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Towards more inclusive and solution orientated community-based environmental monitoring

Louise Mercer[1*], Dustin Whalen[2], Michael Lim[3], Kendyce Cockney[4], Shaun Cormier[5], Charlotte Irish[4] and Paul J Mann[1]

[1] Northumbria University, Department of Geography and Environmental Sciences, Newcastle upon Tyne, NE1 8ST, United Kingdom

[2] Geological Survey of Canada Atlantic, Natural Resources Canada, Dartmouth, Nova Scotia, B2Y 4A2, Canada

[3] Northumbria University, Department of Mechanical and Construction Engineering, Newcastle upon Tyne, NE1 8ST, United Kingdom

[4] Tuktoyaktuk Community Climate Resiliency Project, 274 Inuvialuit Lane Tuktoyaktuk, Northwest Territories, X0E 1C0, Canada

[5] Kota Solutions, 4220 Quentin Avenue Prince George, British Columbia, V2M 5L3, Canada

[*]Author to whom any correspondence should be addressed.

E-mail: louise.mercer@northumbria.ac.uk

Abstract

Rapid climate-driven environmental change continues to threaten front-line communities that rely on Arctic landscapes to sustain their way of life. Community-Based Monitoring (CBM) can increase our knowledge of environmental change and understanding of human-environment interactions occurring across the Arctic. However, the depth of CBM research outcomes have been limited by an imbalance in contributions from external researchers and community members. A detailed literature analysis revealed that the number of studies documenting CBM approaches in Inuit Nunangat (Inuit homeland in Canada) have increased over the last decade. We identify that bottom-up guiding protocols including the National Inuit Strategy on Research (NISR), has increased community engagement in Arctic research processes and equitable outcomes. However, these increases have been concentrated on wildlife-based research where consistent funding streams and pre-existing alignment with community priorities exist. To explore the potential for guiding principles to be more successfully incorporated into impactful CBM, we present a co-developed environmental CBM case study aiming to document and aid understanding of climate-driven landscape change near Tuktoyaktuk, Inuvialuit Settlement Region (ISR), Canada since 2018. A foundation of early dialogue and collaborative partnerships between community members and external researchers formed the basis of a community-based climate monitoring program driven by community research priorities. A succession of funded CBM projects at Tuktoyaktuk demonstrated that longer term and resilient climate monitoring can bring together Scientific and Indigenous knowledge systems. Progressing beyond an emphasis on data collection is vital to sustain monitoring efforts, capacity sharing and co-dissemination processes to ensure research is communicated back in a way that is understandable, relevant, and usable to address community priorities. The need for successful CBM is often at odds with current research funding structures, which risks a fragmented mosaic of early-stage initiatives focused on understanding environmental problems rather than sustained and progressive research development towards cooperative solutions.

Keywords: community-based monitoring, Arctic environmental monitoring, co-development, Inuit Nunangat, Indigenous Knowledge

1. Introduction

The Arctic is warming faster than anywhere else globally (Johannessen *et al* 2016, IPCC 2019, Rantanen *et al* 2022). The Inuvialuit Settlement Region (ISR) is experiencing the direct effects of accelerated warming with increasing air temperatures up to three times the global mean rate (Zhang *et al* 2019), causing warming ground temperatures (Burn and Kokelj 2009) and deeper depths of seasonal thaw (O'Neill *et al* 2019). Rates of sea ice losses have been more rapid than predicted (Stroeve *et al* 2012, Barnhart *et al* 2014a), exposing wide parts of the ice-rich Arctic Ocean coastline to extended periods of open water each year (Barnhart *et al* 2014b) and increasing the potential for damaging storm surges (Vermaire *et al* 2013). Climate-driven environmental change is having spatially varied and multifaceted socio-environmental impacts on communities across the Arctic (Ford *et al* 2012a, 2012b, IPCC 2019, Huntington *et al* 2022, Larsen *et al* 2021). Indigenous Peoples are more vulnerable to climate change due to their close connection to their environment and the landscape, in particular women and youth (Furgal and Seguin 2006, Ford *et al* 2012b). As the immediately disadvantaged, it is important for communities in the ISR to be involved in research that contributes to adaptation, strategic decision-making, and resiliency efforts.

Adequate environmental monitoring is required to inform mitigation and adaptation strategies and aid decision-making (Eicken *et al* 2021). Many monitoring systems struggle to realise their wider aims because the process from data collection to decision-making takes too long (commonly 3-9 years) (Danielsen *et al* 2010), which spans well beyond the duration of available project funding. This has been exacerbated by COVID-19, which severely limited research capabilities in the Arctic (Petrov *et al* 2020). Community-based monitoring (CBM) can address such knowledge gaps (Henri *et al* 2018, Peacock *et al* 2020) and reduce the time taken from data collection to decision-making (Whitelaw *et al* 2003, Danielsen *et al* 2010, 2018). CBM has many definitions depending on the application purpose (EMAN 2003, Danielsen *et al* 2014, Johnson *et al* 2015, Griffith *et al* 2018) with the levels of community engagement in each program varying (Danielsen *et al* 2009). Citizen science - the engagement and participation of non-professional scientists in scientific knowledge production - is becoming a popular way to engage citizens in environmental monitoring initiatives (Fritz *et al* 2022). This method involves professional scientists designing the research project and volunteers participating in data collection (Bonney *et al* 2009). CBM is distinguishable from citizen science in that community members are involved in projects beyond data collection and monitoring addresses their aims and objectives (Hansen 2018). We use CBM as a term that encompasses involvement in one or more areas of the research process (Danielsen *et al* 2018) that can include question development, data collection, analysis, interpretation, outputs and decision-making. CBM has enabled data collection to continue over multiple seasons (Moore and Hauser 2019, Wilson *et al* 2020, Rode *et al* 2021), which is essential in Arctic regions where it is common for external researchers to visit study sites for short periods. CBM has improved science (Eerkes-Medrano *et al* 2017) where collaborative partnerships increase research efficiency, data robustness and longevity contributing to improved evidence-informed decision-making (Pedersen *et al* 2020).

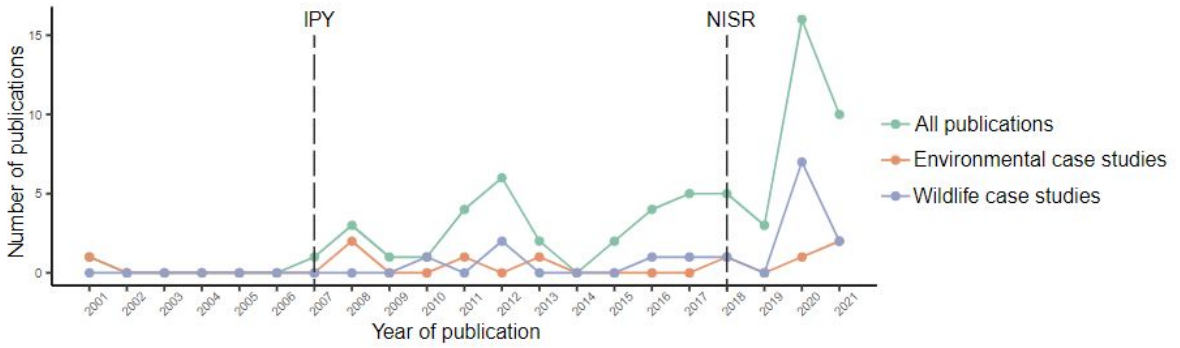

Figure 1. Number of peer-reviewed publications focusing on CBM in Inuit Nunangat since 2001. IPY and NISR represent timings of the International Polar Year and publication of the National Inuit Strategy on Research, respectively. Data based on peer-review literature retrieved using search terms provided in section 2.

In recent years there has been a change in the way that research is approached and conducted in the Arctic. Extracting information from communities is no longer recognized as meaningful engagement. Once undervalued (Sadowsky *et al* 2022), Indigenous Knowledge has been advantageous for monitoring the impacts of environmental change on wildlife and influencing management decisions. Working collaboratively and meaningfully with Inuit and ensuring inclusion in all aspects of the research process can help address community priorities and increase equitable outcomes of research (Danielsen *et al* 2014, ITK 2018, Peacock *et al* 2020, Reid *et al* 2021). Indigenous organizations, national bodies, and funding agencies have produced ethical statements, guidelines and policies that help address power imbalances in research and support community autonomy (Castleden *et al* 2012). Recommendations for non-Indigenous researchers looking to conduct research with Indigenous communities have been helpful for guiding research approaches towards reconciliation (Wong *et al* 2020), youth participation (Pedersen *et al* 2020) and ethical and equitable engagement (TCPS 2018, Inuit Circumpolar Council 2022). The release of the *Inuit Tapiriit Kanatami* (ITK)'s National Inuit Strategy on Research (NISR) (ITK 2018) has provided a mechanism for change in research occurring in Inuit Nunangat (Inuit homeland in Canada), which is comprised four regions – Nunavut, Nunatsiavut, Nunavik and the Inuvialuit Settlement Region. Funding bodies (e.g. UK Research and Innovation) have aligned grant requirements to increase respectful and beneficial research using the five NISR priority policy areas: 1) advance Inuit governance in research, 2) enhance the ethical conduct of research, 3) align funding with Inuit Research Priorities, 4) ensure Inuit access, ownership, and control over data and information, and 5) build capacity in Inuit Nunangat research (ITK 2018). It is not yet known how the release of the NISR and wider policy changes have impacted CBM research in Inuit Nunangat.

Here we analyse how community engagement in CBM research processes in Inuit Nunangat has changed since the release of the NISR. We present a case study of a CBM program that was co-developed by a cross-disciplinary team to provide greater understanding of climate-driven environmental changes occurring to landscape surrounding the hamlet of Tuktoyaktuk, ISR, Canada. We discuss the lessons learned and draw key recommendations to drive the future directions and progressive supporting structures required to enhance CBM efforts towards effective adaptation decision-making by communities.

2. Environmental CBM trends in Inuit Nunangat

Changes to community engagement in the research process were established from a literature search of research in Inuit Nunangat published between 2001 and 2021. Key words to identify CBM ("community-based monito*") related research in the geographical region of Inuit Nunangat ("Arctic" AND "Inuit" OR "Inuvialuit" OR "Nunavut" OR "Nunavik" OR "Nunatsiavut") were used to select relevant peer-reviewed articles in the Scopus journal database. From this search, 23 articles containing 24 CBM case studies met the selection criteria and underwent further analysis. The data processing and analysis method are presented in Supplement S1.

Studies incorporating CBM approaches have increased within Inuit Nunangat over the last decade (Fig. 1),

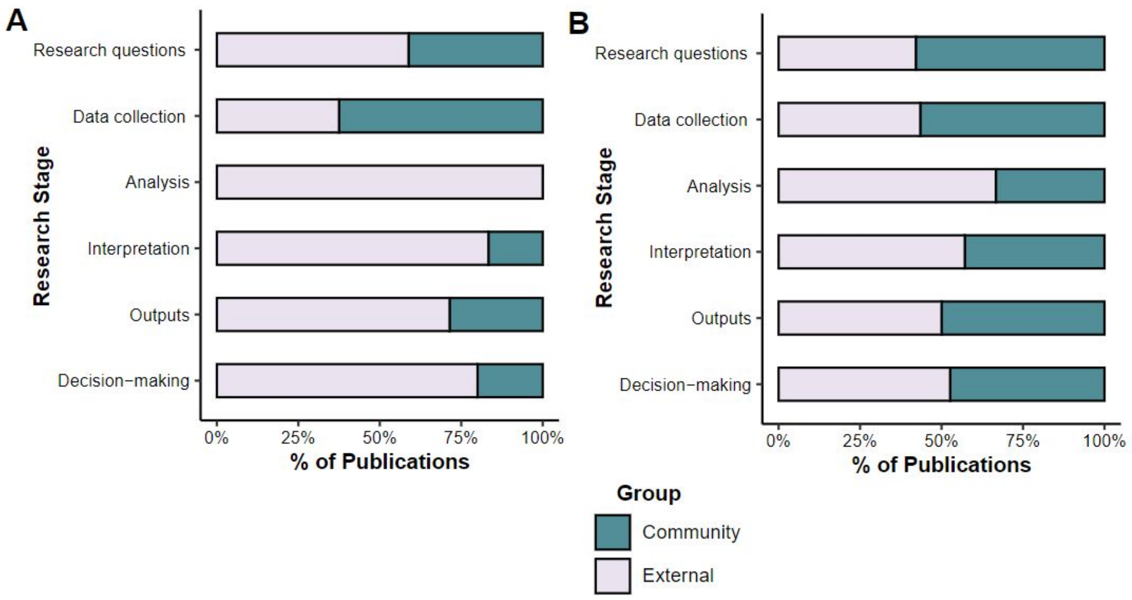

Figure 2. The proportion of publications that report community and external group involvement at different stages of the research process in case studies published A) before 2018 (n = 10) and B) during 2018 and onwards (n = 14).

but 75% were reviews, highlighting the scarcity of unique case studies. There has been a greater increase in wildlife CBM case studies when compared to environmental CBM case studies (Fig. 1). Therefore, while there has been a demonstratable increase in CBM research initiatives in Inuit Nunangat, there is a lack of those that focus exclusively on environmental challenges. The International Polar Year (IPY) 2007-2008 was a coordinated project that supported the initiation of monitoring initiatives across the Arctic. The release of the National Inuit Strategy on Research (NISR) in 2018 corresponded with an increased number of CBM focused reviews rather than the number of unique studies, particularly those addressing environmental studies (Fig. 1). Prior to 2018, community engagement with CBM predominantly occurred during the data collection stage, with no studies reporting community inclusion in data analysis (Fig. 2). This is characteristic of externally driven top-down CBM approaches. Since the release of the NISR, community engagement in data analysis and interpretation has increased, which is likely to have driven the improved equity of research outcomes and decision-making processes (Fig. 2). This indicates that longer-term community engagement may be enhanced by involvement with critical higher levels of the research process. Adequate infrastructure and training are necessary to making this possible.

3. CBM case study

3.1 Setting

The hamlet of Tuktoyaktuk is located on the southeastern Beaufort Sea coast, facing into Kugmallit Bay, east of Mackenzie Delta, in the ISR, Canada. Tuktoyaktuk lies within the land claim boundary of the Inuvialuit people, under terms of the 1984 Inuvialuit Final Agreement (Government of Canada 1984). As of the 2016 census the overall population size of the hamlet was 898 (Statistics Canada 2017).

Wildlife monitoring in Tuktoyaktuk, which aligns well with community interests and activities, has been successfully established through the development of long-term partnerships with the Hunters and Trappers Committee (HTC) and community members (Russell *et al* 2013, Waugh *et al* 2018, Ostertag *et al* 2018, Choy *et al* 2019, Gagnon *et al* 2020, Moore *et al* 2020). However, there remains an urgent need for community-based environmental monitoring initiatives. Over the last two decades, the area has been challenged by climate-driven hazards which threaten infrastructure, livelihoods, food systems and culture (Andrachuk and Smit 2012). A particular challenge facing the community over recent decades has been coastal erosion. Recently measured erosion rates of up to 2m/ yr (Whalen *et al* 2022) combined with rising sea levels (James *et al* 2021) will threaten the current location and configuration of the community in the next 25-75 years. Climate monitoring is required to inform adaptation decision-making that includes preparing Tuktoyaktuk for the possibility of future relocation.

3.2 Co-development of a climate monitoring program

In 2017, representatives from the Tuktoyaktuk Community Corporation (TCC) engaged with external scientific advisors to collaborate on a proposal to receive support from the Crown Indigenous Relations and Northern Affairs Canada (CIRNAC) Indigenous Community-Based Climate Monitoring Program grant (Fig. 3). This began an iterative process, where community input was sought from the outset to design the Tuktoyaktuk Community Climate Resiliency Project (TCCRP) community-based climate monitoring program (Fig. 3).

In 2018, a World Café was held in Tuktoyaktuk, in response to support from CIRNAC. A World Café is an innovative methodology used to facilitate a network of collaborative dialogue surrounding key strategic questions and important challenges (Chapman *et al* 2020, Fonseca Peso *et al* 2020, Prewitt 2011). The World Café was open to all community members with door prizes being used to encourage attendance. This successfully led to contributions from a diverse range of individuals including men, women, youth and elders. Over 50 attendees provided feedback surrounding 6 main objectives: 1) youth participation, 2) benefits for further research, 3) supporting climate change leadership, 4) identification of climate change indicators, 5) knowledge sharing and 6) climate change solutions (Fig. 4). Opening the World Café event to the entire community

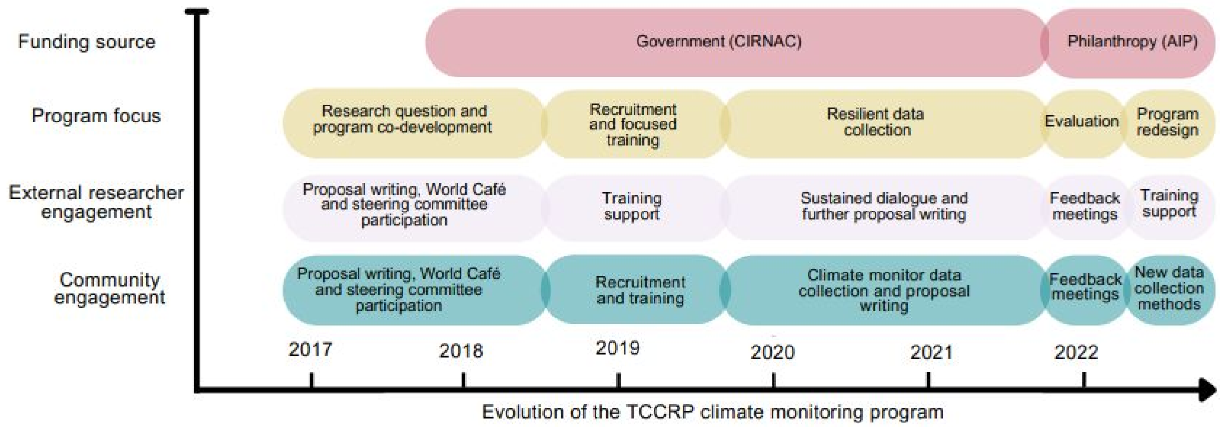

Figure 3. Evolution of the TCCRP community-based climate monitoring program over time. Different stages of the TCCRP progı ... ıal resea

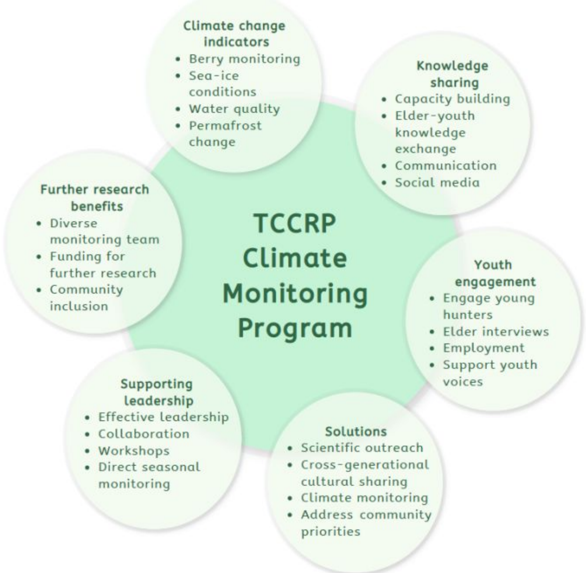

Figure 4. Research priorities identified at the World Café event by participants from Tuktoyaktuk to guide the development of the TCCRP climate monitoring program in 2018.

allowed a range of research priorities to be identified from different perspectives (Fig. 4). A participatory mapping exercise involved harvesters and elders recording locations of observed climate changes on a map of Tuktoyaktuk and the surrounding area. The exercise highlighted important subsistence harvesting locations including areas of fishing, caribou hunting, berry picking and geese hunting that have been impacted by climate change (Fig. 5).

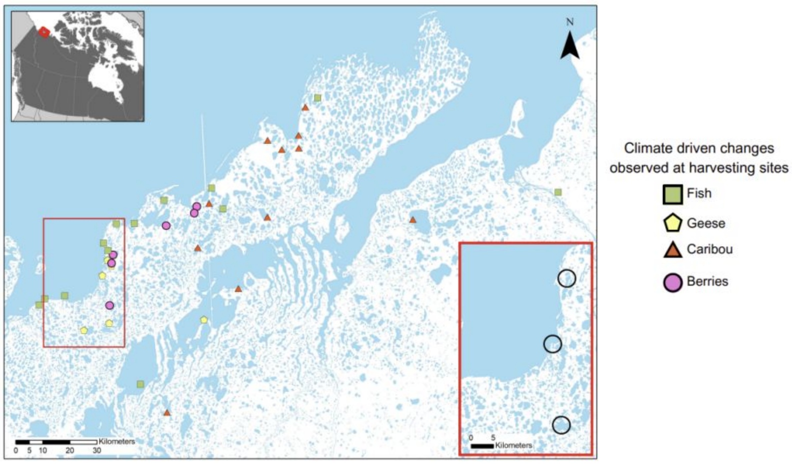

Figure 5. Map of harvesting sites where observed climate change impacts were highlighted by hunters and elders during the mapping session of the World Café event. Black circles on the bottom right inset map indicate the chosen sites for community-based climate monitoring to occur.

An inclusive approach continued to the creation of a steering committee, which brought together diverse representatives including elders, educators, council members, harvesters and an external scientific advisor to oversee the development of the TCCRP monitoring program and provide ongoing guidance. Climate change research priorities identified at the World Café (Fig. 4) helped the steering committee guide the design of the climate monitoring program. Three sites were chosen as the location to focus monitoring efforts based on feedback from the participatory mapping exercise and additional guidance from the Hunters and Trappers Committee- Iqallukvik lake, Tiktalik lake and the Tuktoyaktuk harbour (Fig. 5). Monitoring efforts were targeted toward attaining records for both *in-situ* instrumental measurements and observations from Inuvialuit knowledge holders.

Aurora College designed specialized training to support the creation of 16 community climate monitor roles. Training took place on 3 occasions between 2018 and 2020 and then climate monitors were given responsibility for weekly monitoring of environmental conditions at the predetermined sites (Fig.5). Water monitoring during the Spring, Summer and Winter months includes measuring water temperature and hydrostatic level, in addition to the collection of surface water samples for turbidity analysis. A variety of *in-situ* measurements are collected to investigate the effects of climate change on ice (thickness on land, sea-ice thickness, and black ice/white ice depth), permafrost (active layer depth) and vegetation (rhubarb length and pictures of various berry types). Photographs are used to monitor sea-ice changes in Tuktoyaktuk harbour during break up and freeze up periods. Inuvialuit knowledge is used to document anything new or unusual. Scientific outreach has been achieved through communicating to the public via social media platforms (e.g., The Tuktoyaktuk Community Corporation Resiliency Project https://www.facebook.com/TCCRPClimateCoordinator) and to the wider scientific audience at international conferences such as the ArcticNet Annual Scientific Meeting and the Arctic Circle Assembly.

After nearly 4 years of data collection the TCCRP came to a crossroads where environmental monitoring that addressed community research priorities had been achieved however, it lacked the long-term viability. The future of the TCCRP depended on orienting goals towards long-term funding that will sustain research partnerships and monitoring capacity. In March 2022, the TCCRP was awarded the Arctic Inspiration Prize (AIP) which will support further development of the program (Fig. 3). The AIP proposal was co-written between members of the TCCRP team and scientific advisors including members from the original steering committee (Fig. 3). This new phase will provide the training and infrastructure required to transition the focus from data collection to utilization and effective decision-making. A meeting was held with members of the climate monitoring team and original steering committee to discuss steps towards creating actionable items for empowered decision-making (Fig. 3). This will support the co-creation of a 'Future Tuktoyaktuk' prepared for climate change adaptation.

4. Discussion

4.1 Shift in CBM practices

Despite increases in CBM research initiatives in Inuit Nunangat, few focus specifically on environmental changes. This is an Arctic-wide issue (Johnson *et al* 2015, Kouril *et al* 2016). Data quality may have undermined the publication credibility of environmental CBM research. Low sample sizes and infrequent monitoring have commonly been reported in environmental CBM programs (Peacock *et al* 2012, Anne MacMillan *et al* 2017). This has limited the potential utilization of community-collected data (Wilson *et al* 2018) and impacted the ability to inform decision-making (Wilson *et al* 2021). Existing community networks, sustained funding, and long-term monitoring are notable differences with CBM wildlife monitoring that aligns closely to culture, health and food security (Hovel *et al* 2020, Ndeloh Etiendem *et al* 2020, McNicholl *et al* 2021). The migratory nature of wildlife could enable greater collaboration between communities whereas land ownership and responsibilities impose more restrictions on environmental monitoring initiatives.

Specific initiatives, including the IPY 2007-2008 (Fig. 1), have supported a new era of partnership and collaboration with northern communities (Krupnik *et al* 2010). However, short-term funding structures typically limit the sustainability of environmental CBM programs in the Arctic (Ford *et al* 2013a, 2013b, Johnson *et al* 2016, Danielsen *et al* 2018), while long-term initiatives remain underfunded and lack coordination towards achieving specific goals (Ferguson *et al* 2012). Dependence on short-term funding limits the development of long term reciprocal relationships required to sustain monitoring capacities (Danielsen *et al* 2020, Wilson *et al* 2020).

Communities have predominantly been involved in data collection components of research (Fig. 2), reflective of externally driven CBM approaches that often have a disconnect between the environmental monitoring activities and the priorities of northern communities (Danielsen *et al* 2020). Since the release of the NISR, community engagement has increased in all areas of the CBM research process (Fig. 2). This suggests that new mechanisms have implemented change however, the NISR is not the singular driver of change in CBM practices. Discussions surrounding the involvement of community members in CBM research processes began before the release of the NISR (Peacock *et al* 2012, Tremblay *et al* 2008, Knopp 2010, Gearheard *et al* 2011). The promotion of co-production brings together Indigenous and scientific knowledge systems to create new knowledge and understanding (Yua *et al* 2022). Participatory research philosophies can encourage ownership of the research process (Castleden *et al* 2012) and increases engagement in all research stages (Minkler and Wallerstein 2011). Building equity in the research process, where space is created for all knowledge holders and knowledge systems (Yua *et al* 2022), can increase the equity of outcomes and decision-making processes. Working with community members through co-dissemination processes could help ensure results are interpreted together and translated into decision-making and equitable outcomes.

Improved infrastructure and training are required to store, manage and analyze community collected data. Data management software such as the SIKU app (https://siku.org/) has been developed to support Inuit access, data ownership, and self-determination in the research process: helping to decide what to share and with whom. There is no universal approach to successful CBM research (Johnson, 2016), community requirements and priorities and thus the effectiveness of CBM remain context specific. The time and training required to analyze, interpret and communicate results is extensive (Castleden *et al* 2012). It may not be in a community's best interest to allocate resources toward community-led analysis, emphasizing the need for early and sustained dialogue in research processes.

Enhancing self-determination, where Indigenous Peoples become active participants, enables preparation for the challenges and possibilities that lie ahead (Smith 2021); particularly important in regions undergoing rapid environmental changes. While increasing emphasis on self-determination has given communities more say in research occurring within Inuit Nunangat, it is important to identify what external support is required to help empower communities to translate the data they collect into evidence-informed decision-making.

4.2 Developing beyond CBM

The first phase of the TCCRP focused on project co-development guided by community priorities, working to advance Inuit governance in research (ITK 2018). Co-developing research takes time, flexibility, and adaptability

(Wilson *et al* 2020, Yua *et al* 2022), therefore, it was important for community members in Tuktoyaktuk to be engaged early in the research process (Fig. 3). Early dialogue with communities has been found to create greater scientific and community benefits (Ford *et al* 2013a, Wilson *et al* 2020, Wong *et al* 2020). Time and dedication is required to build trust and effective collaborative partnerships (Blangy *et al* 2018). The TCCRP program has continued to develop collaborative partnerships between external researchers and community members through sustained dialogue, invested relationships, and frequent feedback opportunities (Fig. 6).

Communities experiencing change are more informed, aiding the identification of research priorities (Riedlinger and Berkes 2001). Climate change research priorities identified at the World Café (Fig. 4) helped guide the design of the climate monitoring program, enhancing Inuit self-determination and equity in research outcomes. It resulted in the development of a unique climate monitoring program that focusses on monitoring climate driven environmental changes challenging the community. Community priorities differed from the original stance provided by external researchers who supported the initial project proposal. An interest on monitoring coastal erosion written in the initial proposal shifted to monitoring environmental changes at important harvesting sites (Fig. 5) based on feedback retrieved at the World Café. This highlights the successful role the World Café had in creating a space to receive feedback to guide future monitoring efforts that address community research priorities. It is common for agendas to differ between research collaborators. Researchers are subject to funding and time constraints, whereas communities have other priorities such as education and economic development that work on different timescales (Gérin-Lajoie *et al* 2018). Ensuring that there are tangible, equitable outcomes between communities and researchers is not a straightforward process.

The TCCRP has developed a platform for more inclusive research. Opening the World Café event to the entire community allowed research priorities to be identified from different perspectives. The wealth of land-experience, skills and knowledge that Inuvialuit provide are invaluable contributions to research processes. There is a gender bias in community engagement in CBM programs. It is common for research to include male hunters and elders (Laidler *et al* 2008, Martinez-Levasseur *et al* 2016, Peacock *et al* 2020), limiting the valuable contributions of groups most vulnerable to the effects of climate change, which includes women and youth (Ford *et al* 2012b). Perspectives of women and youth should not be treated passively as their voices are important contributions to research processes. Women have supported the design, initialization, and shaped future directions by occupying leadership positions and youth continue to be involved in the program as climate monitors. Maintaining the diverse representation remains essential to ensuring outcomes of the program address priorities of the whole community.

The TCCRP created a foundation for community members to develop new skills including recording data observations (Fig. 3). This has supported position retainment (short and long-term) with visiting research groups

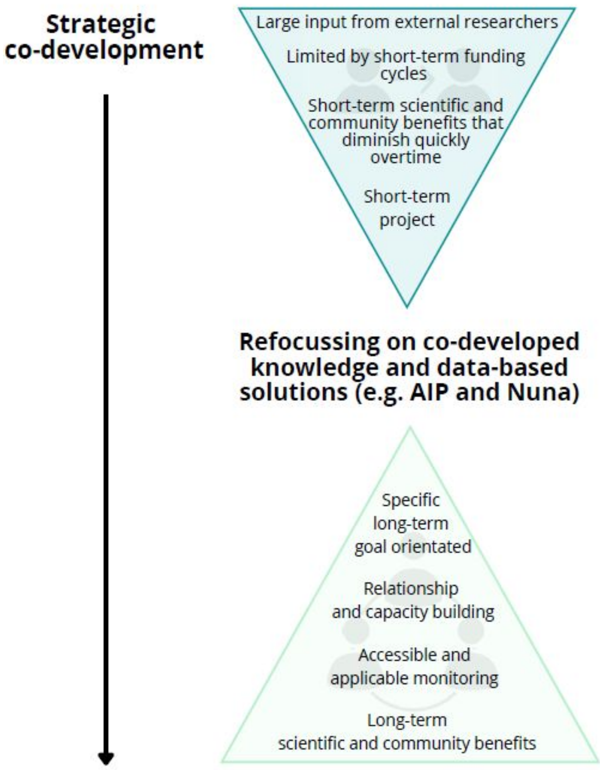

Figure 6. Model of TCCRP community-based climate monitoring program progression, from the processes contributing to the initial phase through to those supporting the progression and evolution towards use and sustainability of the data.

(government and academic). Researchers routinely present the research they wish to conduct to the TCC. It is common for research groups to request that climate monitors participate in environmental research work as a condition to continue research. This has encouraged further CBM initiatives in Tuktoyaktuk including SmartICE (https://smartice.org/).

Sustaining monitoring is essential for providing sufficient baseline environmental data. The impact of the COVID-19 pandemic and associated travel bans on field research created knowledge gaps that will have long-lasting effects on scientific disciplines, policy decisions and communities (Petrov *et al* 2020). However, the TCCRP continued to collect valuable information and reduce data gaps in climate observations (Fig. 3). A different challenge to sustaining the TCCRP program has been high staff turnover, a significant problem across Arctic CBM programs (Danielsen *et al* 2020), impacting the long-term viability of CBM programs and the upkeep of data records (Conrad and Hilchey 2011). Fatigue and disengagement can arise through time intensive survey protocols and insufficient outcomes (Danielsen *et al* 2020). Succession planning and addressing the drivers of staff turnover in the TCCRP is essential to ensuring the continued progression of the climate monitoring program.

4.3 Planning for future resilience

Securing the AIP has sustained the long-term viability of the TCCRP program and enabled refocus towards more accessible and applicable community-based environmental monitoring (Fig. 6). The AIP emphasizes the utilization and analysis of data and is complemented by Nuna, an innovative solutions orientated research program (Fig. 6), where scientists, government agencies, and community members co-lead efforts to address complex and community driven research questions that have evolved from both data and Inuvialuit knowledge. As a result, monitoring sites have been moved closer to the community, which makes them more accessible and relevant to inform decisions on adaptation and mitigation measures. Stronger emphasis has been placed on co-dissemination practices to ensure monitoring findings are communicated back to community members in a way that is understandable, usable, and relevant to community priorities. A key element to the progression of the TCCRP program has been securing external funding that supports new positions for Inuvialuit, working to build capacity in the North by the North. Increasing multiple authority team members within the TCCRP reduces the risk of staff loss impacting monitoring activities. Additionally, the AIP provides a rare example of funding that does not impose set timescales and hence affords flexibility for the project to adapt and adjust to build consistently towards desired outcomes.

Youth engagement is a unifying theme across the TCCRP, the AIP and Nuna. It has been common for youth to take on lead roles as coordinators to oversee CBM efforts when researchers are not present in communities (Peacock *et al* 2012, Kouril *et al* 2016), and there have been calls for youth to be engaged in Arctic research more widely (Brook *et al* 2009, Gérin-Lajoie *et al* 2018, Pedersen *et al* 2020, Stenekes *et al* 2020, Wong *et al* 2020). Knowledge documentation efforts that contribute to educational materials including maps, imagery and different knowledge based lesson plans can help facilitate knowledge transfer between elders and youth (Laidler *et al* 2008). Environmental research that utilizes cultural skills can increase youth researcher connections to the environment, raise education attainment (Spellman *et al* 2016, Wong *et al* 2020), and may help ensure the continued evolution of resilience to climate change impacts within the community.

5. Conclusion

The release of the NISR (ITK 2018) has provided a mechanism for change in CBM research processes in Inuit Nunangat; increasing community engagement in all aspects of the research process since its introduction. We recommend more environmental CBM case studies be presented in the peer reviewed literature to draw guidance from and ensure the impact of policy changes on community engagement in research continue to be evaluated. Comparative analysis of CBM case studies from Inuit Nunangat with those from other Arctic regions will enable the impact of the NISR to be evaluated further. There is much to learn from wildlife-based research in Inuit Nunangat and interdisciplinary collaborations could help bridge the gap between wildlife CBM and environmental CBM success in the ISR. Co-development of CBM programs is becoming an essential component for research in Inuit Nunangat and across the Arctic. Funding must be specifically allocated for external researchers to communicate with communities early in the research process to ensure the co-development of appropriate questions. An inclusive relationship between the community and researchers ensured that the TCCRP community-based climate monitoring program has maintained both the longevity of the data produced and its relevance for addressing community priorities. A successful CBM program is often simply regarded as one that can be sustained (Johnson *et al* 2015), although ultimately the success should be judged on the desired outcomes. The continuation of cross-seasonal environmental monitoring after four years highlights the TCCRP program as an important case study to draw guidance from. Through the case study we highlight how flexible, long-term funding structures can act to enable CBM longevity and the progressive development of collaborative research whilst enhancing Inuit self-determination in the research process. Expansion of the TCCRP program could facilitate the development of CBM networks with other communities and enable a more holistic record of diverse environmental changes and impacts occurring. Such cooperation is common in wildlife based CBM programs to meet the spatially connected migratory patterns of animals and fish (Ndeloh Etiendem *et al* 2020). Ultimately, the key test of the program's success will be its ability to guide strategic community decisions and exert influence beyond the community level.

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