Canada, climate change highlights the intersection of human and ecological sustainability. Rising sea levels and increased storm intensity threaten human settlements and local economies while stressing natural ecosystems. Effective sustainability strategies in this region must incorporate human and ecological considerations, promoting resilience and adaptation to ensure a sustainable future for people and the environment (Staffa et al., 2022).

Climate Change and Sustainability: Varied Impacts on Communities

Sustainability encompasses environmental, social, and economic dimensions, and as climate change accelerates, its effects on Atlantic Canadian communities present complex and varied challenges (Kopnina & Shoreman-Ouimet, 2015). The impact of climate change is influenced by geographic, economic, and social factors (Du Pisani, 2006), making it essential to understand how different communities experience these changes. The evolving concept of sustainability is particularly complex when examined within the context of climate change in Atlantic Canada. Scholars such as Mebratu (1998) and Kopnina and Shoreman-Ouimet (2015) highlight a significant transformation in our understanding of sustainability over time. Historically, concerns during the Industrial Revolution primarily focused on resource depletion (Du Pisani, 2006). The 18th-century introduction of sustainability by Hans Carl von Carlowitz emphasized the need for responsible resource use to ensure availability for future generations. This perspective was further advanced by thinkers like John Stuart Mill and Thomas Malthus, who warned of the potential dangers of unchecked population growth and resource exploitation, thus underlining the necessity of balancing economic progress with ecological integrity (Mebratu, 1998; Du Pisani, 2006; Kopnina & Shoreman-Ouimet, 2015). These foundational insights remain critical for addressing the contemporary challenges posed by climate change in Atlantic Canada.

Sustainability encompasses the intricate interplay of social, economic, and environmental factors (Kopnina & Shoreman-Ouimet, 2015). In Atlantic Canada, the impacts of climate change on sustainability are evident through rising sea levels, particularly in coastal regions like Nova Scotia, and an increase in the intensity of storms (Dietz & Arnold, 2021). Coastal communities face significant threats from rising sea levels and increased storm intensity, which disrupt ecological balance. Saltwater intrusion into freshwater supplies endangers local ecosystems, affecting both wildlife and community health (Lemmen et al., 2016). Moreover, diverse community contexts illustrate the varied impacts of climate change on sustainability across Atlantic Canada. These environmental changes threaten local ecosystems and the communities that depend on them for their livelihoods (Pereira et al., 2019). Therefore, effective sustainability strategies must adopt an integrative approach that considers these interrelated dimensions, focusing on environmental protection while enhancing local economic stability and community resilience (Maclean et al., 2022). Furthermore, a place-based approach to sustainability is essential for understanding how climate change uniquely affects different regions in Atlantic Canada (Zurba et al., 2022). Many Atlantic Canada communities rely heavily on industries such as fisheries and forestry, necessitating climate change mitigation and adaptation strategies closely aligning with local ecological conditions and economic realities. Hence, sustainable development initiatives should emphasize human and ecological resilience, ensuring communities and ecosystems can adapt effectively to changing climatic conditions while taking steps to mitigate climate impact (Kopnina & Shoreman-Ouimet, 2015).

Besides, climate change exacerbates existing social justice issues, disproportionately impacting vulnerable groups in Atlantic Canada, including Indigenous peoples and coastal communities (Cole, 2017). For instance, the Esgenoopetitj First Nation, formerly Burnt Church, faces increased flooding and coastal erosion, threatening infrastructure and traditional ways of life (Dietz & Arnold, 2021). In this context, sustainability involves preserving cultural heritage while ensuring community safety through resilient infrastructure and climate adaptation strategies that incorporate

Indigenous knowledge. Similarly, the Chignecto Isthmus, a vital corridor between New Brunswick and Nova Scotia, is similarly at risk due to rising sea levels and storm surges (Lemmen et al., 2016). Sustainability in this community entails protecting critical infrastructure to maintain transportation and economic stability, necessitating significant investments in resilient engineering solutions. Chignecto Isthmus Indian Island and Ugpi'ganjig First Nations are small Mi'kmaw communities that are also confronting challenges posed by climate change, such as storm surges and coastal erosion (Dietz & Arnold, 2021). For Indian Island, sustainability revolves around preserving the vital connection to the land and water, which is crucial to its cultural identity (Dietz & Arnold, 2021). This necessitates the implementation of climate-resilient practices and the development of infrastructure that can withstand environmental changes.

The economic implications of climate change on sustainability for communities in Atlantic Canada are profound. The region's economy relies heavily on natural resource sectors, such as fisheries and tourism, which face significant threats from climate-related changes. Fisheries and aquaculture industries face disruptions as shifts in ocean temperatures and acidity levels alter fish migration patterns, threatening the sustainability of these critical sectors (Dietz & Arnold, 2021). The tourism industry, too, is vulnerable; climate-related impacts such as extreme weather events and coastal degradation can diminish the attractiveness of tourist destinations, jeopardizing local jobs and economies. Hence, by adopting sustainable practices—such as investing in renewable energy and green infrastructure—Atlantic Canada can seek to harmonize economic growth with environmental stewardship, thereby enhancing the region's resilience in climate change mitigation and adaptation (Lemmen et al., 2016). It is imperative that sustainability initiatives actively involve these communities in decision-making processes and acknowledge their unique knowledge systems, particularly Indigenous wisdom (Bartlett et al., 2012; Johnson et al., 2016). Creating just and effective climate solutions that address the specific needs of those most affected by climate change is essential to ensure social equity.

In Placentia Bay, climate change drives coastal erosion and alters fish stocks, directly threatening the fishing industry's sustainability. The community must adapt its fishing practices and implement effective fisheries management and habitat restoration strategies to address these challenges. These actions are essential for ensuring the long-term viability of both the economy and the ecosystem (Dietz & Arnold, 2021). Similarly, Cape Breton Island is experiencing increased temperatures and deteriorating coastlines, jeopardizing its natural resources and local economies. Achieving sustainability here requires a dual approach: protecting ecosystems while fostering economic activities like tourism and agriculture. This includes adopting sustainable tourism practices, encouraging eco-friendly agricultural methods, and investing in renewable energy solutions to bolster the island's resilience to climate impacts (Dietz & Arnold, 2021; Lemmen et al., 2016).

Throughout Atlantic Canada, climate change presents significant challenges. Urban centers in Atlantic Canada are experiencing extreme heat, worsening air quality, and increased flooding, all of which strain infrastructure and public health systems. Urban centers must address infrastructure vulnerabilities through robust disaster preparedness investments, while rural areas reliant on resource-based industries must adapt to shifting ecological conditions (Lemmen et al., 2016). In rural areas, changing precipitation patterns lead to droughts and flooding, compromising agricultural yields, water quality, and biodiversity. These shifts threaten food security and the

sustainability of local farming (Lemmen et al., 2016). Rising sea levels and frequent storms threaten human communities and ecological systems, highlighting the necessity for a holistic strategy that balances economic resilience with environmental health (Klenk & Meehan, 2015). Socially, communities face issues such as displacement, loss of cultural heritage, and health risks linked to changing weather patterns (Johnson et al., 2016). Effectively addressing these challenges requires integrating social equity into sustainability initiatives, ensuring that the voices of the most affected populations are included in climate action planning (Lemmen et al., 2016). This approach can help create a more sustainable future for all.

Climate change mitigation and adaptation strategies are essential to effectively address these interconnected sustainability challenges (Hellin et al., 2022). Mitigation focuses on reducing greenhouse gas emissions through renewable energy transitions, energy efficiency improvements, and sustainable land management practices (Held & Edenhofer, 2008). In contrast, adaptation involves proactive measures such as constructing seawalls, implementing early warning systems, and promoting sustainable land use planning (Siebenhüner, 2018). Understanding the intricacies of climate change necessitates a multidimensional approach to sustainability. This includes systems knowledge, which encompasses the technical impacts of climate change—like rising seas and ecosystem shifts—enabling communities to prepare and respond effectively (Ives et al., 2020). Staffa et al. (2022) opined that normative knowledge defines sustainable practices and standards, such as responsible coastal management and sustainable fishing, guiding community actions and policies. Ives et al. (2020) added that transformative knowledge is essential for changing mindsets among stakeholders. In Atlantic Canada, this means enhancing resilience through adaptive infrastructure, investing in sustainable practices that can help mitigate climate change, and actively involving local communities in climate action. The emphasis on transformative knowledge highlights the need for proactive engagement in sustainability efforts (Ives et al., 2020). By fostering collaboration among policymakers, scientists, and communities, Atlantic Canada can navigate the challenges posed by climate change, ensuring a sustainable future that integrates environmental health, economic stability, and social equity. Pereira et al. (2019) highlighted that it is essential to integrate sustainability actions at individual, collective, and transdisciplinary levels to create more sustainable and equitable futures and for institutions to develop more inclusive scenarios. Staffa et al. (2022) state that transdisciplinary sustainability science has arisen as a promising approach to address ongoing sustainability challenges, focusing on enhancing collaborative knowledge creation.

Transdisciplinary Approach to Climate Change and Community Sustainability

Researchers have introduced innovative knowledge-creation methods that move beyond traditional disciplinary and institutional limits to tackle complex societal and environmental issues such as climate change mitigation and adaptation (Klenk & Meehan, 2015). Klenk and Meehan (2015) further note that one key concept is “transdisciplinarity,” which promotes a collaborative approach where scientists engage with various stakeholders impacted by environmental challenges. Regeer (2003) added that the term “transdisciplinary research” refers to various research practices that involve integrating knowledge from diverse social and academic stakeholders. Staffa et al. (2022) contended that transdisciplinary sustainability science has emerged as a promising approach to address ongoing sustainability crises, focusing on enhancing collaborative knowledge creation. Klenk and Meehan (2015) agree that transdisciplinarity is

characterized as a reflective and systematic method aimed at developing practical solutions for societal challenges like climate change. It emphasizes the importance of integrating and collaborating across diverse perspectives to produce actionable knowledge.

To further understand the impact of transdisciplinary approaches, it is essential to examine both the advantages and challenges they present in addressing climate change within community sustainability. A closer look at these benefits and obstacles will provide a more comprehensive view of how transdisciplinarity can support climate change adaptation and mitigation while revealing the complexities inherent in integrating diverse perspectives and knowledge systems.

Key Advantages of a Transdisciplinary Approach to Community Sustainability

A significant advantage of transdisciplinary research is its integrative nature, which unites scholars and practitioners from diverse academic and non-academic domains (Pineo et al., 2021). As Regeer (2003) aptly noted, local knowledge is increasingly recognized as indispensable for developing effective and sustainable solutions to various social and environmental challenges. Transdisciplinary research offers a significant advantage in addressing climate change adaptation and mitigation through its integrative and collaborative nature, uniting scholars and practitioners from diverse fields and communities (Staffa et al., 2022). This approach recognizes the value of local and Indigenous knowledge alongside traditional scientific insights, fostering a more holistic understanding of complex issues (Bartlett et al., 2012). By combining diverse perspectives—such as those from policy, economics, and community practices—transdisciplinarity creates innovative and inclusive methodologies tailored to the needs of various communities (Pineo et al., 2021; Staffa et al., 2022). This collaboration strengthens shared knowledge and ensures that solutions are fair and relevant, amplifying Indigenous voices in guiding research while fostering mutual respect between different knowledge systems (Cole, 2017). It also deepens understanding of complex scientific and societal issues, leading to innovative solutions. For instance, addressing climate change mitigation and adaptation requires scientific knowledge and input from policy, economics, and community practices (Klenk & Meehan, 2015). This holistic, collaborative approach enables a more effective problem-solving approach and ensures that solutions are both practical and responsive to the needs of communities.

Furthermore, transdisciplinary collaborations in addressing climate change adaptation and mitigation are their capacity to confront power imbalances among diverse stakeholders (Hellin et al., 2022). Transformative adaptation not only enhances climate resilience for vulnerable populations but also ensures that all voices, including those of Indigenous, academia, and community stakeholders, are recognized and valued (Klenk & Meehan, 2015). By employing an integrative, method-driven approach, transdisciplinarity enables the co-production of normative knowledge and policy-relevant solutions that incorporate a broad range of perspectives (Siebenhüner, 2018). A transdisciplinary approach unites diverse perspectives, leading to innovative and creative solutions for climate change challenges (Regeer, 2003). This collaborative approach can drive the development of new technologies, implement community-based adaptation strategies, and design sustainable policies. For instance, community members may share

traditional ecological knowledge to inform sustainable practices, while scientists can provide data-driven insights.

Finally, this collaborative process relies on structured mechanisms for knowledge integration, such as face-to-face dialogue and cross-cultural communication, which help build trust and foster effective collaboration (Pineo et al., 2021). Engaging civil society groups and local knowledge holders enriches the discourse, leading to balanced and sustainable solutions to sustainability challenges (Hoffmann-Riem et al., 2008). Ultimately, transdisciplinary research encourages scientists to connect with the broader community (Gaziulusoy et al., 2016), promoting inclusivity and enhancing the applicability of research outcomes while facilitating effective climate change mitigation and adaptation measures. By involving diverse stakeholders—local communities, policymakers, NGOs, and scientists—this inclusive approach fosters collaboration, builds trust, and enhances the relevance of strategies, leading to more widely accepted solutions and a stronger sense of ownership among community members.

Key Challenges of a Transdisciplinary Approach to Community Sustainability

Applying a transdisciplinary approach to climate change mitigation and adaptation in Atlantic Canada presents several key challenges. First, diverse epistemological positions among research partners create significant barriers (Lang et al., 2012). Scientists and practitioners often operate from different assumptions about climate issues, complicating problem conceptualization (Pineo et al., 2021). Finding common ground is further hindered by varied priorities and values, necessitating effective conflict resolution mechanisms (Brandt et al., 2013). Successful collaboration depends on establishing a shared understanding, yet interactions may lack the depth needed to form a cohesive community of practice (Brandt et al., 2013). Understanding diverse scientific and societal perspectives is central to transdisciplinary research (Pohl & Hadorn, 2008). Integrating knowledge from multiple disciplines can be complex and time-consuming, requiring effective coordination and communication among differing viewpoints (Pineo et al., 2021). This disconnect can lead to skepticism about research credibility; scientists may question methodological rigor, while practitioners may doubt practical relevance. Therefore, fostering a common framework for dialogue is essential to bridge these gaps and produce socially robust knowledge.

A second challenge involves negotiating diverse stakeholder interests, complicating consensus-building (Lang et al., 2006). Reluctance from non-academic partners, driven by the contested nature of climate change, further complicates collaboration (Klenk & Meehan, 2015). Unbalanced problem ownership can persist, extending project timelines and making funding difficult to secure (Lang et al., 2012). Power dynamics can result in unequal representation and marginalization of certain perspectives, adding to negotiation difficulties. Conflicting interests, such as economic development versus environmental conservation, often require external facilitation (Pohl & Hadorn, 2008). Integrating diverse disciplinary methods also necessitates coherent terminologies and frameworks, making the research process time-consuming and complex. Understanding these methods is crucial for effective collaboration (Brandt et al., 2013). In Atlantic Canada, economic development frequently clashes with environmental conservation goals, leading to potential

stakeholder conflicts (Dietz & Arnold, 2021). Ongoing negotiations underscore the need to integrate different perspectives while highlighting inherent tensions in transdisciplinary contexts. Addressing these challenges is vital for achieving successful climate change outcomes in the region.

Finally, a significant challenge in applying a transdisciplinary approach is identifying the proper methodology to frame the problem effectively (Pohl & Hadorn, 2008). Transdisciplinary research must integrate empirical, evaluative, and instrumental aspects—systems knowledge, target knowledge, and transformation knowledge (Hadorn et al., 2006). A lack of shared framing can arise when scientists and practitioners adopt differing perspectives (Brandt et al., 2013). Insufficient interaction between these groups hinders the development of socially robust knowledge necessary for sustainability challenges (Pohl & Hadorn, 2008). Furthermore, while transdisciplinary research aims to foster collaboration across local and regional scales, the focus often remains limited, undermining broader applicability (Lang et al., 2012). Identifying and engaging legitimate stakeholders can also be difficult, creating uncertainty about who should be involved (Lang et al., 2006). Integrating diverse knowledge systems requires a reflexive and adaptable methodology, emphasizing continuous reflection and improvement throughout the research process (Pohl & Hadorn, 2008). This leads to longer project durations, publishing challenges, difficulties securing adequate funding, communication issues, and pressures to narrow focus, all of which present significant obstacles to a transdisciplinary approach (Pineo et al., 2021).

While a transdisciplinary approach offers valuable pathways for addressing climate change in Atlantic Canada, it faces challenges related to epistemological diversity, stakeholder negotiation, and methodological integration. Addressing these challenges is critical for fostering meaningful collaboration and achieving sustainable outcomes.

Conclusion

In conclusion, climate change's impacts on Atlantic Canada's livelihoods present significant challenges, particularly for vulnerable populations. As rising temperatures and increased precipitation exacerbate risks, especially in coastal areas, the need for a transformative and integrated response becomes paramount. Current approaches to sustainability, often rooted in natural sciences and economic models, fall short of addressing the complex social dimensions required for effective solutions. A holistic, transdisciplinary approach is essential to navigate these multifaceted challenges, bringing together diverse knowledge systems and engaging local communities in co-creating solutions. This collaboration fosters innovative strategies and ensures that marginalized groups' voices, including Indigenous populations, are respected and incorporated.

Moreover, recognizing the historical evolution of sustainability and its varying interpretations across disciplines is critical for crafting context-specific responses. By prioritizing human well-being alongside ecological integrity, Atlantic Canada can develop resilient strategies that address the intertwined issues of climate change, resource management, and social equity. Overcoming the

barriers to collaboration and establishing shared frameworks will be vital to achieving a sustainable future for both communities and ecosystems in the region.

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