Global Environmental Change 49 (2018) 129–139

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation

James D. Ford[a,b,*], Mya Sherman[a], Lea Berrang-Ford[a,b], Alejandro Llanos[c], Cesar Carcamo[c], Sherilee Harper[d], Shuaib Lwasa[e], Didacus Namanya[f], Thomas Marcello[a], Michelle Maillet[a], Victoria Edge[g]

[a] Department of Geography, McGill University, Montreal, QC, H3A0B9, Canada
[b] Priestley International Centre for Climate, University of Leeds, Leeds, LS2 9JT, United Kingdom
[c] Faculty of Public Health, Universidad Peruana Cayetano Heredia, Lima, Peru
[d] Department of Population Medicine, University of Guelph, Guelph, ON, Canada
[e] Department of Geography, Makerere University, Kampala, Uganda
[f] Ministry of Health, Uganda
[g] Public Health Agency of Canada

ARTICLE INFO

Keywords:
Climate change
Health
Community based adaptation
Indigenous peoples
Climate change
Adaptation
Study design

ABSTRACT

Climate change presents substantial risks to the health of Indigenous peoples. Research is needed to inform health policy and practice for managing risks, with community based adaptation (CBA) emerging as one approach to conducting research to support such efforts. Few, if any, studies however, have critically examined the application of CBA in a health or Indigenous peoples context. We examine the strengths, challenges, and opportunities of health-related CBA research in Indigenous community settings, drawing on the experiences of the multi-nation interdisciplinary Indigenous Health Adaptation to Climate Change (IHACC) project. Data collection was guided by a framework developed to evaluate CBA projects. Semi-structured interviews (n = 114) and focus groups (n = 23, 177 participants) were conducted with faculty-based researchers, institutional partners, community members, students, and trainees involved in the IHACC project in Canada, Uganda, and Peru. Results illustrate the importance of CBA in co-generating knowledge on climate-health vulnerability and adaptation options, capacity building, and informing decision choices. There are also significant challenges of conducting CBA which can have unintended negative consequences, with results emphasizing the importance of managing the tension between health research and tangible and immediate benefits; developing a working architecture for collective impact, including team building, identification of common goals, and meaningful engagement of knowledge users; and the need to continuously monitor and evaluate progress. CBA holds significant promise in a health adaptation context, but only in the 'right' circumstances, where considerable time is spent developing the work with partners.

1. Introduction

Climate change has been identified as one of the biggest threats to health this century (Smith et al., 2014; Watts et al., 2015). The impacts on health will be unequal, with Indigenous populations among those identified as highly sensitive, reflecting existing social gradients in health, close relationships with the rapidly changing environment for livelihoods and wellbeing, institutional and educational capacity challenges, and colonial legacies (PROVIA; Ford et al., 2010; Maldonado et al., 2013; Maru et al., 2014). Research has documented climate change to be already challenging human rights, livelihoods, and the health of Indigenous peoples globally (Ford, 2012). Reflecting existing and projected climate impacts, the importance of adaptation involving policies, measures, strategies, or actions designed to reduce climate change vulnerability and support resilience is increasingly being recognized, and has been identified as a grand challenge for global public health (Costello et al., 2009; Moss et al., 2013; Watts et al., 2015; WHO, 2015). Herein, adaptation is synonymous with prevention in a health context, and may involve primary, secondary, and tertiary interventions (Ebi and Semenza, 2008).

Science has an important role in climate-health adaptation, helping to understand decision processes and information requirements,

* Corresponding author at: Priestley Centre for International Climate, University of Leeds, Leeds, LS2 9JT, United Kingdom.
E-mail address: j.ford2@leeds.ac.uk (J.D. Ford).

https://doi.org/10.1016/j.gloenvcha.2018.02.006
Received 3 November 2016; Received in revised form 15 January 2018; Accepted 16 February 2018
Available online 08 March 2018

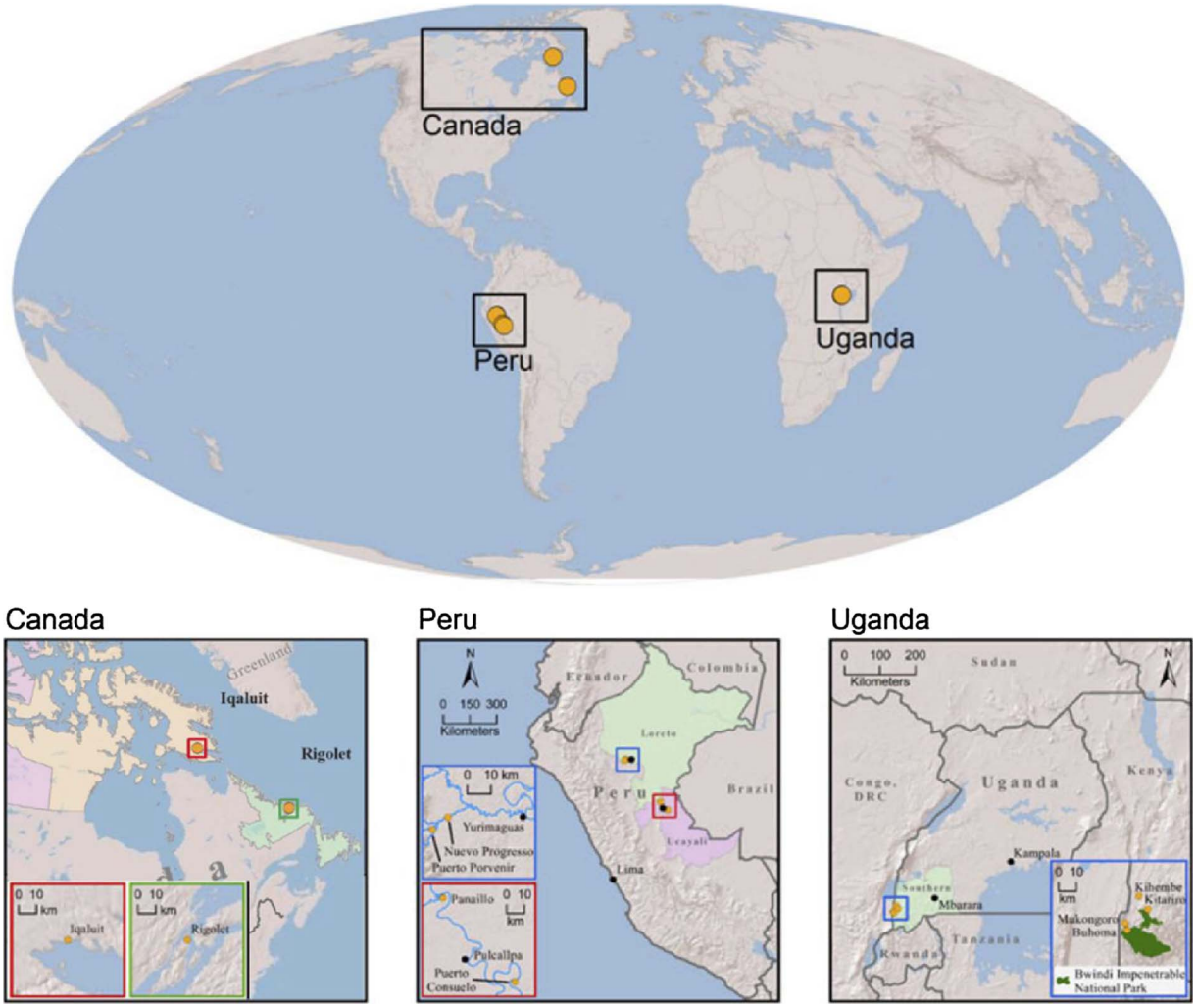

Fig. 1. The IHACC study regions and partner communities.

characterizing current and future vulnerabilities, and for identifying and evaluating potential adaptation options (Ebi and Semenza, 2008; Moss et al., 2013). Adaptation science is expanding rapidly, including research *about* adaptation which seeks fundamental understanding on adaptation processes in human and natural systems, and research *for* adaptation which is explicitly designed to inform policy and practice for adapting (Hosking and Campbell-Lendrum, 2012; Hess et al., 2014; Swart et al., 2014; Preston et al., 2015; Tschakert et al., 2016; Bremer and Meisch, 2017). Community-based adaptation (CBA) has emerged as a key component of research approaches that seek to inform adaptation decision-making (Ebi and Semenza, 2008; Forsyth, 2013; Ford et al., 2016; McNamara and Buggy, 2017; Ensor et al., 2018). Evolving from the participatory action research field, particularly in development studies, CBA can be defined as "a community-led process, based on communities' priorities, needs, knowledge, and capacities, which empowers people to plan for and cope with the impacts of climate change" (Reid et al., 2009, p13).

CBA emphasizes the importance of researchers and practitioners working in collaboration with communities, in which decision-making is shared and underpinned by frequent dialogue (Ensor et al., 2018). The inclusion of local/Indigenous knowledge is central to CBA projects which are diverse in nature, including work centered on vulnerability assessment, adaptation planning and preparedness, and, more recently, the design, monitoring, and evaluation of adaptation interventions. Different orientations are discernible in CBA projects. On the one hand, research-orientated CBA projects have an emphasis on knowledge co-generation and informing decision making on vulnerability reduction through the research process, including through capacity building, knowledge mobilization, empowerment, and training. While such projects may target supporting actual interventions, knowledge co-generation is the primary motivation. On the other hand, development- or policy-orientated CBA projects have an overarching emphasis on developing and supporting interventions and program development, and are typically initiated by civil society organizations, development donors, or communities themselves (Dodman and Mitlin, 2013; Schipper et al., 2014).

While CBA has been widely promoted as an effective approach for research to assist adaptation, some have argued that uncritically adopted community based approaches can be maladaptive, further perpetuate colonization, and may not be appropriate for all situations (Dodman and Mitlin, 2013; Forsyth, 2013; Ford et al., 2016; McNie et al., 2016). Yet few have critically examined CBA approaches (McNamara and Buggy, 2017), and this gap is particularly evident in the climate and health field, which has been slow to focus on adaptation at the community level but is increasingly adopting community-based approaches and recognizing that community action is critical to achieving climate-resilience (Hess et al., 2008; Miller and Bowen, 2013; Tschakert et al., 2014; McDowell et al., 2016; WHO, 2015). In this paper, we evaluate the strengths, challenges, and opportunities of research-orientated CBA projects in rural Indigenous community settings, drawing upon the experience and perspectives of communities, decision makers, students, and faculty-based researchers engaged in a CBA

project on climate change and health. The paper is part of what Preston et al (2015) have termed 'reflexive adaptation research,' with the insights derived from the experience of a specific project used to examine study design in CBA health work more generally and ground expectations in terms of what can reasonably be achieved within the confines of a research initiated project. It is noteworthy that this paper does not focus on *why* community engagement is important for health adaptation or on the imperative for decolonizing research—there is extensive thinking on this elsewhere (Smith, 1999; Pearce et al., 2009; Castleden et al., 2012b; Forsyth, 2013)—but rather reflects on the *process* behind CBA work.

2. Methodology

2.1. Case study of the IHACC project

We focus on the Indigenous Health Adaptation to Climate Change (IHACC) project to develop in-depth insights on the development, operationalization, impact, and design of a CBA project from all those involved. IHACC was a 6-year (2010–2016) research-focused CBA project, involving collaboration between McGill University and the University of Guelph in Canada, Universidad Peruana Cayetano Heredia in Peru, and Makerere University in Uganda. The project worked closely with Indigenous communities (n = 16) with study sites in the Canadian Arctic (Inuit), Peruvian Amazon (Shawi and Shipibo), and southwestern Uganda (Batwa) (Fig. 1), and with institutional partners at local to national scales (see Supplementary materials for full description). All three regions are characterized by geographic isolation, pronounced health inequity, on-going experiences of colonization, and economic challenges, creating significant vulnerability to climate change impacts (Berrang-Ford et al., 2012; Hofmeijer et al., 2013; Harper et al., 2015). 'Health' was conceptualized broadly in the project as embracing physical, mental, and social well-being. The work sought to develop an understanding of the vulnerability and adaptive capacity of Indigenous health systems to climate change, identify and evaluate opportunities for adaptation across scales, and train highly qualified personnel. While IHACC supported small scale pilot adaptation interventions, the work was a research-orientated CBA project.

IHACC was undertaken by an international interdisciplinary team of university based faculty and students (the 'research team') in close collaboration with community members and decision-maker partners at local to national levels (the 'partners'). The team was interdisciplinary, composed of epidemiologists, medical doctors, geographers, climate modelers, and Indigenous knowledge holders. Lead researchers had extensive experience working with communities in the regions, and had well-established working relationships with institutional partners. Each region had a regional operations team (ROT) composed of two faculty-based researchers based in the region and relevant partners, who led the project in each region. A project management committee (PMC) dealt with strategic cross-regional issues and planning. Multiple methods were used, including longitudinal open cohort surveys, laboratory analysis for selected health outcomes, participatory rural appraisal methods, photovoice, digital storytelling, community diaries, and scenario analysis. IHACC was guided by principles of CBA and was informed by one year of consultation and engagement across the regions to document research needs, with research activities focusing on food security, water security, and vector-borne diseases. Core funding (CN$2.5m) was provided by Canada's International Development Research Centre (IDRC) and Canada's three research granting councils (CIHR, SSHRC, NSERC), and managed in each of the three regions, with additional funds leveraged (CN$6m).

2.2. Evaluation framework

Our framework for evaluating IHACC builds upon the general adaptation evaluation scholarship and the development evaluation literature (Trochim et al., 2008; Pearce et al., 2009; Bell et al., 2011; Ayers et al., 2012; Fisher et al., 2015; Brunet et al., 2017), along with consultation with the research team and partners through interviews and focus groups (see Section 2.3). Herein, one way to evaluate success would have been to utilize outcome evaluation approaches to measure vulnerability reduction attributable to a specific project. While often treated as a gold standard in the general monitoring and evaluation literature, such outcome approaches have not been widely used in an adaptation context as it is nearly impossible to causally separate adaptation initiatives from other policies and processes because of their contributive effect (e.g. policies tackling underlying determinants of vulnerability including investments in education, poverty alleviation, healthcare) (Ford et al., 2013). There is also a temporal disconnect between the timescale over which adaptation effectiveness is often manifest, which is often in terms of avoided climate impacts over decadal timescales, and practical need to conduct evaluation over much shorter timescales (Ford et al., 2013, 2015; UNEP, 2017). Indirect measures or proxies for evaluating the success and effectiveness of CBA projects—and adaptation initiatives more generally—are therefore needed.

The evaluation framework developed here draws upon process based evaluation approaches, and seeks to capture how the development, implementation, and results of IHACC influenced the process of learning and decision making around 'adaptation,' defined broadly as "the process of adjustment to actual or expected climate and its effects, in order to either lessen or avoid harm or exploit beneficial opportunities" . Adaptation encompasses a variety of strategies, actions, and behaviors that make households, communities, and societies more resilient to climate change, and may focus directly on reducing vulnerability to climate impacts and/or may involve addressing the underlying social drivers of vulnerability (Smit and Wandel, 2006; Lemos et al., 2016; Sherman et al., 2016). The framework identifies key components of a 'successful project,' focusing on the extent to which IHACC achieved its overarching objective of influencing adaptation through contributing to scientific understanding on Indigenous health and climate change, capacity development, and informing decision-making about health adaptation (see Supplementary materials). These components were developed based on an iterative process, including: i) a review of the literature on project-level adaptation evaluation and community based participatory research evaluation more generally, ii) a workshop attended by research team members and institutional collaborators, and iii) interviews and focus groups with community leaders, research assistants/surveyors, and study participants (see Section 2.3). The final framework thus brings together scientific, community, and decision maker considerations, and while specific to the regions of study, holds broad insights for the development and evaluation of CBA projects in diverse Indigenous contexts. The framework is composed of 6 components (Fig. 2):

- ***Academic excellence*** is concerned with the advancement of scientific knowledge necessary to inform climate-health adaptation, and captures the scientific quality, rigor, and contribution of research outputs on the sensitivity of health outcomes to climate, foresight on potential impacts of climate change determinants of health vulnerability, and climate-health adaptation options. Academic excellence also includes the extent to which cultural values and local/traditional knowledge are integrated into the health research.
- ***Research impact*** captures the extent to which the project has contributed to changes or influenced partners in ways that reduces vulnerability or strengthens resilience to the effects of climate change on health.
- ***Research effectiveness*** refers to the ability of the research program to complete its stated objectives in an efficient, responsive, and timely manner, and is important in CBA where objectives are co-developed with partners, creating expectations about what a project will achieve.

Fig. 2. The community-based adaptation (CBA) evaluation framework used to evaluate the Indigenous Health Adaptation to Climate Change project.

- ***Team dynamics*** focuses on the extent of coordination and the quality of working relationships among research team members, including communication, cohesion, and collaboration across disciplines. While examining research team dynamics can be a sensitive subject, it is included given the importance of teamwork and consistency among researchers for engagement with partners.
- ***Institutional engagement*** is concerned with the nature of researcher-institutional relationships and how institutional partners have been involved in the research program, including the roles of institutions, and their needs and expectations. Institutional partnerships are key determinants of the short and long-term impact of CBA research.
- ***Community engagement*** examines the quality of researcher-community relationships, community awareness and understanding of the project, and whether community expectations were met. Examining engagement also requires consideration of context, reflecting the capacity of community members to engage with CBA research and cultural differences, which can result in quite different expectations and interactions varying by region and community.

Assessment of each component drew upon participatory methods (Section 2.3) and was structured by outcome mapping and most significant change approaches. Outcome mapping was developed to facilitate monitoring and evaluation (M&E) of international development work (Earl and Smutylo, 2001), and focuses on the project's "outcomes", which include changes in behaviors, actions, activities, and relationships within the project's sphere of influence (Anderson, 2006; Nyangaga et al., 2012; Bours et al., 2014; Tremblay et al., 2014; Ehrlich et al., 2015). For each of the components of the evaluation framework, participants helped to identify and characterize outcomes and the conditions that must be met in order to achieve them. For example, participants were explicitly asked to articulate the long-term goals and aim of the project and the specific steps that IHACC took to achieve those goals. Participants were also asked to indicate how much progress has been made for each component of the framework, similar to the "graduated progress markers" utilized in outcome mapping (Earl and Smutylo, 2001). Discussions also encouraged team members to reflect on the original objectives, how well they have achieved those objectives, and how those objectives have changed over time.

Most significant change (MSC) is a story-based approach to M&E, and is also referred to as "stories of change" or "significant change stories" (Ayers et al., 2012; Kraft and Prytherch, 2016). It is considered a flexible approach to M&E since it is not based on pre-determined indicators (Boaz et al., 2009). To evaluate a project, participants are asked to identify and describe the most significant changes of a project (Ayers et al., 2012; Shah, 2014; Reed et al., 2015). These stories are then collected and reviewed by participants, with discussion centering on the major driving factors of that change and why a particular story was selected. Participants can also discuss ways to resolve the negative aspects of the experience and suggest actions that may reinforce the successful aspects of the change. Following this approach, participants here were asked questions including: What is the most significant impact of the IHACC research program? Why is this change significant to you? (see Supplementary materials). Questions focused on IHACC's actual accomplishments and encouraged participants to discuss the aspects of the project that strongly resonated with them and others.

2.3. Methods

Two of the co-authors (MS and TM) led the evaluation process and data collection in each region. Both had been involved with IHACC since 2011 but did not have leadership roles, never worked directly with any of the participating communities in this assessment, and thus had some distance from the project, yet also intimate knowledge of the overarching project goals. As such, the evaluation was internal and underpinned self-reflection and learning, while also exploring broader insights on CBA projects. Such self-reflective evaluation has been promoted in the developmental evaluation literature as essential where projects are working on 'wicked problems' such as climate change and health, nurtures learning through evaluation, and prioritizes the integration of diverse perspectives to foster innovation and progress (Lemos and Morehouse 2005, Silva Villanueva, 2011; Fazey et al., 2014). Also noteworthy is that the study draws upon the experience of researchers involved in IHACC, with most project evaluations focusing only on stakeholders (Fazey et al., 2014; Wall et al., 2017). Such engagement is essential for understanding the process of CBA, contextualizing challenges and decision made in projects, and leading to better informed recommendations.

The role of MS and TM was carefully managed to ensure full team input on the evaluation process but also maintain confidentiality and create an open space for reflection on the project. In Uganda we were able to work with all ten of the partnering communities given their close geographic proximity, and engaged all regional level partners. Given the large distances between partner communities and regions, in Amazonia we focused on the Loreto region and the settlement of Nuevo Progresso, and in the Arctic the territory of Nunavut and community of Iqaluit (see Supplementary materials). The research received ethics approval from [*to be inserted when published*] and a Nunavut Research License (for the Arctic work).

2.3.1. Semi-structured interviews

Interviews were conducted with community leaders (n = 16), community research assistants/surveyors (n = 21), community study participants (n = 11), institutional collaborators at local, regional, and national levels (n = 23), and research team members (n = 43) including students, staff, and faculty covering all ROT and PMC members. The sampling frame covered *all* people who were involved in IHACC, where a list of potential interviewees was drawn-up based on consultations among the research team and with partners across scales, with each person on the list invited to participate. All community members who we interviewed had participated in the longitudinal open cohort surveys conducted during the project, with some participating in individual student projects, meetings, community outreach events, interventions (Uganda and Peru), and/or 'giving back' efforts (e.g. educational workshops etc.). Interviews served two purposes–to inform the development of the evaluation framework and to critically reflect on the IHACC project–and were structured using an interview guide (see Supplementary materials). Within the structure of the guide, specific questions varied by region and type of participant, with a semi-structured and conversational approach used to allow respondents to place emphasis on issues they felt most important to communicate. All interviews were confidential and conducted individually, and were carried out in the respondent's language of choice, which included English and Spanish (spoken by the research team), as well as Rukiga, Shawi, and Inuktitut (with assistants to translate).

2.3.2. Focus groups

Focus groups (n = 22) were carried out with community members in Uganda (n = 19), Peru (n = 2), and the Arctic (n = 1). A total of 177 community members participated, including 104 women and 73 men. A focus group guide structured discussion, with similar questions to those asked in the interviews. The structure and approach to each focus group were tailored to the specific group of study participants. Members of the research team also participated in a one day workshop in 2015, attended by all PMC members and some students. Discussion topics included IHACC's methodology, defining success in IHACC and CBA research, the role of research in community-based adaptation, IHACC and adaptation in its three regions, lessons learned, and most significant change.

2.4. Analysis

Thematic analysis using a constant comparative method was used to analyse the data (Boyatzis, 1998; Boeije, 2002). All interviews and focus group were transcribed, with MS and TM having sole access to associated transcripts and identifiable data. Transcripts were initially read in full, with key themes on the success of CBA projects extracted to help inform the development of evaluation framework. A coding scheme was then developed based on the evaluation framework to extract perspectives on each of the six components scheme (Fereday and Muir-Cochrane 2006; DeCuir-Gunby et al., 2011). As part of results validation (Creswell and Miller, 2000), emerging findings were discussed with the research team and partners, and also compared to findings from other studies evaluating CBA projects. Quotes are used in the results to provide a rich and nuanced description of the data.

3. Results

3.1. Academic excellence

Academic excellence was considered an important contribution of climate-health CBA projects by the research team and institutional partners, with IHACC's scientific articles reportedly increasing "credibility" and "publicity" for partner organizations. Scientific outputs were described as increasing trust in the research, with demand from mostly national level partners for information on local/regional projections of climate impacts and evidence-based opportunities for reducing vulnerability. As one researcher commented, "without research we're shooting in the dark in terms of vulnerability reduction" (ID#37). IHACC was viewed to have made substantial contributions to academic excellence, reflected in contributions to the scholarship, success at integrating traditional knowledge and cultural values into the research, and developing baseline understanding on climate-health outcomes. Comparison across regions was reported to be important, although the tangible benefits to communities of such comparison was questioned by partners given the significant differences between the study regions, with the impact more at the level of contributing to global understanding on climate change and Indigenous issues. A number of challenges to achieving academic excellence were raised, with researchers across regions struggling to maintain a focus on climate change and adaptation with many other pressing issues facing communities (e.g. poverty, unemployment, ill health, health care access). This necessitated balancing the overarching adaptation goal of the project, demands of institutional partners for climate specific information, and immediate community needs, and resulted in a greater focus on present day climate-related health outcomes.

3.2. Research impact

Several respondents commented that the true impact of IHACC will only be apparent in the future by observing the "legacy" of the project on policy, practice, and behavior with respect to climate-health adaptation. However, a number of short-term impacts of IHACC were identified as key contributions and are indicative of achieving such longer-term impact.

- ***Capacity development*** was considered the most significant impact of IHACC by respondents across regions. Institutional partners, for example, described gaining important skills and knowledge in

health research, built relationships with Indigenous communities, and described learning the importance and utility of research. One researcher involved in the Arctic work highlighted how many community members now view research as "a new kind of strength" (ID#92), while another respondent discussed how IHACC "planted seeds of change" (ID#37). Researchers noted that the IHACC experience increased many community surveyors' confidence to pursue other opportunities, and community surveyors from all regions reported being able to get other jobs after IHACC due to the experience and training they gained.

- ***Awareness raising and the development of baseline information*** on health, vulnerability, and adaptation was reported to be an important contribution of IHACC. Some institutional partners reported that IHACC's research has provided the evidence and recommendations needed to prioritize adaptation, and in Uganda and Peru was reported to have helped familiarize institutions with the IHACC partner communities, with research on baseline health status reported to be used in planning health programs.
- ***Increased support for community members and local/regional institutions*** was reported by a number of partners as linked to IHACC, with the work helping institutions to increase their capacity and/or coverage. For example, IHACC's scientific articles reportedly increased the visibility and credibility of partner organizations, which led to some funding opportunities for some organizations. In Peru and Uganda, IHACC supported some partner organizations in the fulfillment of their own mandates by directly providing financial and logistical support for institutional activities.
- ***Community education*** on health behaviors and sustainable livelihoods was identified as a key impact by institutional respondents across regions, who noted how IHACC has directly affected health by introducing community members to important knowledge and health behaviors (e.g. boiling water). Across regions, learning was reported to occur through the surveys, since community members began to think about the health behaviors asked about in the survey. As one institutional respondent noted:

  You're being asked questions that you don't really think about. It gets your brain to start thinking about certain things, so even just the act of being interviewed about the topic probably got people thinking about it (ID#32).

- The importance of ***valuing the knowledge and input of communities*** was noted across partner interviews, particularly in Uganda and Peru where communities are rarely consulted in research or decision making. Community members discussed how IHACC provided an opportunity to "have their voices heard," with some researchers and institutional interviewees asserting that the project's focus on Indigenous health was locally reported to re-affirm the value of Indigenous knowledge:

  Working with communities and valuing their knowledge is to legitimize those knowledge systems…..I think that can play a huge role in a community's self-confidence and legitimization of those knowledge [systems] (ID#170).

In the Arctic, community members reported that they felt more confident to share their stories as a result of participating in IHACC, with one person reporting feeling "lighter" after completing the survey.

3.3. Research effectiveness

As noted in Section 3.1, the scientific rigor of IHACC was widely reported as underpinning the production of high quality research. Concerns were also raised by partners about some of the approaches used to generate such rigor. The completion of > 4000 longitudinal open cohort surveys over 3 years and during different seasons, for instance, was considered a major accomplishment by researchers and institutional partners (including at a local and regional level), who viewed the standardized quantitative data as a significant asset. The multiple surveying, however, was reported to create research fatigue, exacerbated by the fact that the surveys asked the same questions at different times of the year for the purpose of detecting the role of seasonality in health outcomes. Communities generally reported preferring group discussions, while standardized questions in the surveys were reported to not always resonate within the context of the partner communities, despite the fact that they were based on locally adapted questions from well-established and validated methodologies to enable comparison with other studies (e.g. USDA food module).

The scope of IHACC was widely described as too ambitious, with the initial project intending to characterize both current and future climate-health vulnerability. The future vulnerability objectives were not achieved, reflecting time and resources constraints. A key objective of IHACC also involved investing in pilot adaptations in Peru and Uganda to examine the potential effectiveness of small-scale interventions, with support provided from IHACC to create a medicinal garden (Peru), distribute malaria bed nets (Uganda), develop community water initiatives (Uganda), and organize the provision of national identification cards (Peru), responding to partner requests. Yet community respondents believed that IHACC had not done enough to meet its health intervention objectives (see Section 3.6), while some researchers noted that the project lacked the expertise, resources, and mandate to do health interventions properly and should have instead focused just on the research component of the work. One researcher suggested that an "ideal" IHACC program "would stop trying to do adaptation", and instead leverage institutional partnerships to implement positive change for communities through existing organizations (ID#82). In the Arctic, researchers and institutional partners placed less of an emphasis on interventions developed through the project, instead viewing the project's impact through informing institutional decision-making and programming, as well as the community empowerment that can occur from the research process itself.

3.4. Research team dynamics

The coordination and quality of the working relationship between team members in IHACC was generally reported to be strong. The importance of individual traits was repeatedly discussed in interviews, particularly for fieldwork, and interviewees generally described team members to be inclusive, committed, sensitive, and patient, among other qualities. The importance of carefully selecting team members and ensuring a "fit" between their personalities and what is required on the ground was emphasized, along with the importance of supervision of field staff and researchers working on the ground. A shared vision among team members was reported as essential for bringing together the interdisciplinary team. The partnership among the lead researchers was emphasized to underpin this vision, based on trust, respect, and friendship, with the 6-year duration of the project and regional autonomy of the ROTs described as fundamental to such team building. Team building efforts were noted to be important for projects of this nature, including annual meetings rotating between the regions, opportunities for students and faculty members to visit and intern in the different regions, and cross-regional mentorship.

Several respondents described challenges associated with working cohesively across regions to maintain consistency in the research approach, reflecting conflict avoidance to maintain autonomy of the regional teams. Another issue related to the different perceptions of community-based research among the research team within and across regions. Approaches to community engagement were described to be influenced by the local Indigenous context, such as the level of empowerment of communities, and while this flexibility to local context was important, some researchers expressed concern over the adoption of divergent approaches to community engagement rather than a unified (but imposed) view of what community engagement should involve:

> When [IHACC] started there was more of [a] unified vision…and then every region kind of went its own way and we started losing track of what everyone was doing and we started going in different directions. I feel we lost sight of what the common objective was for each region (ID#90).
>
> There are a lot of things that IHACC researchers have done [well] but aren't done consistently…..Like messages that aren't communicated the same way and I think that has led to some messy situations, like mismanaged expectations… (ID#82).

Professional cultures were also reportedly distinct between regions and individuals, resulting in different styles for management and communication, which also had to adapt to the cultural context of communities. Different perceptions were reported to exist among the research team regarding the decision-making structure within IHACC, and some discussed the difficulty of making appropriate decisions on the ground under a vertical decision-making structure. Conversely, a few respondents noted the importance of having one or two individuals within the research program taking a leadership role, and other respondents discussed the difficulty of finding qualified, reliable individuals to work independently in the field.

3.5. Institutional engagement

Institutional partnerships were central to IHACC, with partners engaged in project planning, and were regularly engaged throughout the project, participated in knowledge sharing events at different stages of the project cycle, and in some cases contributed both personnel (Arctic, Uganda) and cash funding (Arctic). The majority of institutional partners reported having a positive experience with IHACC, with the openness of the research team and IHACC's ability to meaningfully integrate institutional feedback into plans, activities, and decisions repeatedly noted. Most institutional respondents stated that it was beneficial to collaborate with IHACC, which increased awareness about the health and livelihoods of the study communities and facilitated skills development. In the Arctic, IHACC's collaborative approach was described to be "gold standard." In Uganda and Peru, institutions also discussed how IHACC's financial support and efforts to improve health in the communities (e.g. interventions, educational workshops) helped institutions to fulfill their mandates and increase coverage of the communities. In the Arctic and Uganda, institutional partners reported that working with IHACC increased local organizations' "credibility" and "visibility," sometimes positioning the organization to receive more funding from other agencies.

When asked to describe the IHACC research program and its goals, the majority of institutional interviewees across regions were able to describe the key research themes (i.e. health, food security, waterborne illness, climate change), although most were unclear about the specific activities, people, and/or research topics. Several reported confusion over their role in IHACC, the structure of IHACC, how it operates, and the bigger picture of the work. Across regions, institutional respondents discussed the desire to receive more guidance regarding how to utilize IHACC's results in decision-making and programming, requested more frequent updates and communication on preliminary results, as well as more follow-ups and continuity between community visits; this contrasts to the research team who perceived these to be areas where IHACC had performed strongly. Institutional respondents reported the need to increase the presence of IHACC personnel in the field in order to facilitate institutional engagement and avoid burdening partner organizations.

Research team interviewees noted the strength of IHACCs working relationship with institutions but also raised concerns around developing and maintaining relationships in regions with significant socioeconomic disparities. Challenges reported included making the research relevant and useful when many institutional collaborators had difficulty articulating their own needs and expectations within a research lens around climate change; the difficulty of meeting expectations of direct financial benefits in research collaboration among institutions (Peru and Uganda); limited understanding on a research project vis-à-vis the role of development organizations (Peru and Uganda); and in Peru particularly, the high turnover of community leaders with high levels of migration which resulted in numerous changes in leadership and vision at a local level, challenging continuity from when the work was initiated.

Unforeseen challenges were also reported. In Uganda, for instance, IHACC built upon the strong rapport between the Batwa Development Program (BDP) and the Batwa settlements. However, this partnership created expectations among communities for a large development intervention through IHACC consistent with previous BDP work, with some community members believing BDP had stolen funds when such an intervention did not happen. In Peru, some local people had a negative perception of the local branches of the Ministry of Health, and some reportedly changed their behaviors and attitudes to the work when they learned IHACC was working with the Ministry.

3.6. Community engagement

Community understanding of the aims and objectives of IHACC varied between the regions, and was primarily associated with individual projects rather than the overarching research program. In Peru and Uganda, the majority of community respondents reported to participate in IHACC to help their community access material items and learn about how to have good health, and viewed IHACC as a development organization, despite repeated attempts throughout the project to communicate that the focus of the project was research, along with discussion on what research projects are about. In this regard, community participants believed IHACC had not done enough to bring substantial material benefit, specifically documenting the need for the project to buy land for the settlements (Uganda) or a communal first aid kit (Peru). Notwithstanding, communities across the regions reported that they benefited from the educational workshops offered (including knowledge around agriculture, sanitation, and disease prevention), the treatment provided through the project for vectorborne diseases, the small scale interventions that were rolled out, the provision of a communal meal during the surveys, and viewed IHACC positively overall. Community respondents in the Arctic reported that their decision to participate in IHACC was motivated by the desire to learn and share their personal experience. While respondents in Uganda and Peru expected IHACC to directly fix the issues asked about in the research, in the Arctic there was expectation that the project would provide information to the government and other organizations to inform policies and programming.

As with IHACCs relationship with institutions, maintaining a balance between research and development in the Ugandan and Peruvian communities was a constant tension. Several researchers noted the "messiness" and "complexity" of CBA on the ground, particularly in settings that experience urgent development needs. Many researchers noted how research does not often result in direct and short-term changes in the communities, particularly amidst weak institutions and/or discrimination:

> Research technically has its benefits but it doesn't have immediate benefits and these communities are living meal to meal… the issue of research not having an immediate benefit for these areas made conducting IHACC research in these areas difficult (ID#82).

The majority of community members interviewed or participating in the focus groups did not report feeling ownership of the work, except for those who had been trained to have a direct role in the project. Several researchers also discussed the difficulty of applying CBA principles when partnering communities lacked the conditions needed for a true partnership:

> A level of empowerment and raw development is almost a pre-requisite to us truly achieving the level of reciprocal kind of participatory partnership that we envisioned and… we can't create the conditions we sort of really need to achieve what we'd like to (ID#93).

4. Discussion

Increasing interest in community based adaptation (CBA) is part of a broader trend around the production of usable knowledge and knowledge co-production that seeks to democratize the research process and make it more relevant to decision choices, transparent, and accountable (Sarewitz and Pielke 2007; Lemos et al., 2012; Knapp and Trainor, 2013; van Kerkhoff and Lebel, 2015; Beier et al., 2017). These are laudable goals but there has been little reflection in an adaptation and health context, and more generally, on the challenges, opportunities, and desirability of CBA in different contexts (McNamara and Buggy, 2017; Wall et al., 2017). We contribute to a nascent body of literature critically examining community based approaches to health adaptation, notable in that we document the perspectives of health researchers and also of community members, institutional partners, students, trainees, and staff engaged in an interdisciplinary multi-region CBA project. While overall the views of IHACC were positive, a number of cross-cutting themes concerning the *process* of community and partner engagement were emphasized across the regions and offer broad insights for the design for research-orientated CBA projects with rural Indigenous communities and more generally, and are timely given increasing interest in community-level adaptation research in the health field.

4.1. Managing the research-intervention challenge

A challenge underlying the majority of concerns raised in the Ugandan and Peruvian work was associated with the limited understanding of the concept of research among communities and local institutions. Locally, many expected the project to invest in immediate and tangible interventions, and were less interested in the potential impact of IHACC on broader level policy development and planning over the next 5–10 years. Effort was made throughout IHACC to clarify the role of the project and of research more broadly, and also respond to community concerns by investing in small scale interventions, with such a balancing act continually evolving with a high turnover of community leaders. Similar challenges on how to incentivize community engagement in CBA in-light of the longer term nature of adaptation benefits, and often limited resources available to projects, are also noted by Reid (2016).

The tension between research and impact raises broader questions about the role of research in CBA. Some have argued that research orientated CBA projects should just focus on the research, leaving interventions to development organizations who have the relevant capacity, mandate, and expertise, while others have questioned whether research has a role in the context of a significant development deficit. The majority of respondents consulted here did not share these views, with partners across scales repeatedly noting the importance of IHACCs research products and value of the pilot interventions that were invested in. Equally, interviews affirmed that research has to go beyond knowledge generation to catalyze change and develop capacity locally, tangibly, and in the immediate- or short-term.

The experience of IHACC illustrates a number of opportunities to manage the research-intervention tension, one of the most important being the need to develop a cross-project strategic vision for partner engagement. IHACC was guided by general principles of CBA and consulted extensively at project inception on research design, but did not have a formalized strategic vison for partner engagement. Consequently, challenges arose across the 5-year project as different field researchers communicated varying messages about local impact. For example, at multiple points team members discussed *potential* interventions that IHACC might catalyze, particularly in the beginning when obtaining the support of communities and in responding to community concerns over impact as the work progressed. While done in good faith and designed to solicit input, it was noted that even if the possibility of an activity or intervention was raised, community members often interpreted this statement as a promise. Miscommunication of this nature could be maladaptive in the long term if it compromises community interest in research and further emphasizes lack of power at a community level. Such challenges were exacerbated by the large number of field personnel and new students consistently joining the team.

A strategic vision on partner engagement would have helped IHACC manage these challenges by clearly outlining how to engage different partners; stating realistically what impacts the work will have and (importantly) will not achieve; promoting the importance of capacity development and training as project outcomes (see below); promoting more consistent responses across team interactions with local people; and, continually monitoring project progress and revising the vision if necessary. Being realistic, honest, and forthright about the outputs and impacts has the potential to weaken partner interest in collaboration, but partnerships are ultimately more likely to be sustainable and mutually beneficial when expectations and limitations are clearly delineated from the outset (Stahl et al., 2010; Briley et al., 2015; Brown et al., 2015; Beier et al., 2017). Protocols for implementing such a vision need to be sensitive to regional context, and underpinned by training for all incoming research personnel and regular engagement with communities, including the potential for research team members to be permanently based in the region.

4.2. Managing the scope of CBA projects

While IHACC benefited from high levels of trust among the research team and regional flexibility was viewed as an asset, more central project planning and coordination including a working 'architecture' which outlined specific activities, timelines, team structures, budget management, as well as delegation of responsibilities across regions, would have maintained a more realistic focus. Such an architecture is particularly important for managing the goals of CBA, which can greatly increase in scope as the needs of partners are integrated and the work evolves. While designing projects to address partner needs is central to CBA, projects need to manage this with available resources and skill-sets that the research team brings. This requires recognition that partner expectations for research deliverables might be unrealistic given scientific limitations (e.g. expectation among decision-makers for immediate decision-specific information with low levels of uncertainty (McNie et al., 2016) or for insights for solving 'grand' problems (Lebel et al., 2015)); partners may not be able to fully articulate their own needs and expectations where understanding on climate change is limited; and may have varying levels of interest in projects and differing capacity to be involved. IHACC promised too much to too many partners, ultimately creating unrealistic expectations and diluting what the work was able to achieve. A working architecture herein would have helped to manage the scope of the work and manage partner expectations. Ultimately, CBA researchers need to be realistic on what research orientated projects can achieve, particularly in the context of working with marginalized communities challenged by pressing socio-economic conditions and in contexts where there is significant power imbalance between formal institutions and community knowledge systems and needs (Kwiatkowski, 2011; Schuttenberg and Guth, 2015). Such sentiments contrast with the CBA literature with its unproblematized descriptions of community engagement and emphasis on success stories.

4.3. The role of research as capacity development

A prominent finding from interviews with communities and institutional partners was the importance of capacity development as the most significant change brought about by IHACC. This went beyond typical capacity development outcomes such as skills development, training, and knowledge transfer, to include influencing community members' sense of confidence and self-value as result of participating in the project; these outcomes are especially pertinent in Indigenous contexts where local/traditional knowledge systems have often been devalued and communities marginalized in decision making (Nakashima et al., 2012; UNFCCC, 2014). In turn, this feeling of self-worth and confidence has the potential to influence and enact other changes in the lives of those individuals, their families, and communities, building resilience not only to climate impacts but also strengthening health systems more broadly. Such community action is central to the World Health Organizations (2015) framework for building climate resilient health systems, and identified as the "principal mechanism for ensuring that people themselves are informed, educated and able to take appropriate action to protect and maintain their individual and families' health." Outcomes of this nature are not visible in typical outcome measurements applied to projects, are rarely articulated or intentionally designed into objectives and methods, and have received limited attention in the literature. Yet the insights from this evaluation indicate that capacity development has the potential to be the most prominent contribution of CBA projects, can help manage the tension between addressing immediate and longer term challenges through its strengthening of the health system, and should be *a priori* integrated and promoted as a central objective.

4.4. Research team composition and management

The composition and management of the research team has a central role in the success of CBA projects. Personal relationships were repeatedly reported to underpin strong collaboration with institutions in IHACC, with most success achieved where the research team had prior engagement with institutions. As McNie et al. (2016) note: "People are more willing to share useful information, listen, and absorb knowledge when the relationship is grounded in trust." Such relationships take time to develop and emphasize the significant non-academic work associated with CBA, which university reward structures do not always incentivize (Castleden et al., 2012a; Preston et al., 2015); although as Beier et al. (2017) note, coproduction is not the professional black hole it is sometimes portrayed to be, and can be part of a diversified and rewarding portfolio of professional activities. Moreover, such insights underscore the importance of long-term funding to develop and build upon relationships. IHACC, for instance, was only able to spend one year engaging partners to develop the project and an additional year developing the data collection approach due to stable long-term funding; and even then, it was only towards the end of the project that strong relationships and trust really began to develop, evident when communities and local partners began to solicit advice from the project and ask 'what's next.' Trust is essential to what van Kerkhoff and Lebel (2015) term 'co-productive capacity,' with an absence of trust noted in a number of contexts to undermine efforts at knowledge co-production (Bowen et al., 2015; Brunet et al., 2016; Beier et al., 2017; Wall et al., 2017).

In CBA projects it is often staff and students, alongside more senior researchers, who spend considerable time on the ground interacting with partners on a daily basis. These interactions are critical, and there were several instances in IHACC where personality mismatches set back the work. Some of these stemmed from the lack of a strategic vision noted above, but also emphasize the importance of: i). Training for students and staff on community based approaches, including communicating in cross-cultural contexts, meeting facilitation, decolonizing methodologies, and candid discussion of what fieldwork involves. An academic training doesn't necessarily cultivate these skills, and such training should be factored into project design (Brugger et al., 2016; Beier et al., 2017). Additional suggestions by students included establishing discussion groups around community based work to resolve various issues and facilitate peer-to-peer learning for new members, and the creation of fieldwork manuals or briefing notes which include general information about the communities, professional culture and structure of local IHACC team, activities implemented each year, strategies and expectations for results dissemination, and other logistical information; ii). Scoping of research personnel for suitability including deep listening, patience, openness to multiple ways of knowing, flexibility, self-reflection, and a willingness to learn (Ford et al., 2016), reflecting the importance of having the "right people" working on the ground; and iii). Maintaining, where possible, continuity of personnel involved in the fieldwork, with regular short visits to communities generally preferred over infrequent but longer duration visits.

4.5. Continuous monitoring and evaluation

Monitoring and evaluation (M&E) can serve multiple roles in CBA projects, measuring program performance and impact, fostering learning and reflexivity, and increasing communication and coordination (Fischer et al., 2015; Wall et al., 2017). The end-of-project exercise reported on here represents the main investment of IHACC in project evaluation, with monitoring informally conducted each year at annual meetings and as part of annual reporting to the funding agency. The evaluation exercise was viewed as a unique and important activity but was only undertaken towards the end of the project and with external funding. The majority of respondents believed that M&E should have had a more central and ongoing role which could have identified and resolved a number of tensions and challenges raised here; other studies, for example, have found that M&E can also further develop networks and collaborations in a project (Wall et al., 2017). To do this, M&E needs a significant budget line, dedicated staff, and a detailed methodology, with the evaluation reported on here led by one-full time staff member over an 18 month period, one part-time field assistant who visited each region, over 12 weeks of fieldwork, and involving a ~CN $200,000 investment. Most projects don't have such resources and wouldn't consider it feasible to re-distribute resources to M&E, with less intensive but equally systematic self-reflective exercises at key milestones identified as one way to integrate M&E in a manageable way.

In drawing out these key themes we note that there is no 'one-size-fits-all' approach to CBA, with each theme resonating differently by context. In Peru and Uganda, for example, communities were unfamiliar with the concept of research and experience significant development needs, highlighting the importance of tailoring the work to focus on multiple issues and clearly defining local benefits of being engaged in the work. In the Arctic there was greater understanding of the role research and how it can inform decision making, creating greater scope for emphasis on co-generating knowledge on climate impacts and adaptation options.

5. Conclusion

This paper examines the strengths, challenges, and opportunities of conducting community-based adaptation (CBA) research with Indigenous communities, drawing upon the experiences of the multination interdisciplinary IHACC project. The work affirms the importance of the 'deep' level of partner engagement embodied in CBA for understanding and preparing for the impacts of climate change on health, and illustrates the significant benefits that CBA can bring beyond conventional approaches. The exercise also underscores the complex and challenging nature of CBA, and unpacks the 'rosy' and uncritical narrative on CBA in the literature.

CBA has the potential to be effective but only in the 'right' circumstances. These circumstances include having strong working

relationships with partners across scales who are able to have a leadership role in the work; a working 'architecture' for collective impact, including team building, identification of common goals, and meaningful engagement of knowledge users across scales; financial resources and personnel to initiate and sustain extensive partner engagement, and continuously monitor and evaluate project progress; and having the 'right' team who have the personality, outlook, and skill-sets required for CBA. While CBA projects may have good intentions, they also risk having unintended negative consequences if poorly implemented, through tokenistic interaction, consultation fatigue, undermining community trust, perpetuating uneven power dynamics, and promoting interventions which do not fully account for community needs and the determinants of vulnerability. Even where 'best practices' are followed and the right circumstances exist, projects may fail to have the desired impact or have unforeseen potential negative impacts.

The most important phase for CBA is project development. Often overlooked and rarely recognized by funding agencies, is the significant time it takes to develop CBA projects. Early interaction with partners establishes the nature of the collaboration and expectations of what the work will achieve, develops friendship and trust necessary for CBA work, and needs to be carefully planned and managed. Such planning needs to closely engage all partners across scales, and is not an endpoint but a continually evolving process.

Competing financial interests

We declare no competing financial interests.

Acknowledgements

This work was supported by the International Development Research Centre IRIACC program, Canadian Institute for Health Research, the Canadian Institute for Health Research Applied Public Health Chair Program, Natural Sciences and Engineering Research Council of Canada, Social Science and Humanities Research Council of Canada, ArcticNet, Fonds de la Recherce en Santé du Quebec, the Public Health Agency of Canada, and the International Development Research Centre. We would like to thank all those who participated in the evaluation project and IHACC more generally, and those who shared their knowledge and experiences with us.

References

Anderson, A.A., 2006. The Community Builder's Approach to Theory of Change: A Practical Guide to Theory Development. Change AIRoC.
Ayers, J., Anderson, S., Pradhan, S., Rossing, T.I., 2012. Participatory Monitoring, Evaluation, Reflection and Learning for Community-Based Adaptation: A Manual for Local Practitioners. CARE, Atlanta, USA.
Beier, P., Hansen, L.J., Helbrecht, L., Behar, D., 2017. A how-to guide for coproduction of actionable science. Conserv. Lett. 10, 288–296.
Bell, S., Shaw, B., Boaz, A., 2011. Real-world approaches to assessing the impact of environmental research on policy. Res. Eval. 20, 227–237.
Berrang-Ford, L., Dingle, K., Ford, J.D., Lee, C., Lwasa, S., Namanya, D.B., Henderson, J., Llanos, A., Carcamo, C., Edge, V., 2012. Vulnerability of indigenous health to climate change: a case study of Uganda's Batwa Pygmies. Soc. Sci. Med. (1982) 75, 1067–1077.
Boaz, A., Fitzpatrick, S., Shaw, B., 2009. Assessing the impact of research on policy: a literature review. Sci. Public Policy 36, 255–270.
Boeije, H., 2002. A purposeful approach to the constant comparative method in the analysis of qualitative interviews. Qual. Quant. 36, 391–409.
Bours, D., McGinn, C., Pringle, P., 2014. Guidance Note 3: Theory of Change Approach to Climate Change Adaptation Programming. SEA Change, UKCIP.
Bowen, K.J., Miller, F.P., Dany, V., Graham, S., 2015. The relevance of a coproductive capacity framework to climate change adaptation: investigating the health and water sectors in Cambodia. Ecol. Soc. 20.
Boyatzis, R.E., 1998. 1998: Transforming Qualitativeinformation: Thematic Analysis and Code Development. Sage.
Bremer, S., Meisch, S., 2017. Co-production in climate change research: reviewing different perspectives. Wiley Interdiscip. Rev. Clim. Change 8.
Briley, L., Brown, D., Kalafatis, S.E., 2015. Overcoming barriers during the co-production of climate information for decision-making. Clim. Risk Manage. 9, 41–49.
Brown, R.R., Deletic, A., Wong, T.H., 2015. Interdisciplinarity: how to catalyse collaboration. Nature 525, 315–317.
Brugger, J., Meadow, A., Horangic, A., 2016. Lessons from first-generation climate science integrators. Bull. Am. Meteorol. Soc. 97.
Brunet, N.D., Hickey, G.M., Humphries, M.M., 2016. Local participation and partnership development in Canada's Arctic research: challenges and opportunities in an age of empowerment and self-determination. Polar Rec. 52, 345–359.
Brunet, N.D., Hickey, G.M., Humphries, M.M., 2017. How can research partnerships better support local development? Stakeholder perceptions on an approach to understanding research partnership outcomes in the Canadian Arctic. Polar Rec. 53, 479–488.
Castleden, H., Morgan, V.S., Lamb, C., 2012a. "I spent the first year drinking tea": exploring Canadian university researchers' perspectives on community-based participatory research involving Indigenous peoples. Can. Geogr.-Geogr. Can. 56, 160–179.
Castleden, H., Mulrennan, M., Godlewska, A., 2012b. Community-based participatory research involving Indigenous peoples in Canadian geography: progress? An editorial introduction. Can. Geogr.-Geogr. Can. 56, 155–159.
Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., Puppim de Oliveria, J.A., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J., Patterson, C., 2009. Managing the health effects of climate change. Lancet 373, 1693–1733.
Creswell, J.W., Miller, D.L., 2000. Determining validity in qualitative inquiry. Theory Pract. 39, 124–130.
DeCuir-Gunby, J.T., Marshall, P.L., McCulloch, A.W., 2011. Developing and using a codebook for the analysis of interview data: an example from a professional development research project. Field Methods 23, 136–155.
Dodman, D., Mitlin, D., 2013. Challenges for community-based adaptation: discovering the potential for transformation. J. Int. Dev. 25, 640–659.
Earl, S.C., Smutylo, T., 2001. Outcome Mapping: Building Learning and Reflection into Development Programs.
Ebi, K.L., Semenza, J.C., 2008. Community-based adaptation to the health impacts of climate change. Am. J. Prev. Med. 35, 501–507.
Ehrlich, C., Kendall, E., Frey, N., Denton, M., Kisely, S., 2015. Consensus building to improve the physical health of people with severe mental illness: a qualitative outcome mapping study. BMC Health Serv. Res. 15.
Ensor, J.E., Park, S.E., Attwood, S.J., Kaminski, A.M., Johnson, E., 2018. Can community-based adaptation increase resilience. Clim. Dev. 10 (2), 134–151.
Fazey, I., Bunse, L., Msika, J., Pinke, M., Preedy, K., Evely, A.C., Lambert, E., Hastings, E., Morris, S., Reed, M.S., 2014. Evaluating knowledge exchange in interdisciplinary and multi-stakeholder research. Glob. Environ. Change Hum. Policy Dimens. 25, 204–220.
Fereday, J., Muir-Cochrane, E., 2006. Demonstrating Rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. Int. J. Qual. Methods 5, 80–92.
Fischer, S., Dinshaw, A., McGray, H., Rai, N., Schaar, J., 2015. Evaluating climate change adaptation: learning from methods in international development. New. Direct. Eval. 147, 13–35.
Fisher, S., Dinshaw, A., McGray, H., Rai, N., Schaar, J., 2015. Evaluating climate change adaptation: learning from methods in international development. New Direct. Eval. 2015, 13–35.
Ford, J., 2012. Indigenous health and climate change. Am. J. Public Health 102, 1260–1266.
Ford, J.D., Berrang-Ford, L., Biesbroek, R., Araos, M., Austin, S.E., Lesnikowski, A., 2015. Adaptation tracking for a post-2015 climate agreement. Nat. Clim. Change 5, 967–969.
Ford, J.D., Berrang-Ford, L., King, M., Furgal, C., 2010. Vulnerability of aboriginal health systems in Canada to climate change. Glob. Environ. Change Hum. Policy Dimens. 20, 668–680.
Ford, J.D., Berrang-Ford, L., Lesnikowski, A., Barrera, M., Heymann, S.J., 2013. How to track adaptation to climate change: a typology of approaches for national-level application. Ecol. Soc. 18.
Ford, J.D., Stephenson, E., Willox, A.C., Edge, V., Farahbakhsh, K., Furgal, C., Harper, S., Chatwood, S., Mauro, I., Pearce, T., Austin, S., Bunce, A., Bussalleu, A., Diaz, J., Finner, K., Gordon, A., Huet, C., Kitching, K., Lardeau, M.-P., McDowell, G., McDonald, E., Nakoneczny, L., Sherman, M., 2016. Community-based adaptation research in the Canadian Arctic. Wiley Interdiscip. Rev.-Clim. Change 7, 175–191.
Forsyth, T., 2013. Community-based adaptation: a review of past and future challenges. Wiley Interdiscip. Rev.-Clim. Change 4, 439–446.
Harper, S.L., Edge, V.L., Ford, J., Willox, A.C., Wood, M., McEwen, S.A., Team IR, RICG, 2015. Climate-sensitive health priorities in Nunatsiavut, Canada. BMC Public Health 15.
Hess, J.J., Eidson, M., Tlumak, J.E., Raab, K.K., Luber, G., 2014. An evidence-based public health approach to climate change adaptation. Environ. Health Perspect. 122, 1177–1186.
Hess, J.J., Malilay, J.N., Parkinson, A.J., 2008. Climate change. The importance of place. Am. J. Prev. Med. 35, 468–478.
Hofmeijer, I., Ford, J.D., Berrang-Ford, L., Zavaleta, C., Carcamo, C., Llanos, E., Carhuaz, C., Edge, V., Lwasa, S., Namanya, D., 2013. Community vulnerability to the health effects of climate change among indigenous populations in the Peruvian Amazon: a case study from Panaillo and Nuevo Progreso. Mitig. Adapt. Strateg. Glob. Change 18, 957–978.
Hosking, J., Campbell-Lendrum, D., 2012. How well does climate change and human health research match the demands of policymakers? A scoping review. Environ. Health Perspect. 120, 1076–1082.
Knapp, C.N., Trainor, S.F., 2013. Adapting science to a warming world. Glob. Environ. Change Hum. Policy Dimens. 23, 1296–1306.

Kraft, K., Prytherch, H., 2016. Most significant change in conflict settings: staff development through monitoring and evaluation. Dev. Pract. 26, 27–37.
Kwiatkowski, R.E., 2011. Indigenous community based participatory research and health impact assessment: a Canadian example. Environ. Impact Asses. Rev. 31, 445–450.
Lebel, L., Wattana, S., Talerngsri, P., 2015. Assessments of ecosystem services and human well-being in Thailand build and create demand for coproductive capacity. Ecol. Soc. 20.
Lemos, M.C., Kirchhoff, C.J., Ramprasad, V., 2012. Narrowing the climate information usability gap. Nat. Clim. Change 2.
Lemos, M.C., Lo, Y.J., Nelson, D.R., Eakin, H., Bedran-Martins, A.M., 2016. Linking development to climate adaptation: leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. Glob. Environ. Change Hum. Policy Dimens. 39, 170–179.
Lemos, M.C., Morehouse, B.J., 2005. The co-production of science and policy in integrated climate assessments. Glob. Environ. Change Hum. Policy Dimens. 15, 57–68.
Maldonado, J.K., Shearer, C., Bronen, R., Peterson, K., Lazrus, H., 2013. The impact of climate change on tribal communities in the US: displacement, relocation, and human rights. Clim. Change 120, 601–614.
Maru, Y.T., Smith, M.S., Sparrow, A., Pinho, P.F., Dube, O.P., 2014. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. Glob. Environ. Change Hum. Policy Dimens. 28, 337–350.
McDowell, G., Ford, J., Jones, J., 2016. Community-level climate change vulnerability research: trends, progress, and future directions. Environ. Res. Lett. 11.
McNamara, K.E., Buggy, L., 2017. Community-based climate change adaptation: a review of academic literature. Local Environ. 22, 443–460.
McNie, E.C., Parris, A., Sarewitz, D., 2016. Improving the public value of science: a typology to inform discussion, design and implementation of research. Res. Policy 45, 884–895.
Miller, F., Bowen, K., 2013. Questioning the assumptions: the role of vulnerability assessments in climate change adaptation. Impact Assess. Project Appr. 31, 190–197.
Moss, R.H., Meehl, G.A., Lemos, M.C., Smith, J.B., Arnold, J.R., Arnott, J.C., Behar, D., Brasseur, G.P., Broomell, S.B., Busalacchi, A.J., Dessai, S., Ebi, K.L., Edmonds, J.A., Furlow, J., Goddard, L., Hartmann, H.C., Hurrell, J.W., Katzenberger, J.W., Liverman, D.M., Mote, P.W., Moser, S.C., Kumar, A., Pulwarty, R.S., Seyller, E.A., Turner, B.L., Washington II, W.M., Wilbanks, T.J., 2013. Hell and high water: practice-relevant adaptation science. Science 342, 696–698.
Nakashima, D., McLean, K.G., Thulstrup, H., Castillo, A., Rubis, J., 2012. Weathering Uncertainty: Traditional Knowledge for a Climate Change Assessment and Adaptation.
Nyangaga, J.N., Grace, D., Kimani, V., Kiragu, M.W., Langat, A.K., Mbugua, G., Mitoko, G., Kang'ethe, E.K., 2012. Outcome mapping for fostering and measuring change in risk management behaviour among urban dairy farmers in Nairobi, Kenya. Trop. Anim. Health Prod. 44, S47–S51.
Pearce, T.D., Ford, J.D., Laidler, G.J., Smit, B., Duerden, F., Allarut, M., Andrachuk, M., Baryluk, S., Dialla, A., Elee, P., Goose, A., Ikummaq, T., Joamie, E., Kataoyak, F., Loring, E., Meakin, S., Nickels, S., Shappa, K., Shirley, J., Wandel, J., 2009. Community collaboration and climate change research in the Canadian Arctic. Polar Res. 28, 10–27.
Preston, B.L., Rickards, L., Fungeld, H., 2015. Towards reflexive climate adaptation research. Curr. Opin. Environ. Sustain. 14, 127–135.
PROVIA In.
Reed, S.O., Friend, R., Jarvie, J., Henceroth, J., Thinphanga, P., Singh, D., Tran, P., Sutarto, R., 2015. Resilience projects as experiments: implementing climate change resilience in Asian cities. Clim. Dev. 7, 469–480.
Reid, H., 2016. Ecosystem- and community-based adaptation: learning from community-based natural resource management. Clim. Dev. 8, 4–9.
Reid, H., Cannon, T., Berger, R., Alam, M., Milligan, A., IIED, 2009. Community-based adaptation to climate change. Participatory Learning and Action 60.
Sarewitz, D., Pielke, R.A., 2007. The neglected heart of science policy: reconciling supply of and demand for science. Environ. Sci. Policy 10, 5–16.
Schipper, E.L.F., Ayers, J., Reid, H., Huq, S., Rahman, A., 2014. Community Based Adaptation to Climate Change: Scaling It Up. Routledge, London.
Schuttenberg, H.Z., Guth, H.K., 2015. Seeking our shared wisdom: a framework for understanding knowledge coproduction and coproductive capacities. Ecol. Soc. 20.
Shah, R., 2014. Assessing the' true impact' of development assistance in the Gaza strip and Tokelau:' most significant change' as an evaluation technique. Asia Pac. Viewp. 55, 262–276.
Sherman, M., Berrang-Ford, L., Lwasa, S., Ford, J., Namanya, D.B., Llanos-Cuentas, A., Maillet, M., Harper, S., Team, I.R., 2016. Drawing the line between adaptation and development: a systematic literature review of planned adaptation in developing countries. Wiley Interdiscip. Rev.-Clim. Change 7, 707–726.
Silva Villanueva, P., 2011. Learning to ADAPT: monitoring and evaluation approaches in climate change adaptation and disaster risk reduction-challenges, gaps and ways forward. Strengthening Climate Resilience Discussion Paper No. 9.
Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity and vulnerability. Glob. Environ. Change Hum. Policy Dimens. 16, 282–292.
Smith, K.R., Woodward, A., Campbell-Lendrum, D., Chadee, D.D., Honda, Y., Liu, Q., Olwoch, J.M., Revich, B., Sauerborn, R., 2014. Human health: impacts, adaptation, and co-benefits. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 709–754.
Smith, L., 1999. Decolonizing Methodologies: Research and Indigenous Peoples. University of Otago Press, New York.
Stahl, G.K., Maznevski, M.L., Voigt, A., Jonsen, K., 2010. Unraveling the effects of cultural diversity in teams: a meta-analysis of research on multicultural work groups. J. Int. Bus. Stud. 41, 690–709.
Swart, R., Biesbroek, R., Lourenco, T.C., 2014. Science of adaptation to climate change and science for adaptation. Front. Environ. Sci. 2.
Tremblay, M., Rabbit, N., Baydala, L., Louis, J., Peigan, R., Potts, M., K'Say-Yin, K., 2014. Using outcome mapping as an evaluation tool in first nation communities. Int. J. Qual. Methods 13, 459–460.
Trochim, W.M., Marcus, S.E., Masse, L.C., Moser, R.P., Weld, P.C., 2008. The evaluation of large research initiatives—a participatory integrative mixed-methods approach. Am. J. Eval. 29, 8–28.
Tschakert, P., Dietrich, K., Tamminga, K., Prins, E., Shaffer, J., Liwenga, E., Asiedu, A., 2014. Learning and envisioning under climatic uncertainty: an African experience. Environ. Plann. A 46, 1049–1068.
Tschakert, P., Tuana, N., Westskog, H., Koelle, B., Afrika, A., 2016. T-CHANGE: the role of values and visioning in transformation science. Curr. Opin. Environ. Sustain. 20, 21–25.
UNEP, 2017. Adaptation Gap Report 2017. United Nations Environment Programme, Nairobi, Kenya.
UNFCCC, 2014. Report on the Meeting on Available Tools for the Use of Indigenous and Traditional Knowledge and Practices for Adaptation, Needs of Local and Indigenous Communities and the Application of Gender-Sensitive Approaches and Tools for Adaptation. Framework Convention on Climate Change SBfSaTA.
van Kerkhoff, L.E., Lebel, L., 2015. Coproductive capacities: rethinking science-governance relations in a diverse world. Ecol. Soc. 20.
Wall, T.U., Meadow, A.M., Horganic, A., 2017. Developing evaluation indicators to improve the process of coproducing usable climate science. Weather Clim. Soc. 9, 95–107.
Watts, N., Adger, W.N., Agnolucci, P., Blackstock, A., Byass, P., Cai, W., Chaytor, S., Colbourn, T., Collins, M., Cooper, A., Cox, P.M., Depledge, J., Drummond, P., Ekins, P., Galaz, V., Grace, D., Graham, H., Grubb, M., Haines, A., Hamilton, I., Hunter, A., Jiang, X., Li, M., Kelman, I., Liang, L., Lott, M., Lowe, R., Luo, Y., Mace, G., Maslin, M., Nilsson, M., Oreszczyn, T., Pye, S., Quinn, T., Svensdotter, M., Venevsky, S., Warner, K., Xu, B., Yang, J., Yin, Y., Yu, C., Zhang, Q., Gong, P., Montgomery, H., Costello, A., 2015. Health and climate change: policy responses to protect public health. Lancet 386, 1861–1914.
WHO, 2015. Operational Framework for Building Climate Resilient Health System. World Health Organization.