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Diversifying knowledge(s) to advance climate-health responses locally and globally

by

Bianca van Bavel

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Declaration of Authorship and Intellectual Property

The candidate confirms that the work submitted is her own, except where the work of others has contributed to jointly-authored publications. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

Chapter 2 of the thesis encompasses the work from the jointly authored publication: van Bavel, B., Berrang Ford, L., Harper, S.L., Ford, J., Elsey, H., Lwasa, S., King, R., 2020. Contributions of scale: what we stand to gain from Indigenous and local inclusion in climate and health monitoring and surveillance systems. Environmental Research Letters, Volume 15, Issue Number 83008. DOI: 10.1088/1748-9326/ab875e.

BvB, the candidate, maintained principal responsibility for the conceptualisation, research design, data collection, quality appraisal, development of analytic framework, confidence of evidence assessment, data analyses, data interpretation, data visualisation, and writing of the manuscript. LBF contributed to the research design, refinement of analytic framework, and confidence of evidence assessment. LBF, SLH, JF, HE, SL, and RK provided expertise and feedback during data interpretation and writing. Giulia Scarpa contributed with secondary screening of data.

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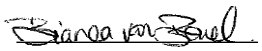

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Rationale for Alternative Format

The decision to submit the thesis in an alternative format was made with the support of the supervisory team—who, from the outset, encouraged that the research findings be disseminated through the peer review publication process. Furthermore, knowing that the Intergovernmental Panel on Climate Change (IPCC)'s sixth assessment cycle (AR6) is underway, we made conscious efforts to feed into this process by publishing and sharing findings from the doctoral research. For example, research had to be submitted for publication by November 1st, 2020 if it was to be included as evidence in the IPCC's Working Group II assessment.

Structuring the thesis into individual papers was deemed appropriate since each chapter is situated within different context, conceptual and analytical framing, methodological approach, and interpretation of findings. This format also afforded the opportunity to span across local and global scopes of investigation and understanding.

The thesis is structured into five chapters: an introduction outlining out the aim, objectives, guiding questions, and key concepts of the thesis (Chapter 1); 3 empirical research chapters (Chapter 2, 3, 4); and a final discussion and conclusion chapter (Chapter 5). A brief summary of each empirical chapter is as follows:

Chapter 2 presents a systematic literature review and confidence assessment of diverse knowledges in climate-health monitoring and response systems to examine key contributions and patterns of engagement.

Chapter 3 presents interviews using participatory approaches with key informants from health and subsistence food systems in Uganda to understand how to integrate climate information into existing knowledge networks.

Chapter 4 presents a document review and analysis of IPCC Special Reports (sixth assessment cycle) to identify changes to Indigenous-focused content and Indigenous knowledge engagement since AR5 (fifth assessment cycle). It also presents discussions with expert advisors and document analysis of

IPCC expert reviewer comments to assess the gap between expectations and existing mechanisms for engaging diverse knowledges and knowledge holders in the IPCC process.

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Abstract

The impacts of climate change on health are not equitably distributed. Likewise, the ability to respond to—and benefit from responses to—climate change is also experienced inequitably. How responses are developed, who they are designed for and by, as well as the context in which they are intended to be implemented will influence the needs, capacity, and success of adaptation responses. The Paris Agreement mandates a path towards just and equitable responses to climate change. Researchers and policy makers are not only interested in understanding how climate change will impact human and ecosystem health, but also how we might adapt to these risks in a way that considers how the burdens and benefits of our responses will be distributed: when it comes to responding to climate change, who wins, who loses, and who decides?

My thesis contributes to assessing the justice and equity dimensions of how we respond to climate risks and impacts, with a focus on how connecting different forms of knowledge can enable a more just response. While the academic and political importance of climate adaptation effectiveness and procedural justice is known, the literature exploring what these concepts mean in practice remains scant. As such, my thesis aims to provide empirical evidence that examines the critiques of existing processes, questions the limitations of conventional approaches, and builds confidence in the possibilities of knowledge diversity and procedural justice. This thesis aims to be transparent and critically reflexive about examining existing and potential ways that knowledges have, and could, come together to advance climate responses across local and global scales.

In asking, why do Indigenous knowledges and local knowledges matter for effective adaptation responses, Chapter 2 critically appraises how diverse knowledges contribute to climate-health monitoring and response systems. In asking, what does procedural justice mean for initiating adaptation responses in practice, Chapter 3 contextualises a process for initiating an integrated climate-food-health response working within existing networks of diverse knowledges. In asking, can climate change evidence assessments achieve a standard of procedural justice necessary for working with diverse knowledges and knowledge holders, Chapter 4 assesses how to equitably and meaningfully bring together diverse knowledges and reform an evidence assessment process that feeds global climate adaptation responses.

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Preface

Be very careful with your words. Your actions. Think it through. Then think it through again.

Think it ahead through time.

Think it backwards through time.

Find seven alternate ways to fix the problem.

Make sure it is a problem.

Make sure it needs to be fixed.

Think about the network as the first line of defence.

Think think think before you speak, type, post.

Each syllable is a log you put on a fire. The fire can uplift or destroy.

Protect individual hearts from hurt, because the processing of hurt is necessary and it takes energy from the group.

The supports needed to process trauma and regenerate are costly.

Remember that words carry the ability to impact the chemistry of brains and the beating of hearts.

Calls should be whispers.

The only one you can hold accountable is yourself.

That really is your only job.

—Leanne Betasamosake Simpson (in Noopiming: The Cure for White Ladies, 2015)

Chapter 1—Introduction, Aim, and Objectives

This chapter presents the aim, objectives, and guiding questions for the entire thesis. It sets out the key concepts that underpin the empirical research presented in each chapter and that are used to braid the work together as a whole. At the centre of this work is a focus on moving towards just and equitable responses to climate change—as mandated in the Paris Agreement. Specifically, this research aims to explore equitable mechanisms and just processes for diversifying knowledges to advance climate responses. A framework on climate-health risks, impacts, and responses is presented to help situate the work within a broader body of climate adaptation research. Here, adaptation is considered as a *process*—how responses are developed, who they are designed for and by, as well as the context in which they are intended to be implemented are likely to influence the effectiveness of this process. Chapter 1 outlines the theoretical and methodological approaches used to ask: why do diverse knowledges matter for effective adaptation responses (Chapter 2); what does procedural justice mean for initiating adaptation responses in practice (Chapter 3); (how) can climate change assessments equitably and meaningfully bring together diverse knowledges (Chapter 4)?

Introduction and Research Rationale

Peoples' health is inextricably linked to their environments. As global temperatures warm above pre-industrial levels, regional climates and land-based processes are affected, in turn presenting new and changing risks to human and ecosystem health such as water scarcity (1), soil erosion, vegetation loss (2,3), wildfire damage (4), permafrost degradation (5), crop yield decline (6), and food supply instabilities (7,8). The dynamic interactions between climate-related hazards, exposures, and vulnerabilities represent complex and compounded risks for human and ecosystem health (7,9–11). Certain health risks related to climate change are already being experienced or can be anticipated, such as risks to food security arising from changes in temperature extremes. Other future risks will be more difficult to predict given the uncertainty of how climatic and non-climatic factors will change over time and space in responses to human systems and decision-making, such as demands on food or land or access to markets (12). Nonetheless, climate change will affect—and is already affecting—human and ecological systems in ways that are complex, sometimes unpredictable, and certainly significant for global health.

The impacts of climate change on health are not equitably distributed. Not everywhere or everyone will experience risks in the same ways. Risks to health posed by climate change are specific to places and to peoples: climate hazards interact with local vulnerabilities and exposures to create contextualised risk (13). For example, the same flooding event in one area will affect the health and wellbeing of individuals and communities differently as determined for example by income, access to insurance, location-specific infrastructure, housing density and quality, as well as social welfare. In addition to peoples' environments, the impacts of climate change on health are modified and mediated through social, economic, spatial, and geopolitical systems (13,14). Globally, this exacerbates existing health inequities to create magnified patterns of inequitable climate-health risk; the people and places most affected are the ones who have contributed the least to global warming (13). Examples of differentiated climate-health risks include how future hotspots of crop yield decline due to climate change are projected to occur in areas of the global south (7,15); and how climate-induced water scarcity is experienced differently across incomes, locations, genders, and age (16–18). Complex examples include how decreasing seafood availability, due to climate changes over land, is compounded by other ongoing modifications to diets caused by social and economic changes. This creates compound risks, for example, for the nutritional health of Indigenous peoples and coastal communities highly dependent on seafood in the Arctic, West Africa, and Small Island Developing

States (9). Risks to health impacts are determined by dynamic interactions between climate hazards as well as exposures and vulnerabilities that are mediated through non-climatic factors and existing determinants.

In addition to the inequities of climate impacts, the ability to respond and benefit from responses to climate change are also experienced inequitably. This includes how responses are developed, who they are designed for and by, as well as the context in which they are intended to be implemented. Contextual factors and local conditions are likely to influence the needs, capacity, and likelihood of success of adaptation responses (19,20). New risks arising from climate-health responses can result from trade-offs with other societal, environmental, and/or economic objectives—such as the Sustainable Development Goals—as well as resulting from uncertainty in the implementation, effectiveness, or outcomes of a response option (7,9,21). For example, the increasing uptake of bioenergy as a response to reduce greenhouse gas emissions also has the potential to create risks for food security by increasing competition for land (7). Researchers and policy makers are interested not only in understanding how climate change will continue to impact human and ecosystem health, but also how we might adapt to these risks in a way that considers how the burdens and benefits of our responses will be distributed: when it comes to responding to climate change, who wins, who loses, and who decides? This thesis is situated within the mandate of the Paris Agreement signed by global nations to move towards just and equitable responses to climate change. In this context, my thesis is not a contribution to advancing the equity of climate impacts or risks, but rather in assessing the justice and equity dimensions of *how we respond* to those risks, with a focus on how connecting different forms of knowledge can enable a just response.

Research Aim and Objectives

This thesis aims to explore equitable mechanisms and just processes for diversifying knowledges to advance climate responses. Table 1.1 presents the overall research aim and objectives alongside the research methodology and scope corresponding to each empirical thesis chapter. Guiding questions are presented before each research objective: why do diverse knowledges matter for effective adaptation responses; what does procedural justice mean for initiating adaptation responses in practice; (how) can climate change assessments equitably and meaningfully bring together diverse knowledges?

The term knowledges, in its plural form, is used throughout the thesis to reflect the recognition of many, diverse, locatable, and autonomous worldviews (22–26). Indigenous knowledges, for example, are part of a holistic system of knowledge and connected to a wider context of people and place, including ways of governance, practices, norms, and orders (22,24).

Table 1.1 Overall research aim and objectives with associated methodology and scope corresponding to empirical thesis chapters.

Aim: To explore equitable mechanisms and just processes for diversifying knowledges to advance climate responses.

Objective	Methodology	Scope—Source	Chapter—Output
Guiding Question: Why do diverse knowledges matter for effective adaptation responses?			
1. To critically appraise contributions and mechanisms for engaging diverse knowledges in integrated climate-health monitoring and response systems globally.	Systematic literature review, evidence synthesis, and confidence assessment of published empirical papers on integrated climate-health monitoring and response systems	Global— Theoretical and empirical secondary evidence	Chapter 2 Published Manuscript
Guiding Question: What does procedural justice mean for initiating adaptation responses in practice?			
2. To contextualise mechanisms for initiating integrated climate responses within existing knowledge networks of community health and subsistence food systems in Uganda.	Place-based key informant interviews, participatory knowledge holder mapping, social network theory and analysis	Local— Place-based empirical primary evidence	Chapter 3 Published Manuscript
Guiding Question: (How) Can climate change evidence assessments equitably and meaningfully bring together diverse knowledges?			
3. To assess mechanisms for equitably considering diverse knowledges in global climate change evidence assessments.	Targeted review and synthesis of IPCC procedures and principles, IPCC Special Reports (sixth assessment cycle), IPCC expert reviewer comments, and interviews with expert advisors	Global— Science-Intergovernmental secondary and primary evidence	Chapter 4 Prepared Manuscript

Theoretical Approach and Key Concepts

Conceptualizing Climate-Health Risk and Impact

This section presents a conceptual framework (Figure 1.1) and key vocabulary applied to understand the risks and impacts of climate change on health. The definitions and framework presented in this chapter are adapted from the Intergovernmental Panel on Climate Change (IPCC) sixth assessment cycle (7,9,21,27). However, these definitions and conceptualisations are not uniform and remain contested, both within the peer-reviewed published literature as well as beyond it. The interactions between climate change and health can be understood using a diversity of perspectives and disciplines.

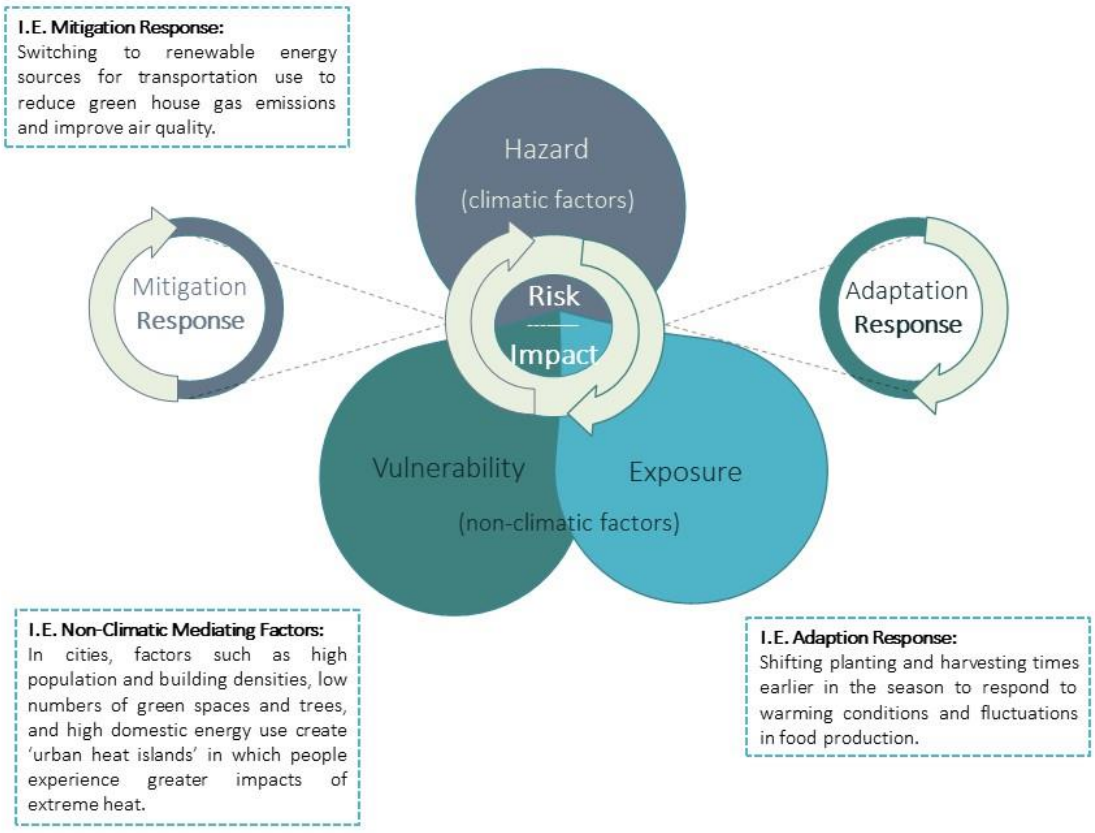

Figure 1.1 Conceptual framework of climate-health risks, impacts, and responses.

Health is not only the absence of disease but complementary and dynamic states of wellbeing—inclusive of physical, mental, social, emotional, spiritual, etc. Throughout the thesis, I adopt a very broad conceptualisation of health (and wellbeing) to enable movement into the relational, dynamic, and uncertain pathways of interdependence with the environment and climate change. This is done in recognition of the multiple understandings and interdependent conceptualisations of health across people and places. To begin, the key search terms used in Chapter 2— 'health' 'disease' 'wellbeing' 'incidence' (p. 32)—intentionally offer a simplistic and broad, albeit tending towards biomedical, definition from which to grow. Evidences from diverse knowledges help to expand and blur the boundaries of what is considered 'explicitly' linked to, or determinants of, dynamic states of health and wellbeing (Table 2.3, p.35). For example, Indigenous ways of knowing that have long since recognised the implicit, as well as explicit, complementarity and interdependence of a diversity of beings—from animals, plants, lands, waters, and humans—disintegrate where the health of one ends and the other begins (28–33). Chapter 3 offers a holistic and contextualised understanding of health in terms of subsistence food and community health systems. Here, discourse from critical epidemiology supports the shift away from a singular definition and conventional model of health, as evidenced in Chapter 2, and makes space for considering the interdependence of societies, knowledges, and nature, through which a complex, multidimensional concept of health undergoes dialectical processes of determination (34–36). Conceptualisations of health that go beyond the human and biomedical will advance responses to the risks and impacts of climate change for a diversity of beings and living entities.

Risk is the potential for adverse consequences to human and/or environmental health, acknowledging the diversity of values and objectives associated with health. Risk becomes realised in the impacts of climate change, as well as human responses to climate change, and depends on the dynamic interactions between climate-related hazards and the exposures and vulnerabilities of an affected human and/or ecological system (21).

Climate-related hazard refers to the potential occurrence of a natural or human-induced physical event or trend in the climate system that may impact the health and wellbeing of human and more-than-human beings (7,9,21,27). Exposure reflects the presence of species, structures, and systems in situations that could be adversely affected, and vulnerability represents the propensity or predisposition of species, structures, and systems to be adversely affected. Together, exposure and vulnerability encompass the non-climatic factors (social, cultural, economic, geographic, historical,

demographic, etc.) that collectively determine how the health impacts of, and responses to, a climate-related hazard are experienced (directly and indirectly) (14). An example of this can be seen in cities, where factors such as high population and building densities, low numbers of green spaces and trees, and high domestic energy use interact to create 'urban heat islands' in which non-climatic factors increase the impacts of extreme heat for people living in these areas (13,37). Both climatic (hazard) and non-climatic (vulnerability and exposure) factors may change over time and space in response to human systems and decision-making (21).

Responses to climate change consist of any strategy and/or measure taken to prevent or reduce the negative impacts of climate change on health. This can range from the development and implementation of a policy or technology, to investment and management, as well as governance mechanisms and entire systems transitions. Mitigation strategies and measures respond by reducing the magnitude and likelihood of a climate-related hazard. For example, switching to renewable energy sources for transportation to reduce greenhouse gas emissions. Adaptation strategies and measures, in contrast, aim to reduce the impact of a hazard on human and ecological systems through pathways of vulnerability and exposure. An example of this would be shifting planting and harvesting times earlier in the season to respond to warming conditions and fluctuations in food production. While responses include adaptation and mitigation strategies, the work of this thesis focusses on adaptation specifically. For climate-health responses, risk results from potential failures to meet intended objective(s) of the response, or trade-offs with other societal objectives, as well as any uncertainty in the implementation, effectiveness, or outcomes of a response option such as a climate policy, technology, or investment (7,9,21).

Situating the Research Within Effective and Just Climate Responses

Not all responses to climate change achieve their intended outcome(s), and not all adaptations are necessarily adaptive. For example, responses to reduce risk may be intentional such as the establishment of a new surveillance system for emerging infectious diseases due to vector habitat shifts associated with climate change. Other responses may be unintentional, such as the health benefits from reduced air pollution and increased exercise arising from an urban bicycle-sharing programme designed to reduce traffic congestion. Similarly, responses to reduce some risks can generate new risks elsewhere in human and/or ecological systems. For example, changing planting and harvesting times earlier to respond to warming temperatures introduces new risks related to frost

damage and loss of harvested crops. It is thus difficult to prioritise which responses will be 'successful', and indeed how to assess effectiveness or success for adaptation responses (38–42). Determining what a desired outcome is and whether it has been achieved is complicated and requires an understanding of adaptation as *process* and *in context* (43). General indicators of effectiveness that have been suggested—though remain difficult to measure or assess—include reduced risk (through reductions in vulnerability and exposure), enhanced wellbeing, improved environment, increased access to resources, and strengthened institutions (38). Supporting effective, sustainable, just, and equitable climate responses to achieve global climate commitments requires an evidence base of what works, for whom, why, and in what contexts.

Since effectiveness is often dependent upon contexts, understanding how local conditions are likely to influence the likelihood of success in adaptation responses is critical (19,20,43,44). This includes not only what *type* of response is most likely to be effective in reducing risk (i.e. surveillance vs. social support vs. capacity building), but also how adaptation as *process* can influence whether a particular response is successfully implemented and sustainable (i.e. who decides, who is consulted, what evidence is used, what consensus is reached). For example, a heat warning system may appropriately respond to reducing heat-related impacts in a population, but may fail due to lack of public awareness, perceived danger of heat, perceived costs of taking action and adjusting behaviours, and consideration for how the system can be adapted for use by vulnerable groups (45). In this sense, understanding the potential effectiveness of adaptation responses requires consideration of local contexts that will influence success or failure (19,42). As such, the same intervention may be successful in one context and unsuccessful in another. This has implications for the type of evidence and knowledge that is used to inform adaptation responses since it implies that, in addition to climate projections and health data, localised forms of knowledge will frequently be necessary in the development of successful adaptation responses to climate change.

Successful and effective climate-health adaptation will require integration of local and global knowledges on climate and health, yet there remain persistent barriers to integrating diverse types of evidence (20,46). Climate and health data are typically investigated at very different temporal and spatial scales, making it difficult to collate and use observations that were not designed to be evidenced together. For example, data from one part of the assessment (climate-related hazards) tend to be global-regional in scale, while important data from another part of the assessment (vulnerabilities and exposures) tend to be very local. For example, warming temperatures are a

measure of global averages, with changes affecting regional climates and land-processes, while the health impacts of these changes are experienced locally when a water source runs dry or the maize harvest is stunted. Furthermore, while climate-related hazards, exposures, and vulnerabilities are each subject to different types of uncertainty (magnitude and likelihood of occurrence) and changes in each may occur and be measured over vastly different temporal scales. Despite this difficulty of integrating across scales of global climate (hazard) data with local contexts (vulnerability and exposure) data, a stronger evidence-base of these cross-scale interactions will ultimately support effective and just climate responses.

Given the challenges of integrating different forms of evidence and knowledge in the field of climate adaptation, non-western scientific knowledges have frequently been overlooked in adaptation policy and planning. This is despite recognition in the literature and the Paris Agreement that justice and equity, and the *processes of adaptation* are critical components of adaptation effectiveness (38,47). In this thesis, I do not aim to assess the overall effectiveness of adaptation responses, but rather focus on one fundamental aspect of effectiveness: procedural justice.

In the context of climate adaptation response, procedural justice is the deliberate engagement and equitable recognition of diverse voices, their autonomy, and decision-making power to participate and influence the way that responses are determined—from their initiation through to their outcomes (9,47,48). *Who* is it that determines participation, outlines the boundaries of governance, shapes the rules of engagement, and defines justice? In considering the inequitable distribution of climate change impacts and abilities to benefit from adaptation responses, this research calls attention to the justice of diversity when developing and implementing responses—"towards the voices that do or do not speak into it" (49). For example, this includes shared governance and collective decisions-making between and within local authorities and communities (human and more-than-human) in processes of climate-induced relocation, migration, and displacement. For many, the danger of injustice within our responses is rooted in the relationships that shape them. Whyte (50), an Indigenous Potawatomi scholar, considers how the qualities of relationships—such as trust, consent, accountability, reciprocity—comprise the fundamental elements of a *just* climate response underpinned by mutual responsibility and coordinate action. The historical and ongoing violation of these qualities through systems of colonialism, capitalism, and industrialisation, has led to what Whyte calls a 'relational tipping point' in developing and implementing effective climate responses. Here, justice centres on the "moral bonds that mature over time as people in different societies develop ties to one another"

as well as repairing those lost or disrupted relationships. This conceptualisation of justice is critical to acknowledge as we consider how these bonds influence the process of adaptation in terms of being able to bring together knowledges of different systems and societies.

Diverse Knowledge(s)

Advancing climate-health responses depends on having an evidence base to underpin each potential pathway. Whether these pathways are effective, sustainable, just, and equitable is predicated on diverse forms and sources of knowledge — *knowledges* — coming together to fill the gaps in our current understandings. How they come together depends on fundamental processes of framing, making, and evaluating knowledges—as well as *who* determines these processes.

In the Great Lakes region, for example:

> "Anishinaabe and Haudenosaunee theoretical frameworks explain that how one knows is inseparable from what one knows; that is, it is inseparable from the world 'out there', the land itself, which is alive, intelligent, and willful, and from the values, moral principles, and laws that govern creation and proper conduct (51,52)"— (22).

Diversity brings more than the expansion of knowledge. Relational cosmologies or worldviews, as shared by many Indigenous peoples, connect being (ontology), with knowing (epistemology), doing (methodology), and accounting (axiology) (22,53,54). Responding to the health impacts of climate change requires as connected an understanding of how our systems (human and otherwise) exist through relationships. Singular approaches to conceptualizing climate-health risks, impacts, and responses are limited in their ability to represent the integrative complexity and interdependency of combined human and natural systems (29–31,55,56). This includes looking at the impacts of sea and river ice decline on access and availability of subsistence food in the Arctic, for example. Inuit hunters hold knowledge about the biophysical and local processes of sea ice that has been passed down from generation to generation using situated observations and techniques to help them decipher when and where it is safe to travel for food (57). As the predictability of ice formation changes, so must the assessment of travel safety. In combination with remote sensing satellite-based radar observations of regional scale ice conditions, diverse knowledges are enabling communities to make informed decisions and respond in uncertain times (57). Bringing these distinct and diverse ways of knowing

together creates a stronger-evidence base to support our capacity to deliver effective climate responses.

One "dominant knowledge obscures or under-privileges other forms of knowing, and the voices of other knowers" (58). In contrast, the recognition of many, diverse, and localised knowledges oppose the dominance of a single worldview. By engaging in acts of opposition and recognition, we as researchers can make space for connecting different ways of knowing (22,25). By making space for the expression, transmission, and valuing of diverse knowledges, we can begin to re-examine the fundamental processes of framing, making, and evaluating that inform our understandings and responses to climate change (59–62).

Procedural Justice—Processes for Bringing Knowledges Together

How to bring different knowledges together is not straightforward given substantial and meaningful differences in format, curation, and epistemology. *Who* decides how knowledges are differentially validated, what knowledges count, and what format integrated evidence should take underpin ongoing tension in bringing diverse knowledges together. As diverse as the knowledges, there is not one process for bringing them together, with different protocols having developed from within different systems of knowledge. Tengö et al. (63) note, for example, that while diverse knowledges have always experienced 'cross-fertilisation' or transfer, it is vital to consider the differences of power and perspectives in the process of how new knowledge is created. Tengo et al. (63) distinguish between: the *integration* of knowledges, approaches to developing synergies across knowledge systems, and the co-production of knowledge. Knowledge integration, for example, generally implies some aspects of one knowledge system (implied as secondary) are incorporated into another (implied as primary) through validation of the secondary knowledge system within the framings of the primary knowledge system. Additional complications arise as knowledge systems are not always mutually exclusive, distinguishable, nor categorisable by consensus (64). The literature demonstrates a diversity of applications and acceptances of such evaluation and validation approaches.

There is extensive documentation and critique of the integration of local knowledges and Indigenous knowledges being 'validated' within western scientific framings (64–68). Examples of this include (ab)using knowledges out of context and (de-)valuing them as and when it suits a western scientific framing. Expropriating knowledges by 'translating' and '(in)validating' their insights through the lens of western science acts to exclude knowledges and disempower knowledge holders (63,66,69).

Increasingly, authors have argued that bringing knowledges together should be a 'two-way' process in which knowledge holders from different systems each have the equal opportunity and authority to critique findings and framings (70). Both experts situated within as well as those spanning the boundaries beyond western science have argued the validation process should only take place *within* knowledge systems and not between them (22,24,53,63,66,71–74). For example, Indigenous knowledges, local knowledges, and western scientific knowledges cannot, and should not, be integrated within a single framing of evidence given such fundamental differences in their epistemologies, ontologies, methodologies, and axiologies. A parallel approach, therefore, applies a process in which knowledges remain distinct and separate, maintaining their own integrity and quality, while simultaneously being considered together (63,75). Knowledge co-production, sometimes referred to as 'bridging', are collaborative processes of knowledge generation in which multiple paradigms are applied at all stages of knowledge generation (43,69,76).

There is much potential and ongoing navigation of processes for making new knowledge to understand and respond to our changing climate (77). Ensuring justice, within these processes, not only refers to the equitable benefits of responses but also to the autonomy of engagement in the process informing responses (47). "The critical issue is the nature of the interactions among knowledge systems and that all involved are part of a collaborative process to determine which approach is desirable" (63). Just as there is a diversity of knowledges and processes for bringing them together, there are different ways to conceptualise the justice of this process. Here, the leadership of Indigenous knowledges, principles, values, and legal orders will be critical in broadening our conceptual understandings and practical applications of justice in the context of climate change (78). For instance, the extension of rights and responsibilities to diverse beings and living entities beyond humans, such as lands and waters (50,78). Changing the terms of engagement with local communities, Indigenous peoples, and practitioners in our response to climate change not only helps build an evidence base that is equitably diverse and contextually meaningful, but also informs the usability of information and connects knowledges into decision-making and action-oriented processes (55,79–84).

Diversity presents opportunities for advancement through complementarity and synergy, as well as through dissonance. Attempting to overcome diversity, and often dissonance, by universalizing systems of knowledge, truth, and value is something Löfmarck and Lidskog (85) describe as "doing violence to other ways of knowing". Rather than perpetuate violence, scholars suggest that approaches for diversifying knowledges be transparent, critically reflexive, collective, dialectic, and

adapted to their specific context and scale using careful consideration of existing and transcending relationships between knowledge systems (63,77,79,86). *Who* determines *what* we consider as knowledge and *how* it comes together will not only determine what evidence feeds our global and local responses to climate change but also whether they are just and equitable responses.

Reflecting on and Accepting my own Positionality

In this section, I would like to acknowledge the ways that I know, who I am, and why this matters for how I approach my research and what I have learned how to see. For example, there are multiple disciplinary backgrounds that inform my work, such as epidemiology, ecology, and anthropology (ontologies). My training in quantitative, qualitative, place-based, participatory, action, comparative, and critical approaches (methodologies) also informs my work. The ethical review and guidance from social and medical sciences (axiologies) informs my work. I have derived and continue to evolve a set of values and priorities from both the natural and human worlds around me, which also informs my work. Growing up in the Great Lakes, Naadowewi-Gichigami, of Canada, on Michi Saagiig Nishnaabeg territory (Treaty 6), a settler learning to be a guest, a child of first generation immigrants, is one part of a story that informs my work. Having lived, studied, and worked in Italy, Kenya, Uganda, Indonesia, Ireland, and the UK, there are stories of many places and peoples that continuously feed and inform my work.

From ecosystems to health systems, and now knowledge systems, I am constantly learning and eager to apply relational and connected ways of inquiry. Still, the key concepts of this thesis—how the empirical work has been framed, what methods of inquiry have been selected—have been explored from a western scientific lens (epistemology). For instance, this includes the decision to frame and define the impacts of and responses to climate change on health adapted from the IPCC (Figure 1.1)—an institution which provides a scientific view on the state of knowledge about climate change and its impacts (although I will present a critique of their evidence assessment process and mandate in Chapter 4). This bias is also reflected in various methodological decisions and prioritisations in the thesis, such as excluding non-peer reviewed articles from the systematic literature review (Chapter2). Chapters are presented in the same chronological order of how they were written and, as such, also follow a trajectory of how my own path and positionality as a researcher has developed over time. Throughout this doctoral journey, I reckon with the critiques and feasibilities of approaches for diversifying knowledges and acknowledge that this doctoral thesis—being positioned within a western

scientific institution and restricted by its own set of protocols and evaluation procedures—does not hold the same potential for collaborative and dialectic processes of creation as other research and relationships may.

This is not the thesis I intended to write, however, in doing so I've opened my research to worlds and ways of knowing (being, doing, and accounting) that are teaching me the complexity and diversity of what exists and what is needed to shape new ways of knowing (being, doing, and accounting) in this dynamic and interconnected ecosystem. Often with research you have a question that you want to investigate, however, upon deeper inquiry you realise that before you can approach answering this question, you need to step back and focus on answering another question first. It is being positioned from within a western scientific understanding that challenges me to learn the responsibilities and accountabilities of conducting research, such as the protocols and procedures required, when working with people from diverse worldviews and ways to that of my own (22,25,53,54).

While I see diversity as a solution to advancing climate adaptation responses, I do not attempt to actively bring together diverse knowledges in this thesis. Rather, this thesis provides a mechanism to be transparent and critically reflexive about examining existing and potential ways that knowledges have, and could, come together to advance climate-health responses across local and global scales. It is through this work of challenging the abuse of knowledges taken out-of-context and acknowledging existing relationships between knowledge systems that I am attempting to make space for connecting different ways of knowing (22,25). Giving up space to others from within non-western scientific knowledge systems takes work. As I see it, not only is this the work that I am positioned to do as a researcher, but it is also the work I am responsible and accountable for.

Methodological Approaches

The thesis explores how adaptation responses can reduce risk through knowledge diversification and procedural justice. The empirical research moves across scales to critically appraise, contextualise, and assess mechanisms for equitable and ethical processes that bridge diverse ways of detecting, attributing, and responding to climate-related changes in the health of humans and ecosystems. In doing so, each chapter presents a different scope of analysis—from global, to local, and intergovernmental (Table 1.1). Finally, each empirical chapter invokes three core concepts: effective adaptation response to the impacts of climate change (on health) as a mandate for focusing the

empirical work; **diverse knowledges** as an entry point for inquiry; and **procedural justice** and equity as a frame for investigation.

Each empirical chapter is motivated by relational, situated, responsible ways of understanding and approaches to research (22,53,54). This motivation is reflected in the various approaches used to investigate how we can, and do, span epistemological and methodological boundaries to advance (just/transformational) global, local, and intergovernmental climate responses (87–89). Each empirical chapter explores the limits of singularity, the added-value of diversity, and realisations of sovereignty needed for integrated and situated climate responses.

The research builds on how participatory approaches and place-based evidence can be applied as methods for bridging together diverse knowledges by centring on the equitable and just processes for doing so. Using specific methods for bridging together diverse knowledges in practice from participatory knowledge holder mapping (chapter 3), place-based monitoring (chapters 2, 3), and evidence assessments (chapter 4) (63,76,86). Critical action research and workshops—common approaches for bridging knowledges (72,90–92)—were originally part of my doctoral training process and thesis plan. However, these approaches were not ultimately used in my thesis since we had to adapt my research plans due to an outbreak of Ebola and the Covid-19 pandemic (see 'Case Study Rationale' for a more detailed explanation).

Place-based and participatory methods are applied in this thesis to explore *what* (knowledges are considered in building a climate-health evidence base), *how* (to bridge different knowledges together equitably and meaningfully), *who* (determines how knowledges are bridged and differentially validated), and *why* (connecting diverse knowledges matters for advancing effective and just adaptation responses) from a plurality of perspectives monitoring and responding in real-time. Both the theoretical and empirical work emphasises the importance of contextual factors, both in monitoring and responding as well as conducting research (19,20,79,81). Systematic methods are used in this thesis to emphasise the transparency and intentionality of process for critically appraising evidence, including details of how information has been identified, selected, coded, and synthesised (46,93,94).

Methodological justifications of specific research approaches are detailed within each empirical chapter of the thesis.

Case Study Rationale

Chapter 3 of the thesis presents an empirical case study from southwestern Uganda. The rationale for selecting this specific case study had to do with the disproportionate impacts, exposures, and vulnerabilities of climate change, the present and future risks to health and food systems, as well as the complex diversity and connectivity of existing knowledge networks and systems. This case study grew out of ongoing, and longstanding, climate change adaptation research partnerships with local communities and Indigenous peoples in the area. Food insecurity security was identified as a key climate-sensitive health risk and priority area of investigation by members of the communities (95).

My original thesis plan involved extended participatory, community-based fieldwork, framed primarily around critical action research approaches, with most chapters being place-based in Indigenous and non-Indigenous communities in southwestern Uganda. Unfortunately, I was not able to conduct as much of my thesis work in Uganda as originally planned. This was initially due to an outbreak of Ebola (August 2018-June 2020) in the neighbouring region of North Kivu Province in the Democratic Republic of the Congo (DRC), and then further constrained by Covid-19 (2020-present). Through active monitoring of the Ebola situation in the DRC, and communications with colleagues in Kanungu, the original fieldwork planned for January to June (2019) was initially postponed before being cancelled in July (2019). The research for this thesis was adapted and the final empirical chapter designed to accommodate for flexible and remote approaches—which has proven helpful during the ongoing Covid-19 pandemic—removing any remaining possibility of fieldwork in Uganda. At the time of writing, a resurgence in cases of Ebola have been identified in North Kivu Province (February 2021).

Climate projections for Uganda indicate greater extremes in weather with increased variability in seasonal trends, with changes in rainfall varying dramatically (96,97). Climate change most affects the people and places who have contributed the least to global warming (13). Southwestern Uganda provided a case study for investigating both situated and integrated climate-food-health nexus of monitoring and response (98), where experienced changes in seasonal variability were affecting health via pathways of food insecurity. For example, longer and hotter dry seasons or extended short rains are resulting in crop losses and changes in harvest yields (96). The incidence of extreme weather events, such as heavy rain, flooding, intense sunshine, and drought, is reducing the availability of subsistence foods (95).

In Kanungu District, Uganda, existing and inequitable burdens of disease and poverty amplify vulnerabilities and exposures to the impacts of climate change as well as limit adaptation options (99–101). Furthermore, differentiated vulnerability (and adaptation) to the affects of climate change on food security have also been identified within the local population. The extent of impact, exposure, and vulnerability depend on where people live, what land they have access to, their employment options, their level of income, as well as the expression of inter-generational knowledge of food systems and cultivation practices (95,99,100). Such inequality cannot be disconnected from a wider relational and historical context of land dispossession, acculturation of Indigenous ways of knowing, and ethnic discrimination. Given the complex diversity and connectivity of existing knowledge networks and systems in Kanungu, situating and integrating climate-food-health monitoring and response within processes of adaptation, power, and inequality was another fundamental part of this case study and rationale for conducting place-and community-based research.

Thesis Structure and Contributions

Thesis Structure

The thesis is structured into five chapters: this introductory chapter maps out the research aim and objectives, positions the work within a wider context, and provides a conceptual overview of the thesis and key contributions (Chapter 1); 3 empirical research chapters (Chapter 2, 3, 4); and a concluding chapter to summarise key contributions and reposition the relevance of this work (Chapter 5). Chapter 2 presents a systematic literature review and confidence assessment of diverse knowledges in climate-health monitoring and response systems to critically appraise contributions and assess the gaps in the engagement process. Chapter 3 presents interviews with key informants from health and subsistence food systems in southwestern Uganda to contextualise a process for initiating an integrated climate-food-health response into existing networks of diverse knowledges. Chapter 4 presents a review and synthesis of IPCC principles and procedures, the sixth assessment cycle Special Reports, expert reviewer comments from drafted versions of Special Reports, as well as in-depth interviews with expert advisors to assess formal IPCC mechanisms for equitably considering diverse knowledges, specifically Indigenous knowledges, along a process of evidence assessment.

Thesis Contributions

The empirical work in my thesis contributes to assessing the justice and equity dimensions of how we respond to climate risks and impacts, with a focus on how connecting different forms of knowledge can enable a just response. Specifically, this work is intended to contribute to answering *how* we bring together diverse knowledges to advance climate adaptation responses. This is done through conceptual, methodological, and practical contributions. Conceptual contributions include empirically demonstrating how diverse knowledges contribute to adaptation (Chapter 2). Methodological contributions include empirically exploring what procedural justice could look like in practice for initiating a place-based climate-food-health adaptation response (Chapter 3). Finally, practical contributions include empirically providing substantial guidance on how to bridge diverse knowledges and reform an evidence assessment process that feeds global climate adaptation responses (Chapter 4). As a whole, this thesis empirically demonstrates why *process* matters for climate adaptation responses—both intrinsically and fundamentally in terms of justice as well as practically in terms of effectiveness. While the academic and political importance of climate adaptation effectiveness and procedural justice is known, the literature exploring what these concepts mean in practice is still scant. As such, the work of this thesis contributes—conceptually, methodologically, and practically—to the nexus of global climate adaptation research and policy in assessing the justice and equity of processes for diversifying knowledges to advance climate-health responses.

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Chapter 2—Contributions of scale: What we stand to gain from diversifying climate and health monitoring and surveillance systems

This chapter answers the guiding question set out in Chapter 1: why do diverse knowledges matter for effective adaptation responses? This work considers what is needed to move towards just and equitable responses to climate change that are integrated with health systems. This chapter presents a systematic literature review, evidence synthesis, and confidence assessment of published empirical papers on integrated climate-health monitoring and response systems. The findings presented here have implications for realising procedural justice in global climate change discourse and policy where arguments about the value of diverse knowledges persist—namely from western scientists, policymakers, and institutions. This chapter builds confidence in—and recognition for—the possibilities and potential of knowledge diversity, equity, and procedural justice.

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Bianca van Bavel[1], Lea Berrang Ford[1,2], Sherilee L. Harper[3], James Ford[1], Helen Elsey[4], Shuaib Lwasa[5], and Rebecca King[2]

1. Priestley International Centre for Climate, University of Leeds, Leeds, West Yorkshire, UK

2. Nuffield Centre for International Health & Development, University of Leeds, Leeds, West Yorkshire, UK

3. School of Public Health, University of Alberta, Edmonton, Alberta, Canada

4. Department of Health Sciences, University of York, York, North Yorkshire, UK

5. Department of Geography, Geo-Informatics & Climate Sciences, Makerere University, Kampala, Uganda

Abstract

Understanding how climate change will affect global health is a defining challenge this century. This is predicated, however, on our ability to combine climate and health data to investigate the ways in which variations in climate, weather, and health outcomes interact. There is growing evidence to support the value of place- and community-based monitoring and surveillance efforts, which can contribute to improving both the quality and equity of data collection needed to investigate and understand the impacts of climate change on health. The inclusion of multiple and diverse knowledge systems in climate-health surveillance presents many benefits, as well as challenges. We conducted a systematic review, synthesis, and confidence assessment of the published literature on integrated monitoring and surveillance systems for climate change and public health. We examined the inclusion of diverse knowledge systems in climate-health literature, focusing on: 1) analytical framing of integrated monitoring and surveillance system processes 2) key contributions of Indigenous knowledge and local knowledge systems to integrated monitoring and surveillance systems processes; and 3) patterns of inclusion within these processes. In total, *24* studies met the inclusion criteria and were included for data extraction, appraisal, and analysis. Our findings indicate that the inclusion of diverse knowledge systems contributes to integrated climate-health monitoring and surveillance systems across multiple processes of detection, attribution, and action. These contributions include: the definition of meaningful problems; the collection of more responsive data; the reduction of selection and source biases; the processing and interpretation of more comprehensive datasets; the reduction of scale dependent biases; the development of multi-scale policy; long-term future planning; immediate decision making and prioritisation of key issues; as well as creating effective knowledge-information-action pathways. The value of our findings and this review is to demonstrate how neither scientific, Indigenous, nor local knowledge systems alone will be able to contribute the breadth and depth of information necessary to detect, attribute, and inform action along these pathways of climate-health impact. Rather, it is the divergence or discordance between the methodologies and evidences of different knowledge systems that can contribute uniquely to this understanding. We critically discuss the possibility of what we, mainly local communities and experts, stand to lose if these processes of inclusion are not equitable. We explore how to shift the existing patterns of inclusion into balance by ensuring the equity of contributions and justice of inclusion in these integrated monitoring and surveillance system processes.

Keywords: climate change, public health, Indigenous knowledge systems, local knowledge systems, monitoring, surveillance systems, systematic review, confidence assessment

Introduction

Understanding how climate change will affect global health is a defining challenge this century (1,2). This is predicated, however, on our ability to combine climate and health data to investigate the ways in which variations in climate, weather, and health outcomes interact. Information from satellite observations and geographical information systems, for example, have improved our understanding of changing patterns in climate, environments, and biodiversity (3). These patterns can play an important role in driving incidence and changing distributions of several vector-borne diseases of public health importance (e.g. malaria, dengue, Rift Valley fever, schistosomiasis, Chagas disease, and leptospirosis) (3–5). Though critical for global health and climate policy, such research requires access to climate data and health data that are available for similar geographical areas and periods of time to be integrated and compared.

Despite this need for data integration, the fields of climate change and public health have evolved very different approaches and systems for data generation and evaluation over time. Surveillance reflects the systematic and repeated cycle of observation, data analysis, and the conversion of data into actionable information for implementing change and improving population health (6). While the main motivation of a surveillance system is to collate information that drives action (6), every system has bespoke objectives and methods. Each surveillance system is designed to gather high-quality and timely information at a resolution and in a format relevant to the particular context (6). This results in substantial differences between climate observation systems and health surveillance systems design; owing to the different temporal and spatial scales at which climate and health are typically and often differentially investigated. For instance, while climate observation systems might monitor weather or climate variation in relatively large areas over years, decades, and centuries (e.g. change in sea surface temperature over 2 centuries), public health surveillance systems more frequently focus on monitoring mortality or prevalence or incidence of morbidity of individuals, populations, or smaller spatial units over days, months, and years (e.g. weekly malaria counts in urban neighbourhoods). Rarely are climate and health datasets opportunistically complementary in resolution and availability. These differences mean that combining climate and public health data is challenging, and difficult to integrate if developed separately.

There is growing evidence to support the value of place- and community-based observation, monitoring, and surveillance efforts (7–14), which can contribute to improving both the quality and

equity of data needed to understand the impacts of climate change on health (15–19). Just by working within existing expertise and capacities of local communities to collect information that is both familiar and accessible to them brings benefit to both the quality of data processes as well as the principled ethics of monitoring and surveillance systems research (14,17,18,20–22). Embedded within Indigenous knowledge systems (IKS) and local knowledge systems (LKS), place- and community-based observation, monitoring, and surveillance also have the ability to provide locally accurate, precise, reliable, and valid information about the health impacts of environmental and climatic change that can be used in complementarity with instrumented observation networks and coordinated with other information systems (10,15,23).

The inclusion of multiple and diverse knowledge systems has been recognised as a key element in robust decision-making for informing policy, science, and social action (24–27). This is also true in the context of climate change (28–30), where information produced with, and by, diverse knowledge systems has been documented as an important source for informing, and improving, decision making processes in climate-health policy, practice, and research (31,32). The inclusion of local and Indigenous knowledges in such decision-making processes is leading to a growing recognition of rights and realisation of justice for peoples and communities (33–35); with value of this inclusion extending into areas of resource management, environmental policy, and climate change adaptation (31,36–40). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the Intergovernmental Panel on Climate Change (IPCC) consider both Indigenous knowledges and local knowledges as key elements of the social and cultural systems that influence observations of, and responses to, climate change (41).

Both Indigenous knowledges and local knowledges encompass personal experience and observation, explanatory inference and interpretation, as well as indirect experience and oral history to continuously generate collective, inter-generational, place-based knowledges (42–44). However, Indigenous and local also refer to distinct knowledge systems (i.e. Indigenous knowledges can be local; local knowledges are not always Indigenous). Indigenous knowledges refer to the understandings, skills, and philosophies developed by societies with long histories of interaction with their natural surroundings. The United Nations Sub-Commission on the Promotion and Protection of Human Rights explains how Indigenous knowledge systems include scientific, agricultural, technical, and ecological knowledges that pertain to a particular people and its territory (45). Indigenous knowledges embody a web of relationships within a specific ecological context and evolve through dynamic inter-

generational transmission (34). Indigenous scholar Battiste (2005) describes Indigenous knowledges as systemic, "covering both what can be observed and what can be thought"; comprising "the rural and the urban, the settled and the nomadic, original inhabitants and migrants" (34)(pp. 4). For many Indigenous peoples, Indigenous knowledges inform decision-making about fundamental aspects of life, from day-to-day activities to longer term actions and governance. These knowledges are integral to cultural complexes, which also encompass language, systems of classification, resource use practices, social interactions, values, ritual, and spirituality (41). Local knowledges refer to the understandings, skills, and theories developed by individuals and populations that are specific to a place (41). While local knowledges can also inform decision-making about fundamental aspects of life, from day-to-day activities to longer-term actions and governance, they are not necessarily based on a specific culture or embedded in a wider system.

Despite well-established recognition of the importance of diverse knowledge systems, sources of information, and scales of evidence, however, the practical integration of these systems has been more difficult to operationalise (22,35,46,47). Some constraints of integration include informational, financial, institutional, technological, linguistic, educational, political, cultural, epistemological, ontological, and human factors (11,24,48–50). Existing literature reviews on integrated climate and health monitoring and surveillance have begun to highlight diverse benefits and challenges of knowledge diversity and inclusion (15,16,19). As such, a comprehensive or systematic review of the contributions and inclusion of diverse knowledge systems in climate and health monitoring and surveillance would make a necessary contribution to the existing body of literature. In this review, we systematically map the published literature on integrated climate-health monitoring and surveillance systems. We examine the inclusion of diverse knowledge systems in climate-health literature, focusing on: 1) analytical framing of integrated monitoring and surveillance systems (MSS) processes 2) key contributions of Indigenous knowledge systems (IKS) and local knowledge systems (LKS) to MSS processes; 3) patterns of inclusion within these MSS processes[1].

[1] We use both terms 'monitoring' and 'surveillance' in our analyses of integrated climate-health data. While they are similar and sometimes overlapping concepts (i.e. a surveillance system encompasses monitoring activities), we made this distinction to incorporate diverse evidence from place-and community-based observation and monitoring that may not necessarily include pre-defined or deliberate courses of action.

Methods

We conducted a systematic review and evidence synthesis of published literature on integrated monitoring and surveillance for climate change and public health. We applied the reporting standards for systematic evidence syntheses (ROSES) forms to guide the review process (51,52). The literature search aimed to systematically and transparently identify empirical papers that: 1) documented monitoring and/or surveillance system; 2) integrated climate and health information or data; 3) included locally inclusive or participatory approaches; and 4) included multiple and diverse knowledge systems in MSS processes.

Data Source and Document Selection

Search terms were included as either topic or key terms: ["community*"OR "local*" OR "place*"] AND [participat*] AND [monitor* OR observ* OR surveill*] AND [health OR disease OR wellbeing OR incidence] AND [climat* OR weather OR season* OR meteor*]. A final search string was used to search the academic citation databases of Scopus®, PubMed®, and Web of Science™ in November 2018 (Table 2.1). The search was completed again in July 2019 to include publications from November and December 2018. Web of Science™ search results include international databases from a range of disciplines, including health, agriculture, food science, technology, biology, ecology, and zoology: BCI, BIOSIS®, KJD, MEDLINE®, RSCI, SciELO. Search results were limited to 2006-2018. This limit was determined using the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4; Working Group II) effective cut-off date for submission of supporting literature (October 2006) to focus on recent and up-to-date climate-health research. We did not restrict articles by language. The reference management software Mendeley® was used to extract and store lists of citations identified in the initial searches. Lists were merged and duplicates removed, then transferred to the review software Covidence.

Table 2.1: Final search strings utilised in Scopus®, PubMed®, and Web of Science™ databases.

Database	Search String
Scopus®	KEY (community*) OR KEY (local*) OR KEY (place*) AND KEY (participat*) AND (KEY (monitor*) OR KEY (observ*) OR KEY (surveill*) AND KEY (health) OR KEY (disease) OR KEY (wellbeing*) OR KEY (incidence) AND KEY (climat*) OR KEY (weather) OR KEY (season*) OR KEY (meteor*))
PubMed®	(((((((local*[Title/Abstract]) OR community*[Title/Abstract]) OR place*[Title/Abstract]))) AND participat*[Title/Abstract]) AND ((((monitor*[Title/Abstract]) OR observ*[Title/Abstract]) OR surveill*[Title/Abstract]))) AND ((((climat*[Title/Abstract]) OR meteor*[Title/Abstract]) OR weather[Title/Abstract]) OR season*[Title/Abstract])) AND ((((health[Title/Abstract]) OR disease[Title/Abstract]) OR incidence[Title/Abstract]) OR wellbeing[Title/Abstract])
Web of Science™	TS=(community* OR local* OR place*) AND TS=(participat*) AND TS= (monitor* OR observ* OR surveill*) AND TS=(health OR disease OR wellbeing OR incidence) AND TS=(climat* OR weather OR season* OR meteor*)

Predefined selection criteria (Table 2.2) were applied in the first round of screening based on the title and abstract of each study. MSS were defined by related activities, stages, and processes involved in the systematic and repeated cycle of observation and informed response pertaining to changes within a climate-health boundary. The Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5; Working Group II) Chapter 11 was used to define how climate change (i.e. meteorological shifts, or environmental disruptions departing from the average) impacts on human health, or contributes to ill health (i.e. shifting patterns of disease; displacement of populations; heat-related injury, illness and death; crop failure; reduced food production; induced undernutrition)(53). As per IPCC AR5, eligible health impacts due to climate included three dominant causal pathways: direct exposure; indirect exposure mediated through natural systems; and socio-economic disruption mediated through human systems (53). Although our review targeted climate-health literature, we recognise that the bulk of literature relevant to climate-health does not directly document climate data, rather proxies of climate variation. Therefore, we included papers focusing on meteorological and environmental variations that are presumed to be proxies of climate change along the causal pathways impacting health. Definitions and examples of core components for climate, health, and

impact pathways are given in Table 2.3. These boundaries were defined *a priori* and based on scoping the literature before conducting the search. We recognise that there are different terminologies used within inclusive and participatory approaches in place-and community-based literatures; from "consultation" to "participation", to "engagement", to "leadership". We have decided to use the term "inclusion" to reflect this spectrum of scaled levels and applications. Potentially relevant articles were retained for full-text screening and assessed based on the inclusion criteria in Table 2.2. Following the selection of eligible articles from our search, reference tracing was undertaken to identify additional relevant articles either cited by (forward tracing) or citing (backwards tracing) included articles. This is a method used to search for reports of studies that may not have been indexed in the electronic databases originally searched. A secondary reviewer, unfamiliar with the review beyond the specific inclusion criteria, screened a random sample of returned studies (n = 64).

Table 2.2: Inclusion and exclusion criteria applied to the screening and selection of studies.

Inclusion criteria	Exclusion criteria
(1) Empirical paper that clearly describes a monitoring and/or surveillance system (aims, objectives, context, methods, data)	(1) Does not give empirical examples of monitoring or surveillance activities
(2) Contains both health and climate related monitoring and/or surveillance data	(2) Focus of paper is not within defined climate-health boundaries
(3) Papers that substantively discuss more than one type, source, or scale of monitoring and/or surveillance data	(3) Describes only one type, source, or scale of data
(4) Papers that substantively discuss elements of inclusive and participatory approaches involved in monitoring and/or surveillance system processes	(4) Inclusive or participatory approach is absent/indeterminate

Table 2.3: Definition and examples of core review components used to guide document selection.

Core Component	Boundary Definitions	Examples (Included)	Examples (Excluded)
Climate	Climatic variables, as well as environmental and meteorological proxies	Unseasonable environmental conditions (i.e. river flow, sea-ice formation, flooding, forest fires) or unusual changes in weather (i.e. heavy precipitation, drought, extreme temperatures)	Environmental or meteorological conditions with no indication of change/variability
	Indicating change/variability that departs from the average	Changes in wildlife populations (seasonal distribution) Changes in vegetation / plant populations (seasonal flowering and budding) Changes in river flow and sea-ice formation	
Health	Outcomes and determinants of human health and wellbeing Including access, availability, quantity, and quality of food, water, air, shelter, and security	Incidence of heat stroke / exhaustion Disruption to livelihoods and cultural practices Loss of homes and livestock Incidence of disease in wildlife and plant populations used for subsistence	Disruption to animal populations (vector-borne, zoonotic diseases) without explicit link to human health Vector-borne zoonotic diseases with sensitivity to change / variability that doesn't depart from the average (i.e. seasonal distribution)

Pathways of Impact	Adaptation pathways (within IPCC WGII) Not mitigation (within IPCC WGI)		Anthropogenic influences and emissions (i.e. impacts of air quality on health as a result of traffic related air pollution; impacts of ecosystem depletion on health as a result of over-fishing, urbanisation, human encroachment)
	Direct impacts	Unintentional injury/fatality, including frostbite and hypothermia, as a result of unusual weather	
	Indirect impacts (mediated through natural systems)	Food insecurity due to reduced harvest and consumption of wildlife as a result of increasing temperatures and decreased winter severity	Impacts on ecosystems (i.e. coral reef resilience, river composition, forests diversity) without explicit link to human adaptation pathways
	Socio-economic disruption (mediated through human systems)	Changes in social activities, travel, and changes in work or other activities explicitly linked to wellbeing as a result of moderating effects on temperatures	

Data Extraction

Information from each of the included studies was extracted using a data extraction form. Theory and definitions taken from public health surveillance evaluation approaches (6,54,55), quality assessment methods (56,57), as well as community-based participatory monitoring (7–14,17,19) were used to design the data extraction form. The form was piloted and refined before undertaking the final extraction process. Data extracted for each study included general bibliographic information and details of the integrated climate-health MSS: who was involved (expertise, background, experience); where was the MSS (geographic region and scale); what was the aim of the MSS (climate-health focus, causal pathway, measures); and what were the methods used. Consistent with the focus of our

review, we also extracted information pertaining to: the limitations of the existing MSS; the contributions of IKS and LKS to MSS processes; the insight resulting from the inclusion of multiple and diverse sources, scales, and types of information in MSS.

Appraisal of Information Quality

A quality appraisal of included studies was performed. Given the challenges of performing critical appraisal for assessing methodological limitations—for example, the considerable variability of quality appraisal in qualitative research—Munthe-Kaas et al. (2018) recommend using an approach that fits the review question and synthesis methods to assess the methodological strengths and weaknesses of the reviewed studies (58). This was an important consideration as many of the studies included in our review use participatory approaches and mixed methodologies. Therefore, we chose the Mixed Methods Appraisal Tool (MMAT), which has been developed and applied in public health and medical research for the appraisal stage of systematic reviews that include qualitative, quantitative, and mixed methods studies (59). The MMAT is an evidenced-base critical appraisal tool developed from literature reviews, user interviews, and expert consensus (60). We adapted the present version of the MMAT (2018) to include additional questions from the population health evidence cycle; specifically those relating to issues of utility, internal validity, and practical implications (61). The adapted tool is included in the supplementary material (Appendix 1).

Analytic Framework Development

During the analysis, an analytic framework of MSS processes was iteratively developed (Figure 2.1). Firstly, we identified key stages of integrated monitoring and surveillance along with examples of associated activities: initiation (i.e. problem definition); system design (i.e. tool and technique development); implementation (including data collection); analysis (including interpretation); evaluation, dissemination (including feedback of findings); and action (including utility and application of findings). Then, we aggregated this information into three overarching processes of MSS: detection; attribution; and action. Associated attributes of MSS data quality assessment measures and outcomes retrieved from public health surveillance evaluation approaches (6,54,55) and quality assessment methods (56,57) were applied alongside these stages and processes to assist with the coding in further analyses of studies included in the review. This framework helped to extract information about MSS activities reported in studies and characterise the extent to which the literature describes the inclusion of diverse knowledge systems in broader processes of climate-health MSS. Within the

focus of our evidence synthesis, we used inductive qualitative coding and content analysis to identify key contributions and patterns of inclusion. These findings are evidenced below in text with direct quotes and examples from included studies.

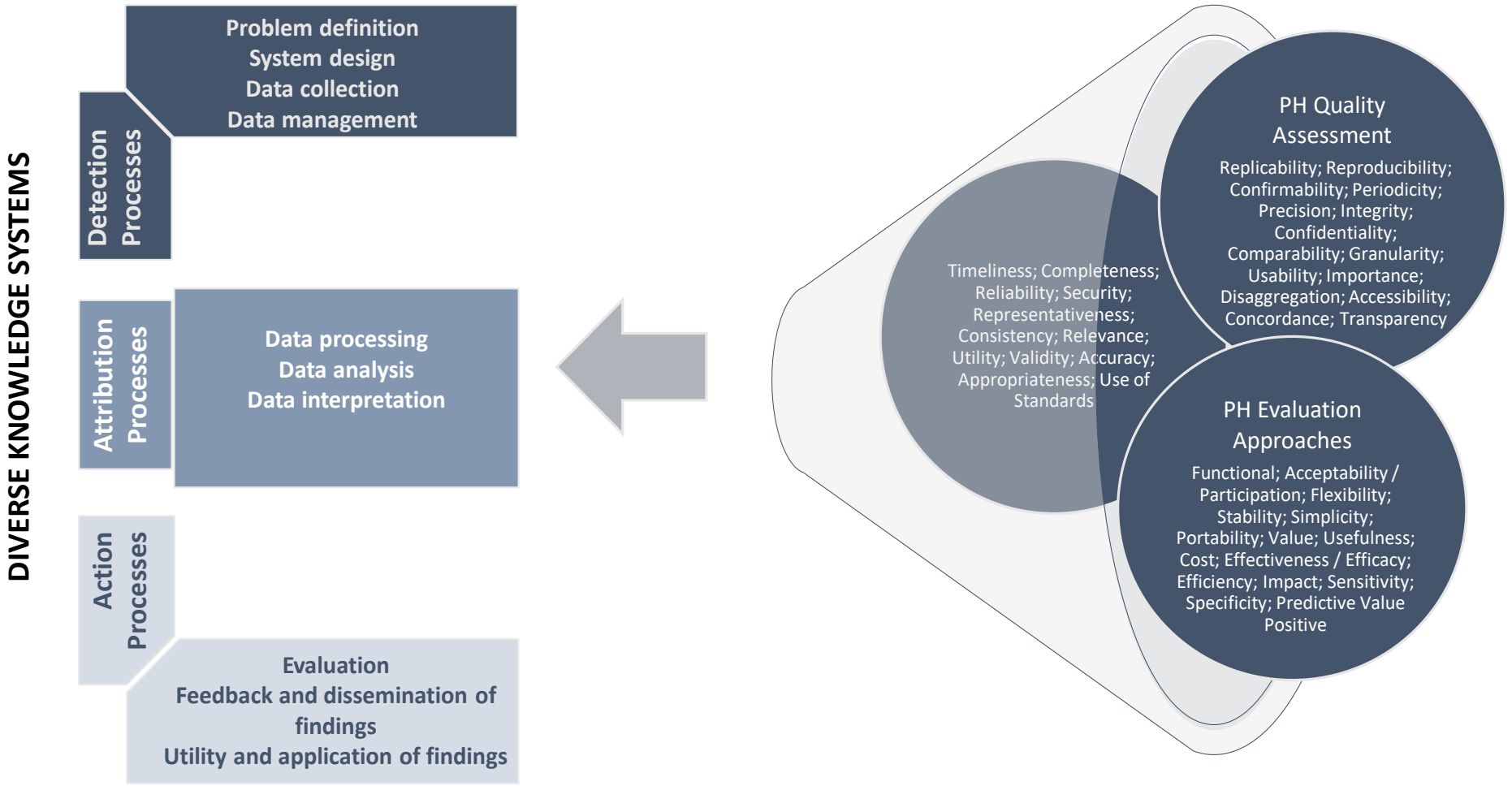

Figure 2.1: Analytic framework developed of integrated monitoring and surveillance system processes.

Confidence of Evidence Assessment and Summary

A Confidence in Evidence from Reviews of Qualitative Research tool developed by The Grading of Recommendations Assessment, Development, and Evaluation (GRADE-CERQual) was applied to a summary of each review finding (58,62–67). We used this approach to assess the extent to which our review findings are a reasonable representation of integrated climate-health MSS. This process is recommended to support the use of findings from qualitative evidence syntheses in decision making processes such as guideline and policy development (62). Refer to the supplementary material for the complete metadata and evidence profiles with explanations contributing to CERQual judgements (Appendix 1). Judgements are made based the underlying confidence in evidence and have been assessed as per the level of concern with methodological limitations, adequacy, relevance, and coherence. Definitions for each component, as well as levels of confidence, can be found in Table 2.4 (62,63). No or very minor concerns are considered those *unlikely* to reduce confidence in a review finding; minor concerns are considered those that *may* reduce the confidence; moderate concerns are considered those that will probably reduce confidence; and serious concerns are considered *very likely* to reduce the confidence in a review finding (62,63).

Table 2.4: Definitions of CERQual components and levels of confidence used to assess review findings.

Component	
Methodological Limitations	The extent to which there are concerns about the design or conduct of the primary studies that contributed evidence to an individual review finding.
Adequacy	An overall determination of the degree of richness and quantity of data supporting a review finding.
Relevance	The extent to which the body of evidence from the primary studies supporting a review finding is applicable to the context (perspective or population, phenomenon of interest, setting) specified in the review question.
Coherence	An assessment of how clear and compelling or supportive the fit is between the data from the primary studies and a review finding that synthesises that data.

Level of Confidence	
High	It is highly likely that the review finding is a reasonable representation of the phenomenon of interest.
Moderate	It is likely that the review finding is a reasonable representation of the phenomenon of interest.
Low	It is possible that the review finding is a reasonable representation of the phenomenon of interest.
Very Low	It is not clear whether the review finding is a reasonable representation of the phenomenon of interest.

Results

Descriptive Findings of Climate-Health Monitoring and Surveillance Systems

19 studies met the selection criteria; with 7 additional studies identified through reference tracing. In total, 24 studies were included for data extraction, appraisal, and analysis (Figure 2.2). Approximately three quarters (75%) of the total documents included from our search were published since 2013, the latter half of our search period, underscoring the recent rise of publications in this field (Figure 2.3). The greatest proportion of studies (n=11) represented MSS in the Arctic, with the remaining distributed between (non-Arctic) North America (n=5), South Asia (n=5), South America (n=2), and Northwest Asia (n=1) (Figure 2.4a).

One third of MSS were motivated by a combined climate-health perspective, while a greater proportion (n=11) were focussed mainly on climate-oriented information (Figure 2.4b). In the reviewed studies, there was representation of MSS information that related to all three of the identified climate-health causal pathways (Figure 2.4c). The majority (n=23) of MSS monitored indirect exposures of climate change impacting on health, as mediated through natural systems and modified by environmental, ecosystem, and social factors (Table 2.3). Many MSS investigated multiple exposure pathways; 14

combined ‘indirect exposure’ and ‘social and economic disruption’, while one looked at all three pathways (‘direct exposure’, ‘indirect exposure’, and ‘social and economic disruption’).

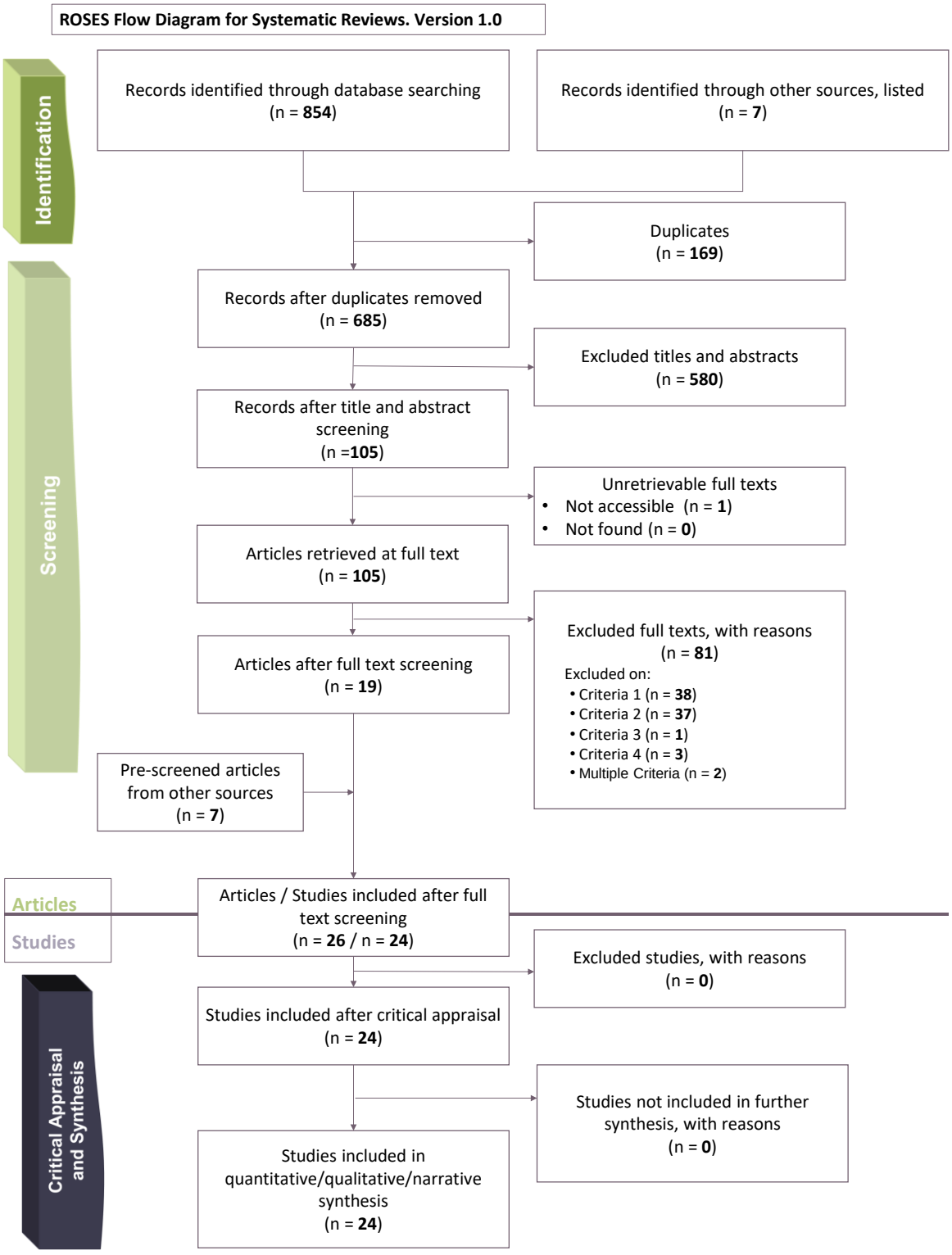

Figure 2.2: Flow diagram of study identification, screening, eligibility, and inclusion. Format follows Haddaway et al. (2018) ROSES flow diagram for systematic reviews, version 1.0 (52).

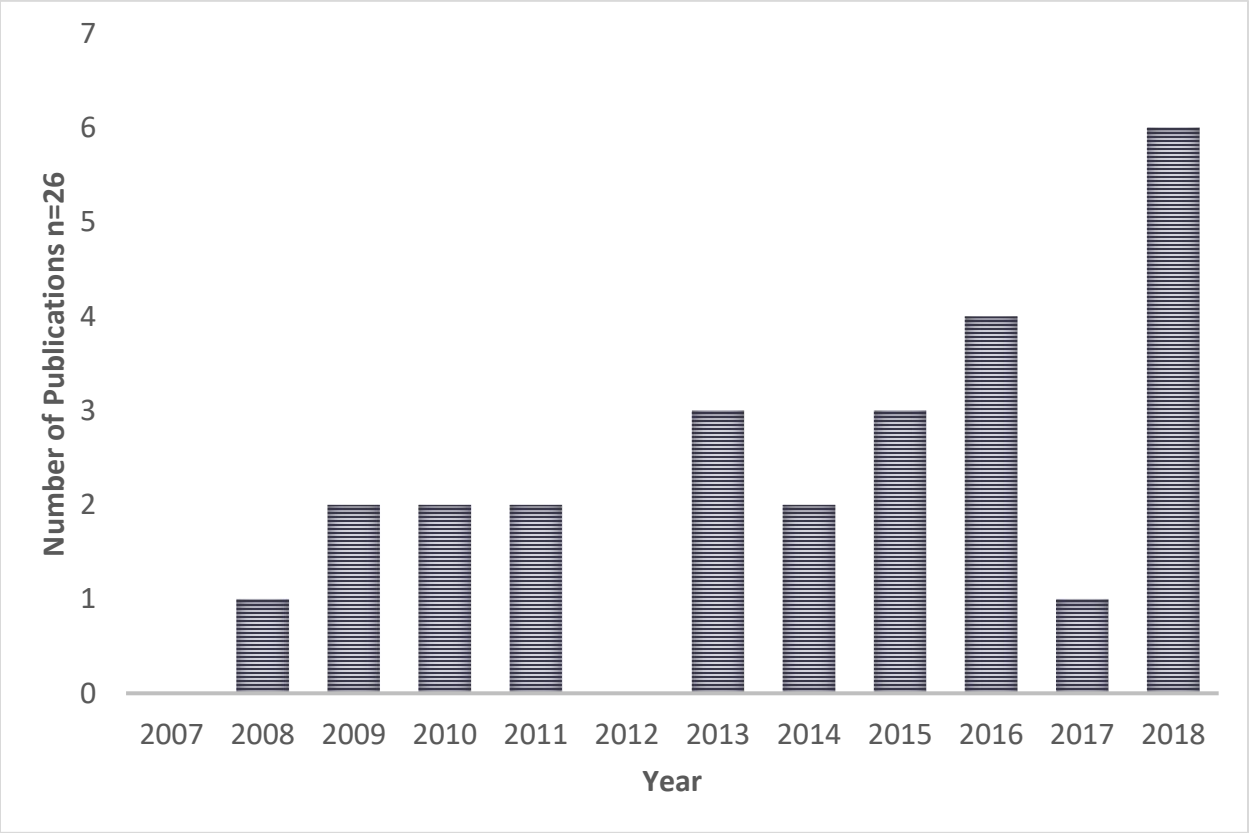

Figure 2.3: Distribution of articles included in the review by year of publication.

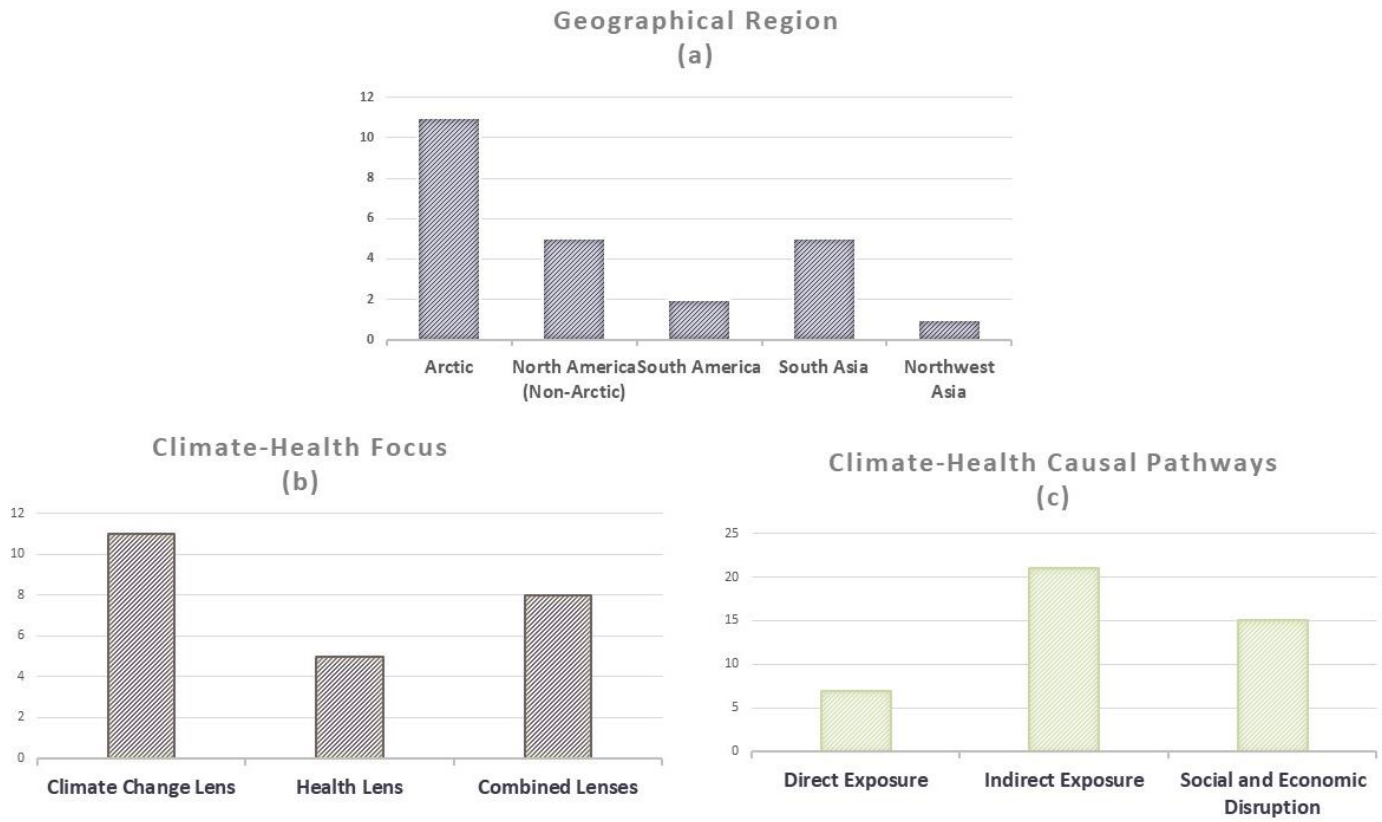

Figure 2.4: Studies presented by geographical region (a); climate-health focus (b); and climate-health causal pathways (c).

A majority of studies (n=23) indicated that inclusion of IKS and LKS occurred in the monitoring and collection of data (Figure 2.5). In four of these studies, monitoring and collection were the only stage where IKS and LKS were involved, while more than a quarter (n= 6/23) indicated the inclusion of IKS and LKS in every recorded stage and activity of MSS. Over two-thirds of studies (n=17) local and Indigenous experts and knowledge systems led or participated in the design of the monitoring project or surveillance system, and of those, 10 included evidence of IKS and LKS included in, or leading, the initiation of a monitoring system, defining the problem, and focusing the initial research. One example is from Iverson et al. (2016), where a large number of newly deceased birds were observed by local Indigenous harvesters (68). This spurred a collaborative investigation with monitoring and collecting tissue samples for laboratory analysis, which eventually confirmed an outbreak of Avian Cholera. Another example from Doyle et al. (2013), discussed how "observations made by Tribal Elders about decreasing annual snowfall and milder winter temperatures over the 20th century initiated an investigation of local climate and hydrologic data by the Tribal College"(69). This same study was the only one to have local Indigenous

principal investigators and lead authors. Another study, Parlee et al. (2014), included local Indigenous co-authors on the publication (70).

Figure 2.5: Inclusion of diverse knowledges across stages and activities of monitoring and surveillance systems. Axis lines reflect the number of studies reporting the inclusion of diverse knowledge systems broken down by previously identified MSS stages and activities: initiation; design; implementation; analysis; dissemination; evaluation; action. Data were also captured for studies that specified tool or technique development, as well as those that referred to data ownership or intellectual property.

We found that over one third of studies (n=9) specified the inclusion of diverse knowledge systems in the development of a monitoring and collection tool or technique; including a fire potential index (71); safe practice guide for land and ice travel (72); and infrastructure assessment tool (73). Driscoll et al. (2016) offer a description of their process, and its value, for co-producing a surveillance tool; "developing first metrics, then an instrument, and finally a primary data collection protocol in collaboration with both content-area experts and residents of rural and isolated villages in Alaska has resulted in a valid and actionable surveillance tool for use in a region of the country with few secondary data-sources" (20).

Only four studies made reference to the ownership of information or intellectual property of IKS and LKS (71,73–75). One study referred to this as a "previously unapproachable avenue for research, in that the communities were aware that all resources stayed in the community, and any potential intellectual property that may arise from [a discovery] remained in the hands of the communities" (74). Mustonen (2015) reflected on the past, present, and ongoing insider-outsider dynamics claiming that "the notion of community ownership of visual histories and materials [data] is on the rise. This means that some aspects of cultural, communal visual histories may be off-limits for those actors, such as researchers, who come from outside a specific community"(75). Hendricks et al. (2018) discuss how an emphasis on local ownership of the data collected (and assets produced) could positively affect morale, enthusiasm, and perhaps even impact the quality of the data (73).

Contributions of Including Diverse and Multiple Knowledge Systems

In most studies, the contributions of diverse and multiple knowledge systems focussed on MSS processes that improve a system's ability to detect and gather information; including defining the problem, designing the system, collecting data, and managing data. Fewer studies demonstrated how IKS and LKS contribute to MSS processes that improve a system's ability to attribute, process, interpret the information gathered. Again, few studies evidenced how IKS and LKS contribute to MSS processes that improve a system's ability to invoke action and response. Table 2.5 presents a summary of the key contributions of diverse knowledge systems to a variety of MSS processes. This evidence is further interpreted by applying our analytic framework, which relates key contributions to MSS processes through corresponding impacts on quality attributes and outcomes (6,54–56).

Table 2.5: Contributions of diverse knowledge systems to integrated monitoring and surveillance system processes.

	Contributions to Monitoring and Surveillance System Processes	Impact on Monitoring and Surveillance System Quality & Outcomes	Examples	References
1. Detection Processes *Defining the problem; Designing the system; Collecting and Managing the data*	1.1 Definition of meaningful problems	Acceptability; Relevance; Utility; Appropriateness	Local observations about decreasing annual snowfall and milder winter temperatures initiated the scientific investigation of climate and hydrologic data	(44)(76)(77)(68)(78)(69)(79)(75)(70)
	1.2 More representative data	Accuracy; Validity; Predictive Value; Sensitivity; Relevance	Experiential knowledges gained through daily environmental interactions and dependence Capturing interactive, complex, and contextual health-environment-climate relationships	(73)(70)(44)(75)(80)(81)(72)(82)(83)(84)(85)(78)(86)(87)(76)(69)(79)
	1.3 More responsive data	Timeliness; Flexibility	Indigenous harvesters identify an outbreak of Avian Cholera in previously unmonitored populations and locations	(68)(44)(85)(76)(75)(80)(71)(73)(72)
	1.4 Reduces selection and source-dependence biases	Credibility; Internal Validity; Confirmability; Reliability	Parallel, regionally distributed local observations of declining snowfall provide multiple data points and are invaluable in the absence of weather stations	(68)(70)(88)(83)(44)(89)(85)(71)(76)(82)(72)

2. Attribution Processes *Processing and Interpreting Data*	2.1 More comprehensive data	Sensitivity; Completeness	Local observations of sea-ice conditions provide measurements of ice thickness with the sensitivity needed to determine if ice is safe to walk or drive on for subsistence activities Conveying finer spatial scale; greater detail than coarser general models and predictions; longer temporal scale; greater range of longitudinal data required for analysis	(83)(79)(72)(86)(85)(68)(70)(88)(90)(80)(82)(69)(44)(71)(73)(81)(76)
	2.2 Reduces scale-dependence bias	Transferability; External Validity; Confirmability; Reliability	The transmission of vector-borne diseases in spatial scales that exceed the limits of the insect vector and/or parasite dispersion	(71)(70)(85)(90)(83)(79)(44)(69)(76)(81)(86)(80)(72)
3. Action Processes *Reporting, Disseminating, and Using the Results* *Evaluating the system*	3.1 Multi-scale policy development	Usefulness; Utility; Efficacy; Impact	Using integrated climate-health monitoring systems to create political and economic pressures and safety concerns	(69)(91)(80)(79)(74)(76)
	3.2 Long-term future planning	Usefulness; Utility; Efficacy; Impact	Using local monitoring and surveillance data to inform local and regional wildlife and resource management	(69)(71)(86)(91)(44)(70)(73)(85)(74)(81)(76)(78)(83)(80)(72)(79)
	3.3 Immediate decision making and prioritisation	Timeliness; Efficiency; Impact; Utility	Locally led efforts made air pollution and environmental health a municipal priority	(68)(86)(91)(84)(76)(85)(44)(81)(74)(73)(78)(80)(72)(79)
	3.4 Effective knowledge-information-action pathways	Acceptability; Efficacy; Impact; Relevance; Utility; Appropriateness	Using local knowledges about soil conditions, water distribution, farming and environmental practices to adapt scientific approaches	(69)(89)(76)(86)(85)(91)(75)(74)(73)(78)(80)(72)(79)

Key Insight 1: Improving the Detection of Climate Change and Health Impacts

Reviewed studies highlighted the potential for IKS and LKS to contribute to the definition of meaningful problems, as well as the collection of more representative and meaningful climate-health data. Local and Indigenous experts in the reviewed studies include subsistence harvesters, pastoralists, farmers, Elders, observers, fire-watchers, urban residents, and rural villagers. Represented here are communities connected by an interactive and relational understanding of their environment, employing holistic mechanisms of change, and perhaps with a perspective and heightened sensitivity to detect broader climatic changes and impacts (44,70,83,84). For example, Shukla et al. (2016) note how community perceptions are developed from "daily interactions with their environment" as well as a "dependence on weather conditions to ensure sustenance"(84). Similarly, another study considered local urban residents and communities to have expert knowledge of the built environments they interact with on a daily basis (73). This included community members' interactive understanding of local socio-political contexts, which may impact the management of physical infrastructure and thus influence the climate vulnerability of certain neighbourhoods. The community-specific, place-based, experiential knowledges of local socio-political contexts, socio-cultural values, and environment-dependent practices were exemplified in several studies (70,72,73).

Other studies indicated the potential for IKS and LKS to contribute to more responsive data collection and timely detection of monitored changes. For example, subsistence-oriented communities are well positioned to function as an early warning system that detects immediate changes in human and wildlife health, such as an outbreak of disease in moose populations or a shift in seasonal migration patterns of caribou (44,68–70). This exemplifies how the interdependence of human and animal populations brings a broader perspective and approach for situating changes in abundance, distribution, migration, and physical conditions of wildlife that have been instrumental for subsistence and survival for thousands of years (70). Another study described the indispensable and timely information generated by the "vigilant eyes" of local community forest managers, or "fire watchers", to help establish an advance warning system for forest fires in the Indian Central Himalaya (71).

Included studies also presented the potential for local observations and alternative forms of monitoring to reduce selection and source biases that result from logistical feasibility and resource restraints. For instance, the active observations of local harvesters were indicated as useful to fill information gaps when other detection methods were not feasible (70). Mustonen (2015) highlight that scientific methods,

which use remote sensing and site-specific expeditions and observations to monitor changes, provide biased information and are unable to account for the many local and Indigenous societies in these territories who continue to dwell in and occupy remote, peripheral sites, and areas outside current scientific monitoring efforts (75). Another study, by Laidler et al. (2011), demonstrates the potential of incorporating detection methods like remote sensing and radar imagery into the suite of existing traditional indicators and local tools to improve how we monitor changes within the complexity of human-animal-environmental systems like subsistence sea-ice monitoring (79). While radar and areal imagery were indicated as important methods used to measure relative sea and river ice thickness and stages of freeze-up, they do not capture locally significant levels of detail about ice conditions, changes in those conditions, and safety indicators; like when ice is thick enough to walk on versus drive on (79,82).

Key Insight 2: Improving the Attribution of Health Impacts to Climate Change

The evidenced studies provide examples of the potential for IKS and LKS to provide more comprehensive data by improving the sensitivity and completeness of existing scientific and instrumental monitoring data. For example, in addition to long-term government-operated bird monitoring stations, Indigenous Inuit Eider harvesters reported outbreaks at three locations on the northern coastline of Québec in Nunavik that researchers were unable to investigate previously as a result of logistical constraints (68). Similarly, another study evidenced how the knowledges of Indigenous and local experts and subsistence harvesters was able to provide valuable information of previously undocumented population mortality events and changes (44). In another example, Dixit et al. (2018) demonstrate how diverse demographic, health, and environmental surveillance datasets can be integrated, or "harmonised", into one geospatial surveillance platform and processed with additional types of information from others sources such as research projects, health facilities, and institutional records (81).

Reviewed studies evidenced the potential for IKS and LKS to contribute more comprehensive data in the absence or limits of scientific monitoring observations. For example, in the absence of weather stations, parallel and regionally distributed observations of declining annual snowfall and warming winter temperatures made by generations of Indigenous Elders provide numerous and invaluable, or otherwise missing, data points to help understand the more recent hydrological impacts of climate change experienced in streamflow and flooding (69). An epidemiological investigation to assess the impacts of climate change on syndromic health outcomes in the circumpolar north highlighted how the information contributed through community-based surveillance systems is "substantially more sensitive than more

traditional passive surveillance systems" and "far more flexible than many active surveillance systems requiring participants to self-disclose their health outcomes and behaviours"(20). Another study explained how a seasonal surveillance response to Zika Virus could collect timely and comprehensive state-wide information on transmitting species of mosquitoes with the participation of multi-level stakeholder groups. Studies highlighted the value of locally acquired information, spatially scaled data, and procedural knowledges to fill some of the existing gaps of scientifically unknown and clinically uncaptured information (20,86,88).

Studies noted the potential of collective, long term, living knowledges to improve scientific monitoring data deficiencies and dearth by contributing to baseline information and datasets upon which we can track change and build future comparisons (70,79). The history and time scale of IKS and LKS epistemology extends over many generations; "strengthening the credence of their claims"(83). Such is the case in Northern Canada, where the understandings, expertise, and theories of Indigenous Elders and subsistence harvester have been developed over generations of observation and validation, and are based on an inter-dependent relationship with caribou and moose populations (70). Despite quantitative projections of climate change induced impacts requiring extended term data analysis, this connected history can provide an essential baseline for tracking changes in Arctic ecosystems and understanding the effects on wildlife and human health, as well as socio-economic impacts (70). The included literature demonstrated the potential of synergizing local and regional scaled contributions to improve the attribution of health impacts to climate change and address existing limitations of data deficiencies (such as incompleteness or incongruence). Fidel et al. (2014) note this contribution in the combination of different spatial scales of data, whereby spatial data from local reports of subsistence activities allowed the holistic exploration of human and animal adaptive responses to environmental changes over time (80).

Studies also emphasised the potential of IKS and LKS to improve how we process and interpret integrated climate-health data by reducing biases associated with the scale dependence of trended and aggregated data analyses. Such contributions include applying statistical analyses to track general trends in local observations of changes to biological resources used for subsistence over time scales (15-20 years, or one generation) as well as across large geographic scales (The Bering Sea) (80). Parlee et al. (2014) evidence how an Indigenous perspective and broader approach has the potential to situate specific health outcomes, like chronic wasting disease, in the context of scaled environmental and climatic change (70). Studies also indicated how diverse systems of knowledge and observation had the potential to inform

general models and scaled predictions (83). For example, rather than analysing environmental and climatic trends using a scientific model that relies on average changes in individual variables, the LKS of pastoralist communities interprets change using a holistic mechanism that accounts for feedback between vegetation and weather; this local model allows them to integrate several variables at once and "to apply cues or rules of thumb in difficult, extraordinary situations and is founded on observations of extremes and variability" (83).

Key Insight 3: Improving Action related to Evidence on Climate Change and Health Impacts

The reviewed studies demonstrated the potential of IKS and LKS to contribute tangible benefits by improving the MSS action process related to reporting, dissemination, evaluation, and use of findings. This included evidence for contributions supporting the immediate decision making and prioritisation of key issues. For example, Limaye et al. (2018) evidence how locally led planning, implementation, and evaluation of air quality monitoring networks made air pollution and environmental health a municipal priority for a city in India (91). Another study demonstrated how monitoring tools and techniques developed with Indigenous Barí and Wayúu communities in Colombia were used to influence decision making by providing "timely information to strategically plan and focus actions and resources" towards addressing climate-health issues, such as the prevention, vigilance, and surveillance of changes in vector-borne diseases (86).

Included studies evidenced the potential of IKS and LKS inclusion in the benefit of long-term future planning. Laidler et al. (2011) discuss how access to the longitudinal and time series data produced by IKS and LKS not only allows us to make analytical comparisons over time, "but also to facilitate hazards assessment, plan travel routes, and support search and rescue operations" for Inuit communities in Nunavut, Canada (79). Another example, taken from Doyle et al. (2013), is where the addition of local data to regional climate projections resulted in more "engaged community discussions" and provided a "basis for community policy development and long range planning" to reduce current and future climate-related health impacts (69). Examples of planning also included management whereby a "greater recognition of traditional systems of monitoring can result in useful empirical data for management" of wildlife and human health in connection to climate change (70). Furthermore exemplified by the application of IKS expertise and knowledge to inform regional co-management plans for muskoxen and caribou herds put forward in the National Species at Risk Act Management Plan Series (44).

Evidenced studies showed the potential of diverse knowledge systems to improve how we report, disseminate, evaluate and use integrated monitoring and surveillance information; both for community policy development as well as multi-scale policy development. Fidel et al. (2014) identify the inclusion of IKS in climate-health research as an "avenue that can bring the voices of the people to the policy-making table" and lead to adaptive strategies for responding to changes affecting the societal-ecological systems of Indigenous Arctic communities (80). Particularly when it comes to monitoring the impact of climate change on health, as in the example of the declining and unpredictable sea ice conditions, "bridging scales and knowledge systems will be essential in developing integrated monitoring systems to respond to increased political and economic pressures as well as safety concerns for travelling on or within ice-covered oceans" (79).

Included studies presented how contributions of diverse and multiple knowledge systems and scales of evidence could lead to effective knowledge-information-action pathways. One study provides evidence for how a community epidemiological health assessment, driven by local observations of extreme weather, access to land, water, food, and risk of injury, was able to "deliver direct utility" and "develop appropriate responses" with the support of the public health sector in Alaska (76). A local scaled understanding of how priority health issues relate to the type, timing, and rate of wider environmental changes, such as the premature thawing of underground food cellars spoiling food and leading to increased food insecurity, can be used to help prevent negative health outcomes (76). Contributions of IKS and LKS engagement were considered vital to both the success and stimulus of implementing integrated MSS (85,89). Even more, there was evidence to support the contributions of local capacity and innovative approaches to act and address the "new normal" and the impacts of climate change on health; as they themselves experience it (75,89). Other studies evidence how the local application, local adaptation, and even local appropriation, of monitoring and surveillance approaches presents the "greatest chance" of disseminating knowledge, stimulating action, and reducing climate-health impacts (68,89).

Confidence in the Evidence Supporting Key Insights 1, 2, 3

The assessment of evidence presented in the review studies enabled us to determine the extent to which our review findings are a reasonable representation of integrated climate-health MSS. Overall, there were moderate concerns in the evidence base contributing to each of our three keys insights regarding methodological limitations. There were minor concerns regarding the adequacy, and very minor to no

concerns regarding the relevance and coherence, of evidence to support the findings that the inclusion of IKS and LKS contributes to MSS detection processes (key insight 1). Otherwise, the evidence base supporting findings that IKS and LKS contribute to MSS attribution and action processes (key insights 2 and 3) had very minor, or no concerns regarding components of adequacy, relevance, and coherence. The summary of confidence judgements in evidence supporting these key review insights are presented in Table 2.6. Complete metadata and evidence profiles with explanations contributing to these judgements are included in the supplementary material (Appendix 1).

Table 2.6: Summary of confidence in evidence supporting key insights.

Aim: To synthesise qualitative and quantitative evidence on the inclusion and contributions of diverse knowledge systems to integrated climate-health monitoring and surveillance systems.

Perspective: Empirical evidence of inclusion and contributions of diverse knowledge systems to integrated climate-health monitoring and surveillance systems worldwide.

Summary of review findings	Studies contributing to the review finding	CERQual assessment of confidence in the evidence	Explanation of CERQual Assessment
1. The inclusion of diverse knowledge systems can improve the detection of climate change and health impacts through: the definition of meaningful problems (finding 1.1); the collection of more representative data (finding 1.2); the collection of more responsive data (finding 1.3); and the reduction of selection and source biases (finding 1.4).	(87)(78)(82)(76) (81)(69)(85)(55) (73)(68)(79) (77) (83)(75)(70)(88) (89)(86)(71)(84) (44)(72)	Moderate confidence	Moderate concerns regarding methodological limitations, minor concerns regarding adequacy.
2. The inclusion of diverse knowledge systems can improve the attribution of health impacts to climate change through: the processing and interpretation of more comprehensive datasets (finding 2.1); and the reduction of scale dependent biases (finding 2.2).	(82)(76)(81)(69) (55)(73)(68)(90) (79)(83)(70)(88) (86)(71)(44)(72) (85)	Moderate confidence	Moderate concerns regarding methodological limitations.

3. The inclusion of diverse knowledge systems can improve the action taken based on climate-health evidence through: multi-scale policy development (findings 31.); long-term future planning (finding 3.2); immediate decision making and prioritisation (finding 3.3.); and effective knowledge-information-action pathways (finding 3.4).	(78)(76)(81)(69) (85)(55)(73)(68) (90)(79)(91)(83) (75)(70)(89)(86) (71)(84)(44)(72)	High confidence	Moderate concerns regarding methodological limitations.

Key Insight 4: Improving Monitoring and Surveillance Systems with the Divergence and Discordance of Evidence

There are many potential challenges that may arise from trying to synergise the contributions of diverse knowledge systems in MSS processes. In the reviewed studies, we noted instances when authors described divergence or discordance between the methodologies and evidence of different knowledge systems.

Some studies explored the potential reasons for these discordances. For example, Marin (2010) demonstrates that local observational methods of abundant rainfall are measured by the duration of rain (83). This differs from scientific meteorological methods that measure abundance by the amount of rainfall. Since the latter does not always account for locally significant levels of change, it was recommended that recording "a combination of rain's duration, 'hardness' and its impact on soil and vegetation might allow them to distinguish between significant and insignificant rains." Several studies highlight a similar discordance between different measures of ice thickness and freeze-up. Scientific methods (such as radar and areal imagery) give measures of *relative* ice thickness and record ice break-up and freeze-up as single-day events. Alternatively, local and Indigenous methods (such as Inuit sea-ice evaluations, in-situ observation, cumulative seasonal recordings, and navigation techniques) measure change in ice conditions as series of processes with safety indicators necessary for those who rely on this information for their livelihoods (75,79,82). It is useful to note how the applications of different methodologies can result in divergent measures the 'same' phenomenon; further still divergent interpretations of 'significant' change in that phenomenon.

Much the same, different applications of the same methodology can also result in a discordance of evidence. Hendricks et al. (2018) highlight this discordance between the margin of error being greater for persons "lacking extensive professional training" and collecting data using scientific technology such as

laser and radar (73). Reed et al. (2018) suggest similar reasons for discordant findings, which may be due to variations between how local participants and agencies collected their information, "*our* methodology required the participation of many different contributors… [However] most participants had limited or no prior experience with [this survey method]" (88). The discordance between local observations and meteorological data using trend analysis can be exemplified for estimating changes in winter temperatures; explaining that differences in evidence could be due to confounding a decrease in daily or nightly minimum temperatures with the simultaneous increase in daily maximum temperatures (87).

Reviewed studies also highlighted potential divergences between diverse knowledge system contributions of resolution and scale. For example, the difficulty of drawing generalisations from data and attribution-related processes. Fidel et al. (2014) exemplify the challenges of aggregating Indigenous walrus harvester observations and location data from a participatory mapping exercise into a more general trend analysis: "while these [participatory mapping] techniques are extremely valuable to provide insights into adaptive actions [like 'hotspot' analysis] and may provide the basis for scientific discovery and discussion, they cannot create aggregate statistics of general trends" (80). While extrapolating aggregated data to establish trends remains a challenge, as mentioned previously, there is a unique expanse in geographic and temporal scale that IKS and LKS can contribute (44), which should not be discounted. Instead, we note the limitations of taking a singular scaled analytical approach, like geospatial or epidemiological, to account for the complexities of local climate-health interactions; consider, for instance, how changes in local land cover can influence micro-climate conditions in temperature, evapotranspiration, and run-off (76).

Few studies described whether/how these discordances were reconciled. Often, the tendency was to try and 'resolve' or 'explain' the divergence from one methodological perspective (i.e. Western scientific) by using more methodologies (i.e. employing statistical methods and trend analyses) (72,76,80). Other studies explained discordances in terms of constraints on the availability of certain resources, be they scientific or local, with inevitable compromise on how to allocate and use certain resources such as time, funding, training, and expertise. This was particularly relevant since all of studies included in the review were set in limited or constrained resource contexts, with many identified as remote. Tomaselli et al. (2018) give examples of these contextual challenges associated with monitoring and surveillance of animal and human population health in the Canadian Arctic (44). Limaye et al. (2018) suggest that, while challenging, the coordination of monitoring and surveillance stakeholders to clarify roles and avoid

duplication or discordance can relieve this constraint and even reduce administrative and financial burdens (91).

Limitations and Biases

Here, we would like to discuss the limitations and biases in this review, evidence synthesis, and confidence assessment. Firstly, the literature evidenced in this review was only selected from published sources. This resulted in a publication bias with an emphasis on retrieving significant and/or positive results and may have affected the findings and key insights presented (51). We attempted to mitigate this bias by searching across multiple databases and using different search methods, like reference tracing, to search for reports of studies that may not have been indexed in the electronic databases searched. Furthermore, the focussed selection strategy and narrow eligibility criteria will have increased the likelihood of reporting bias in the evidenced data contributing to our findings and insights; again, towards significant and positive results (51). We attempted to mitigate this bias by highlighting these methodological issues in both the quality appraisal and confidence assessment processes. Given the focus of our review, we considered that many communities initiating and undertaking integrated climate-health monitoring and surveillance would not have access, opportunity, or always interest to publish empirical results. While these initiatives would not necessarily contradict the review findings, the non-identification of studies would certainly affect the contributing evidence base that we have synthesised our findings from.

More than just the quality of evidence, there are several factors that can influence the judgement of confidence in evidence(92). One limitation that is not accounted for in the CERQual confidence assessment is dissemination bias; when included studies are systematically unrepresentative of the complete body of research (65). This can occur when dissenting evidence or findings from studies are systematically made less accessible or available, and is a relevant consideration for qualitative or participatory research findings, which are often only partially or selectively disseminated, or sometimes not at all. Where possible, we have made considerations of these factors that may influence the confidence in our review findings. Furthermore, while the iterative process of evidence assessment enabled a critical interrogation of our findings, there remains an element of subjectivity in the overall confidence judgements. Similar challenges exist for the uncertainty assessment process in the IPCC, in which the calibrated language used to characterise and communicate levels of confidence, or degrees of certainty, in findings has been criticised for being overly subjective and ambiguous (93,94). To facilitate

transparency in our own confidence assessment, the complete metadata and evidence profiles along with explanations contributing to our assessment process have been included in the supplementary material (Appendix 1).

Discussion

From the review, synthesis, and confidence assessment of integrated climate-health monitoring and surveillance literature, we found that the inclusion of diverse knowledge systems contributes to these systems through the collection of more representative data; the reduction of selection and source biases; the processing and interpretation of more comprehensive datasets; as well as immediate decision making and prioritisation of key issues. Furthermore, the inclusion of diverse knowledge systems contributes to integrated climate-health MSS through the definition of meaningful problems; the collection of more responsive data; the reduction of scale dependent biases; the development of multi-scale policy; long-term future planning; as well as creating effective knowledge-information-action pathways. Lastly, the inclusion of diverse knowledge systems contributes to integrated climate-health MSS through the divergence and discordance of methodologies and evidence.

Equity of Methodologies and Evidences

There is a tendency in our own knowledge systems to prioritise or suppress preferential types of evidence. As was the case for many studies in this review (44,68,72,73,76,84,87), integrated MSS that cherry-pick components of IKS and LKS only when they are convenient to “integrate” and able to be corroborated by “accepted” or “standard” scientific methodologies and evidence (as per quality and outcome measures) go on to reproduce a fallacy of incomplete evidence. In doing this, scholars have argued that we run the risk of losing the original meaning created by and within the structures of these knowledge systems (28–30,33,95). By continuing to reference and explain local and Indigenous processes using the same methodologies and concepts taken from Western science, not only do we lose meaning, but we also delegitimise other ways of knowing, and even jeopardizing the opportunities of being able to work together; researchers, scientists, local and Indigenous communities (30). Battiste (2005; pp.2) clarifies that Indigenous knowledge, for example, is "far more than a binary opposite of Western knowledge"; rather it can be used to benchmark limitations of these methodologies and evidence and fill ethical and knowledge gaps present in one singular approach to understanding (34). Agrawal (1995) suggests that 'productive' engagement of diverse knowledge systems requires us to go beyond the dichotomy of pinning one against another and work towards greater autonomy of each knowledge

producing system (i.e. recognizing the intimate links between knowledges and power)(95). Recognizing that each system brings with it a set of methodologies and produces evidence that in turn have their own biases is also fundamental (44).

Returning to how the inclusion of diverse knowledge systems contributes to integrated climate-health MSS, we choose to focus on the divergence and discordance of methodologies and evidence. Marin (2010) describes the "subjective, contextual nature" in which climatic changes and impacts are, and need to be, interpreted; including a different perspective than the standard estimations of meteorological measures (83). Different knowledge systems have different scales of interpretation, time, and space, and applying one to another threatens our ability to create meaningful MSS. Mustonen (2015) describes the challenge to scientist looking for general data and running the risk of ignoring evidence that is considered relevant and significant by different methodologies and perspectives (75). Perhaps, this divergence and discordances could be more insightful than when both knowledge systems agree or corroborate each other.

Patterns for Just Processes

Alongside these insights of what we stand to gain from the inclusion of diverse knowledge systems, let us critically entertain the possibility of what we stand to lose if these processes of inclusion are not equitable. Our findings indicate that the inclusion of diverse knowledge systems contribute to integrated climate-health MSS across multiple processes. Our analyses indicate areas, or practice gaps, where the inclusions and contributions of diverse knowledge systems to integrated climate-health MSS processes could be developed (Figure 2.5 and Table 2.5). For example, more attention needs to be placed on having local and Indigenous experts initiating and defining these MSS from the beginning; including problem definition and tool development. This is consistent with the literature emphasizing early involvement with initiation and development stage in community-based or led-climate and health monitoring research (15,22). Natcher (2007; pp. 114) argues that “a more equitable role for community members in the research process" is created during critical stages of initiation and design; in particular when developing research methodologies (29). A recent systematic review of Indigenous community participation and decision-making in climate-related studies found that community participation in all stages of research varied depending on who initiated the project; where research initiated with (in mutual agreement between outside researchers and Indigenous communities) or by Indigenous communities had higher levels of engagement and inclusion throughout the entire research process (35).

From Inclusion to Ownership

We cannot disregard the ethical implications that arise from engaging diverse knowledge systems; and that cut across all three MSS processes. Particularly in an Indigenous context, where an explicit emphasis on self-determination and relational accountability to human, and more-than-human, communities exists, we are reminded that ethical practice is more than just the extent of engagement, but also the consistency and quality of that engagement (35). Our findings indicate an ethical practice gap in the recognition and actualisation of Indigenous and local autonomy, intellectual property rights, and data sovereignty in integrated MSS (Figure 2.5). This concerns recognizing the right that Indigenous and local peoples possess to govern how their knowledges are generated, organised, stored, and shared; as well as to maintain, control, protect, and develop their intellectual property over these knowledges (28,33,95–97). There is intrinsic value that knowledge systems create for their own knowledge holders; far outside of the added-value to scientific research approaches, aims, and activities (33). Unfortunately, a majority of climate-related studies that access IKS and LKS still employ an extractive model of practice when engaging with Indigenous and local communities (35). This is where outside researchers use knowledge systems with knowledge holders and communities having minimal participation or decision-making authority. Despite IKS and LKS being recognised for their importance in climate-health monitoring and response and climate-related research, experts in these fields note that many studies still lack participatory design and substantial evidence to demonstrate community engagement and participatory processes in practice (22,35,46). Whether it be for the purposes of integrating climate-health MSS or otherwise, researchers and scientists need to recognise and uphold the different bodies that protect the knowledge, intellect, and well-being of Indigenous and local communities; just as we respect, and expect others to as well, our own ethical bodies.

Conclusion

The value of our findings and this review demonstrate how neither scientific, Indigenous, nor local knowledge systems alone will be able to contribute the breadth and depth of information necessary to detect, attribute, and inform action along pathways of climate-health impact. If we are to advance our understanding of how and to what extent climate change is affecting health, then the inclusion of diverse knowledge systems is paramount. Bates (2007) demonstrates that by exploring "contrasting views" and an "apparent impasse" of Indigenous and Western scientific knowledges we begin to focus on practical realities of limitations and actionable solutions (30). One way is “to see from one eye with the strengths

of Indigenous ways of knowing, and to see from the other eye with the strengths of Western ways of knowing, and to use both of these eyes together" (98)(pp. 335). This is referred to as 'Two-Eyed Seeing' and is being employed by many Indigenous scholars as a practical way of framing and navigating this integration of diverse knowledge systems; giving equity to evidences and methodologies (99).

As argued by Danielsen et al. (2008), for example, the contributions of multiple and diverse knowledge systems must be substantive and meaningful in order to add value to decision-making (100). This includes recognition that different knowledge systems reflect more than useful data or placeholders to corroborate or substitute favoured sources; the extent to which diverse sources and types of knowledges are integrated and favoured, or excluded, has important implications for prioritisation of diverse perspectives, value judgements, and ultimately outcomes. Often, the contributions of diverse knowledge systems depends on the acceptance of them by the relevant scientific, policy, and practice communities (101); as much as the acceptance of science by Indigenous and local knowledge holders. While there is evidence emerging from studies in this review (69,75,79,82) and others in this field (35) to consider the intrinsic value and contributions of different knowledge systems as standalone contributors with value given by and for communities themselves (33).

As Marin (2010) and Danielsen et al. (2010) reiterate, the inclusion of diverse knowledge systems is not an isolated exercise of validating one system against the other to the benefit of removed stakeholders and outsiders. We argue that for improving integrated climate-health MSS the ethics for involving IKS and LKS is no different, and stems from ensuring the equity of diverse forms of evidence and methodologies, as well as a just process of inclusion throughout. *What* knowledges are considered legitimate and *how* knowledges are integrated reflect fundamental yet under-examined aspects of MSS detection, attribution, and action processes. Given the recognised value of local and Indigenous communities and knowledge systems for understanding and addressing the impacts of climate on health (22,28–32). The values and contributions of diverse knowledge systems is of particular significance as we consider the needs and challenges of integrating climate-health information and producing new knowledge and understanding. Should we begin to address these needs and challenges together, the gains in the quality and ethics of our information and systems is certain. Just as the gaps in knowledge that we trade off, should we continue to develop our information and understanding separately.

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Chapter 3—Integrating climate in Ugandan health and subsistence food systems: Where diverse knowledges meet

This chapter answers the guiding question set out in Chapter 1: what does procedural justice mean for initiating adaptation responses in practice? This work considers the disproportionate impacts, exposures, and vulnerabilities of climate change, the present and future risks to health and food systems, as well as the complex diversity and connectivity of existing knowledge networks and systems. The aim of this chapter is to contextualise a process for initiating an integrated climate-food-health response working within existing networks of diverse knowledges. It presents an empirical case study from southwestern Uganda using place-based key informant interviews and participatory knowledge holder mapping. This case study grew out of ongoing, and longstanding, climate change adaptation research partnerships with local communities and Indigenous peoples in the area. The findings presented here have significant implications for realising procedural justice when initiating complex place-based adaptation responses across health and food systems. This chapter challenges the application of conventional approaches to adaptation responses in contexts with a rich diversity of knowledges and existing forms of monitoring and response—as well as differentiated vulnerabilities, exposures, and adaptation capacities.

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Bianca van Bavel[1], Lea Berrang Ford[1,2,3], Rebecca King[2], Shuaib Lwasa[3,4,5], Didacus Namanya[3,6], Sabastian Twesigomwe[7], Helen Elsey[8], and Sherilee L. Harper[3,9]

1. Priestley International Centre for Climate, University of Leeds, Leeds, West Yorkshire, UK
2. Nuffield Centre for International Health & Development, University of Leeds, Leeds, West Yorkshire, UK
3. Indigenous Health Adaptation to Climate Change Research Team
4. Department of Geography, Geo-Informatics & Climate Sciences, Makerere University, Kampala, Uganda
5. The Global Center on Adaptation, Rotterdam, The Netherlands
6. Ministry of Health, Kampala, Uganda
7. Buhoma Community, Kanungu District, Uganda
8. Department of Health Sciences, University of York, York, North Yorkshire, UK
9. School of Public Health, University of Alberta, Edmonton, Alberta, Canada

Abstract

The effects of food insecurity linked to climate change will be exacerbated in subsistence communities that are dependent upon food systems for their livelihoods and sustenance. Place-and community-based forms of surveillance are important for growing an equitable evidence base that integrates climate, food, and health information as well as informs our understanding of how climate change impacts health through local and Indigenous subsistence food systems. We present a case-study from southwestern Uganda with Batwa and Bakiga subsistence communities in Kanungu District. We conducted 22 key informant interviews to map what forms of monitoring and knowledge exist about health and subsistence food systems as they relate to seasonal variability. A participatory mapping exercise accompanied key informant interviews to identify who holds knowledge about health and subsistence food systems. Social network theory and analysis methods were used to explore how information flows between knowledge holders as well as the power and agency that is involved in knowledge production and exchange processes. This research maps existing networks of trusted relationships that are already used for integrating diverse knowledges, information, and administrative action. Narratives reveal inventories of ongoing and repeated cycles of observations, interpretations, evaluations, and adjustments that make up existing health and subsistence food monitoring and response. These networks of local health and subsistence food systems were not supported by distinct systems of climate and meteorological information. Our findings demonstrate how integrating surveillance systems is not just about *what* types of information we monitor, but also *who* and *how* knowledges are connected through existing networks of monitoring and response. Applying conventional approaches to surveillance, without deliberate consideration of the broader contextual and relational processes, can lead to the re-marginalisation of peoples and the reproduction of inequalities in power between groups of people. We anticipate that our findings can be used to inform the initiation of a place-based integrated climate-food-health surveillance system in Kanungu District as well as other local contexts with a rich diversity of knowledges and existing forms of monitoring and response.

Keywords: public health surveillance, subsistence food systems, climate change, seasonal variability, knowledges, participatory knowledge holder mapping, place-based monitoring and response, networks, Uganda

Background

Climate change impacts human, animal, and environmental health globally (1–5). Extreme climate and weather events are projected to reduce food production, availability, access, and utilisation (6–8). As well as impacting the quantity and quality of food, climate change is expected to alter the nutritional composition of food (6). Undernutrition associated with drought and flooding may be one of the most important consequences of climate change with extreme estimates suggesting that up to half the world's population could face severe food shortages by the end of the century (9). The effects of food insecurity linked to climate change will be exacerbated in areas already vulnerable to risk of hunger and undernourishment (2,7,8). Subsistence communities that are dependent on food systems for their livelihoods and sustenance are expected to experience increased vulnerability (8,10–15).

Climate change impacts on health, caused by changes in local and Indigenous subsistence food systems and food security, are substantial and may exceed other climate-related health impacts (16). However, the impacts of climate change on health include present known risks, as well as future known and unknown risks, and the data we have are limited (9,17). Improving evidence based surveillance methods that capture information about the impacts, exposures, and vulnerabilities of climate change to health will be critical for communities and institutions in adapting a response to climate change (1,18,19). Globally, integrated climate and health surveillance systems are essential for monitoring present and future health effects, as well as guiding public health responses (1,18). Understanding the attributable impact of climate change on specific health outcomes, such as undernutrition, and reducing associated risks of exposure and vulnerability, like food security, requires an approach that prioritises surveillance across multiple spatial and temporal scales (17). Leveraging existing surveillance systems, that both monitor and use information about the health impacts, exposures, and vulnerabilities to climate change, will be critical in building an integrated evidence-base of both known and unknown, present and future, risks (20,21). The use of information that monitors the impact of interventions or policies to mitigate these risks will also be vital.

Existing surveillance systems and conventional epidemiological approaches, however, do not always consider broader contextual, cultural, historical, social and political processes of health inequities, and thus have the tendency to further discriminate against and omit marginalised groups of people (22–26). Place- and community-based forms of monitoring and response are important in underpinning the development of both an integrated as well as equitable evidence base that will inform our

understanding of climate-health impacts (27–32). Meaningful engagement of local communities, Indigenous peoples, and experts in this surveillance process not only helps build an evidence base that is equitably diverse and locally meaningful, but also informs the usability of information and connects knowledges[2] into decision-making and action-oriented processes (32–38). Yet place- and community-based forms of surveillance are not uniform, and involve communities and experts in different ways, to different extents, and at different stages (39). The degree of inclusion and leadership plays an important role in determining the extent to which surveillance systems will be locally relevant, contextually-appropriate, sustainable over time, and able to create impact within communities (38,40,41).

A surveillance system includes various stages of monitoring and response: initiation, design, implementation, analysis, dissemination, action, and evaluation. Each stage holds an opportunity for community engagement. A systematic literature review of place-based integrated climate-health surveillance systems globally identified practice gaps in the inclusion of local communities, Indigenous peoples, and diverse knowledges for each of these surveillance stages (32). The potential for greater engagement and leadership in problem definition, tool and indicator development, as well as data ownership and sovereignty in place-based integrated surveillance systems was also highlighted. This paper will focus on improving the practice gap in the initiation stage of surveillance, specifically how local communities, Indigenous peoples, and diverse knowledge holders can, and do, contribute to and/or lead the definition of meaningful problems, in their own terms. The extent of inclusion and leadership in the initiation stage can inform the subsequent stages of surveillance design and implementation. Particularly when place-based and Indigenous communities are partners from the inception, we see how decision-making and procedural processes can be influenced in a way that reflects more than just scientific practices and ways of knowing (42). Connecting diverse knowledges—technical public health, tacit local, and Indigenous—through participatory approaches in surveillance systems is both an entry point as well as a requirement for the just integration of place-based climate-food-health surveillance responses. In the valuing of diverse worldviews there is

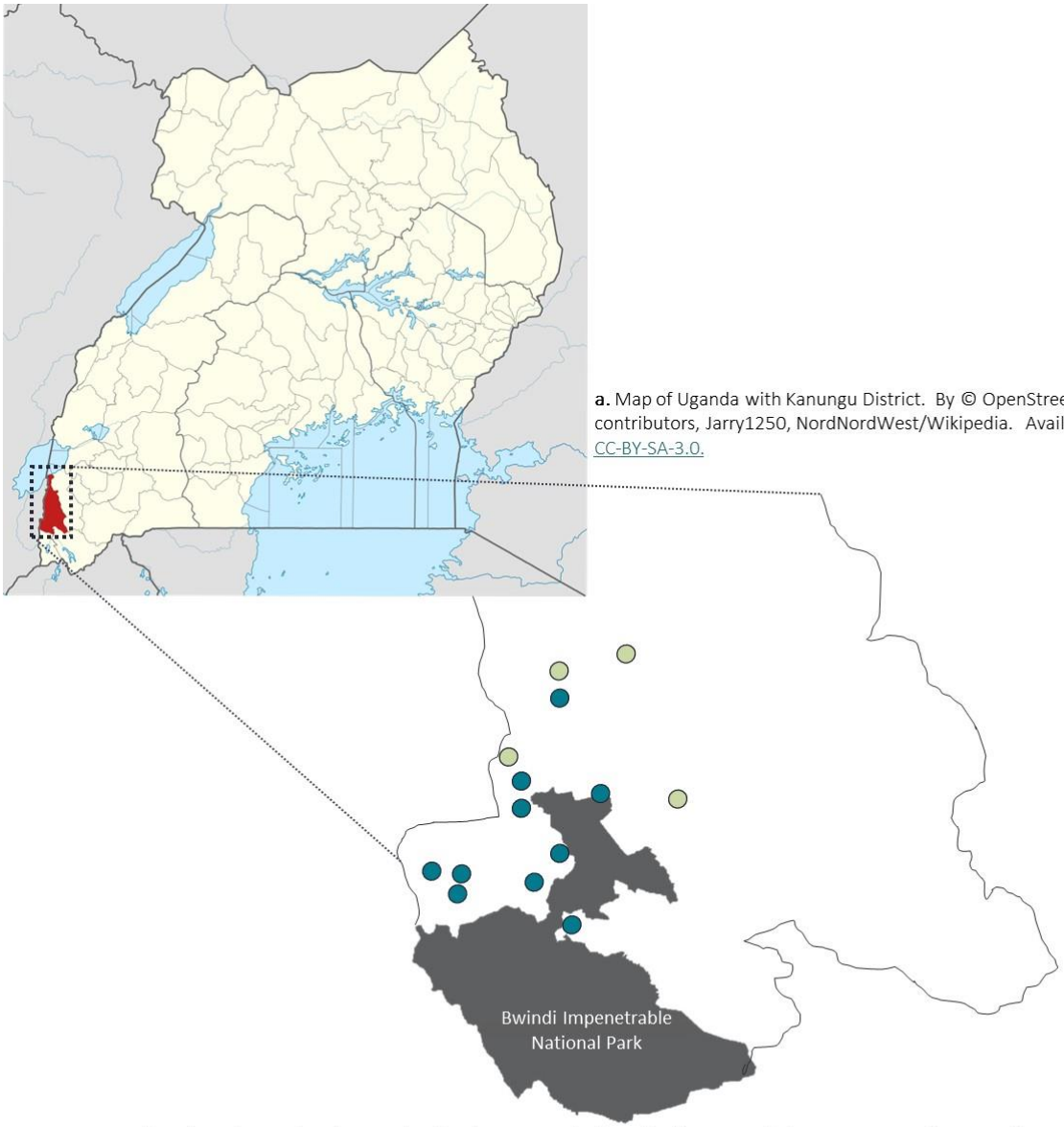
[1] Knowledge, as a noun, is pluralised throughout the paper to reflect the diversity of knowledge forms and dimensions embedded in unique systems, networks, and individual holders' experiences (42,103). Knowledge systems are not always mutually exclusive neither are they distinguishable nor categorisable by consensus (104). We acknowledge that there is far more diversity and variety than could ever be captured in the networks of knowledge, monitoring, and response presented here.

opportunity for new epidemiologies and equitable forms of surveillance that can respond to the impacts of climate change on health via food systems (23).

Methods

Study Context

The Batwa are Indigenous people of the Congo Basin (Uganda, Democratic Republic of the Congo, Rwanda, Burundi) and the oldest recorded inhabitants of the Great Lakes Region in Central Africa (43). In 1991, the Batwa were evicted from their ancestral land, the Bwindi Impenetrable Forest, in denunciation of their rights as Indigenous peoples (44). The Bakiga people of southwestern Uganda (and northern Rwanda) are the fourth largest ethnic group in Uganda, comprising approximately 7% of the population. Situating our research in Kanungu's cultural and historical context is vital because it helps us recognise how underlying issues of land dispossession, acculturation of Indigenous ways of knowing, and ethnic discrimination may create differences in power, knowledge, and information within communities, and affect how we conduct place-and community-based research.



a. Map of Uganda with Kanungu District. By © OpenStreetMap contributors, Jarry1250, NordNordWest/Wikipedia. Available under CC-BY-SA-3.0.

b. Enlarged map of study area showing the case study sites of Indigenous subsistence communities as well as local health and administrative facilities in relation to the shaded area of Bwindi Impenetrable National Park.

Figure 3.1 a. Map of Uganda with Kanungu District. By © OpenStreetMap contributors, Jarry1250, NordNordWest/Wikipedia. Available under CC-BY-SA-3.0. b. Enlarged map of study area showing the case study sites of Indigenous subsistence communities as well as local health and administrative facilities in relation to the shaded area of Bwindi Impenetrable National Park.

Kanungu is a district located in the southwestern region of Uganda, sharing its western border with the Democratic Republic of the Congo (Figure 3.1). Population estimates for the district were 274,900 people in 2020 (45). Kanungu District has 35 Level 2 health centres (HCII—serve as the interface between the community and healthcare system, consisting of outpatient clinic facilities, with in-charge

nurse), 15 Level 3 health centres (HCIII—comprise basic curative and preventive services, 24 hour maternity, accident and emergency services, inpatient facilities including minor surgery, with in-charge clinical officer), and 2 general hospitals with the nearest regional referral hospital in Mbarara (146 km) (46–48). The Ugandan health system is a combination of private and government financed facilities and services. Our study catchment is served by both a private health centre as well as government financed facilities, including those receiving support from NGOs and development partners. Indigenous medicinal knowledge and traditional medicinal knowledge also provide a network of care for communities in this area (49). Our case study is focused in four sub-counties and 10 settlements surrounding the Bwindi Impenetrable National Park. Research sites were selected based on their projected vulnerability to climate-food-health impacts (15,50), as well as ongoing climate change and food security research partnerships with local communities and Indigenous peoples (51). Many communities living in this region rely on the small-scale farming of agriculture and livestock for their subsistence; both for sustenance and income generation. This dependence means their livelihoods and health are vulnerable to changes in weather and climate.

Regional climate projections for Africa indicate an increase in average annual temperatures that is likely to exceed 2°C by the end of this century (52). Over this period, the range of warming in East Africa is likely to be anywhere from 1.7-5.4°C (53). Models of rainfall projections for Uganda indicate an increase in average rainfall, with changes in rainfall varying dramatically by region and season (March, April, May and September, October, November) (54,55). Across the continent changes in extreme weather (both wet and dry) may become more severe (56). These climate projections are regionally scaled, however, with a lack of localised meteorological information and services (the nearest operational weather station is 47 km away in Kabale) making the ability to provide locally relevant and accurate weather and climate predictions poor. The most likely projections for Kanungu District include: greater extremes in weather with more variability in seasonal trends; wetter rainy seasons that will be more prone to flooding; hotter and drier dry seasons that will be more prone to droughts. Furthermore, the security, productivity, and yield of local rain-fed food systems are particularly vulnerable to the mean and variability of temperature and precipitation described (6,54,55,57).

Framework: Applying a Case Study Approach to the Initiation of a Place-Based Integrated Climate-Food-Health Surveillance System

This research draws on ongoing climate-food-health collaborations with Batwa and Bakiga subsistence communities in Kanungu District of southwestern Uganda and responds to the practice gap of ethical community engagement and leadership in place-based integrated surveillance initiation. To do this we used an applied case study approach (58–64). We developed a framework with four components to inform the research process and contribute to improving place-based integrated surveillance initiation (Figure 3.2). Specific questions emerged and were used to guide our investigation of health and subsistence food systems: what forms of monitoring and knowledge exist; who holds knowledge; how does information flow; and why might information flow this way? We anticipated that by starting from the beginning—learning the context in which a place-based surveillance system is initiated, designed, implemented, and evaluated—would create space for needed ethical engagement, usable information, and appropriate courses of action in each stage of surveillance.

Figure 3.2 Four components used to inform the surveillance initiation and problem definition in a place-based integrated climate-food-health surveillance systems.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) defines a knowledge system as "a body of propositions that are adhered to, whether formally or informally, and are routinely used to claim truth" (65). Furthermore, knowledge systems can refer to the developed and validated understandings, skills, philosophies, and ways of knowing that inform decision-making about fundamental aspects of life, from day-to-day activities to longer-term actions and governance (66). Some, like Indigenous knowledge systems, are embodied, relational, placed-based systems, inseparable from the socio-cultural, political, legal complexes that include language, classification, resource use practices, social interactions, values, ritual, and spirituality (66–68). Others, like local knowledge systems, are acquired from experiences, observations, explanatory inference, and interpretations; they are not necessarily based in wider systems or cultures. Latulippe and Klenk (2020) highlight the importance of understanding the place-based relations and obligations that give rise to holistic knowledge systems (68). While Starkey et al. (2017) emphasise the importance of mapping local knowledges and systems as a key part of understanding community-

based surveillance processes (63). Similarly, Schneider and Lehmann (2016) highlight the need to map knowledge holders and key actors within the community health system, as well as the relationships between them "…as they will shape what can be achieved in [and by] communities and will therefore need to be understood and engaged"(62).

Data Collection and Analyses

Table 3.1 outlines our mixed design, describing the methods of data collection and analyses for each of the four conceptual framework components (Figure 3.2) that were used to define, understand, and contextualise place-based integrated climate-food-health surveillance initiation in our case study (59,69–71). Key informant interviews were used to collect data about *what* forms of monitoring and knowledge exist (formally or informally) about health and subsistence food systems as they relate to seasonal variability. In addition to interviews, a participatory mapping exercise was used to identify *who* holds knowledge about health and subsistence food systems. Social network analysis was used as a methodological approach to explore *how* information flows between knowledge holders as well as the power and agency that is involved in knowledge production and exchange processes. We considered the intended nature of participatory processes in research more broadly, which attempt to offer ethical, adaptive, inclusive, and reflexive methodologies for empowering the holders of multiple and diverse knowledges (22,23,72–76). Throughout the entire research processes, a reflexive research journal was kept by the lead investigator to reflect on positionality—as non-Indigenous, mostly non-local, researchers—and how this may have influenced the process and these findings.

Table 3.1 Conceptual framework components and associated research methodologies.

Framework Component	Data Collection Methods	Data Analysis Methods
What—existing forms of monitoring and knowledge	Key Informant Interviews	Manifest Content Analysis
Who—knowledge holders	Key Informant Interviews Participatory Mapping	Manifest Content Analysis and Quantification
How—information flows and patterns of connectivity	Key Informant Interviews Participatory Mapping	Descriptive Network Analysis
Why—information flows and relationships and dynamics of influence	Key Informant Interviews	Latent Content Analysis

Component: What

We conducted 22 key informant interviews to map *what* forms of monitoring exist and knowledges that are held locally (formally or informally) about health and subsistence food systems. Members of the research team (BvB, ST) identified an initial group of potential participants based on their positionality within the local health and/or subsistence food systems. Additional participants were recruited using targeted snowball sampling. The distribution of participants included representation from all (n=10) of the Indigenous subsistence communities and associated sub-counties: Kayonza (n=13), Kanyantorogo (n=5), Nyamirama, and Kirima (n=4) in Kanungu District, Uganda in 2018. Participants were purposively selected to include a range of knowledge holders, from subsistence community members, chairpersons, village health teams, clinical in-charges, and sub-county officials (Table 3.2). Just over half of those interviewed (n=12) were women. Interviews were conducted by the lead investigator (BvB) and a local researcher (ST) in either Rukiga or English, depending on the participant's preference. Interview topic guides and questions focused on current health and subsistence food systems in terms of the local, often seasonal, activities (MAMJJ, 2018). Participants were also asked to share examples of changes they had experienced, either in this rainy season or over multiple growing seasons, in terms of health (i.e. incidence of disease, severity of symptoms, behaviours, health promotion, associated and perceived risks) and/or food (i.e. subsistence farming activities, times of harvest, yields, supply) (Appendix 2). Manifest content analysis of the interview data was performed (70).

Table 3.2 Key Informant Characteristics. *Numbering indicates instances where two key informants participated in one interview: 8.1, 8.2 and 10.1, 10.2

No.	Role	Gender	Ethnicity	Informant for Mapping Health Network	Informant for Mapping Subsistence Food Network
1	Health Assistant	Male	Bakiga	✖	✖
2	Community Development Officer (HCII)	Male	Bakiga		
3	Chief Medical Officer (In-Charge)	Male	Bakiga	✖	
4	Village Health Team	Female	Bakiga	✖	
5	Village Health Team	Female	Bakiga	✖	
6	Clinical Officer (In-Charge)	Male	Bakiga	✖	✖
7	Health Assistance	Female	Bakiga	✖	
8.1	Village Health Team	Female	Bakiga	✖	✖
8.2	Village Health Team Link Facilitator	Male	Bakiga	✖	✖
9	Health Assistant	Male	Bakiga	✖	
10.1	Village Health Team	Female	Bakiga	✖	
10.2	Village Health Team Coordinator	Male	Bakiga	✖	
11	Subsistence Community Member/ Village Health Team	Female	Batwa	✖	✖
12	Indigenous Chairperson	Male	Batwa	✖	✖
13	Subsistence Community Member	Female	Batwa	✖	✖
14	Subsistence Community Member	Female	Batwa	✖	✖
15	Indigenous Chairperson	Male	Batwa	✖	✖
16	Subsistence Community Member	Female	Batwa	✖	✖
17	Subsistence Community Member	Female	Batwa	✖	✖
18	Subsistence Community Member	Female	Batwa		✖
19	Subsistence Community Member	Female	Batwa		✖
20	Subsistence Community Member	Male	Batwa	✖	✖

Component: Who

A participatory mapping exercise accompanied key informant interviews to define *who* holds knowledge about health and food systems. Participatory mapping is a process in which participants

created their own visual 'map' of influential and knowledgeable actors engaged in monitoring and responding to health and subsistence food information (77–80). This approach is adapted from participatory research and methodologies, like multi-level stakeholder influence mapping, which are used in the context of climate change adaptation research to help elucidate relationships and power dynamics within and between diverse perspectives of actors and groups (77,80,81).

In scoping discussions with members of the research team, drawing from our own local knowledge (ST) and experience (LBF, SL), we compiled a list to begin an initial round of interviews with potential knowledge holders. Interviews with key informants were used to validate the list of knowledge holders. The list was then used to prompt the participatory mapping exercise. In this exercise, participants were given a blank sheet of paper with labelled x-knowledge and y-influence axes and a series of coloured stickered labels. Some had labels already printed from the first round of potential knowledge holder identification, while others were blank for participants to write their own responses. Throughout the interviews, participants could either confirm, add, or subtract identified knowledge holders to the page. Labels were placed within quadrants according to how 'knowledgeable' and or 'influential' each labelled individual or organisation was considered in their respective monitoring information networks (77,80,82,83). Applying this participatory mapping technique across key informant interviews led to an iterative list of identified key knowledge holders and the number of times they were referenced. The iterative nature of identifying knowledge holders contributed to the analytical rigour of the research process and findings (75). We applied manifest content analysis and quantification of both the interview and participatory mapping data (70). Members of the research team with extensive contextual experience and knowledge also reviewed knowledge holder and information categorisations.

Component: How and Why

We applied social network theory and descriptive analysis methods to map and assess *how* information flows and is connected between knowledge holders. Network analysis is an approach used to characterise the relationships and structures between individual actors and organisations (84–86). Networks are used to visually represent features of the relationships and relational properties between key knowledge holders. A central focus in social network analysis is how individuals are embedded into larger structures; often through their own agency (85). Social network theory and methods have been applied to understand how rural community networks operate and share

information to adapt to climate change variability, and which actors are likely to affect rural climate change adaptation strategies (87).

We organised the data from the interviews and maps into blocked asymmetric matrices in Microsoft Excel (Appendix 2) and visualised the spreadsheet data using Tableau Desktop (2018) (85). Network data were cleaned. Some identified knowledge holders were grouped together (i.e. district officials were grouped under the district technical planning team; religious leaders were included under local leaders; community drug distributors were grouped with village health teams). We used our network graph (Tableau Desktop) and blocked asymmetric matrices (Microsoft Excel) to identify and assess patterns of reciprocated information flows—the number of times information flows from a knowledge holder (out-degree) and to another knowledge holder (in-degree). Examples of this were educational information during a vaccination campaign, adaptive learning in response to drought, change in the incidence of disease within a community or household. We analysed the *centrality* of a knowledge holder, as indicated by the size of the node and the number of times information flows both to and from a specific individual (64). We analysed the *connectivity* of knowledge holders, occurring between groupings of monitored information, knowledge networks, and administrative levels (64). We analysed reciprocal flows of information within groups (85), and on bridging flows of information between groups (87). The network analysis was further complemented by latent content analysis of interview data to further contextualise the relationships and dynamics influencing *why* information might flow a certain way (70,88). Members of the research team with extensive contextual experience and knowledge also reviewed matrices and network interpretations.

Results

Defining *What* Knowledges are Already Held Locally and by *Whom*

Participants discussed information held by knowledge holders within their respective health and subsistence food systems. Narratives reveal inventories of ongoing and repeated cycles of observations, interpretations, evaluations, and adjustments that make up existing health and subsistence food monitoring and response. This information was about present local, often seasonal, health—holding clinics, monitoring households, making referrals, conducting outreach—and subsistence activities—clearing the land, planting, harvesting, and preparing food. Knowledges conveyed were both tacit and technical in nature (89), including an inherent understanding of their roles and responsibilities as holders, as well as how these activities fit within a wider network.

Participants gave examples of both the short-term (present season) and long-term (multiple seasons) changes they were experiencing. Changes observed included the reliability of environmental cues, disruptive and unusual weather events, the associated and perceived risks of those extreme weather events, subsequent behaviours, and subsistence practices. Participants mentioned changes in the crops that they cultivate, for example, cassava and potatoes are more resilient to drought than beans and millet [Key Informants 11, 15,18]. One subsistence community member shared changes about where they cultivate, for example, potatoes are planted lower in the valley if the season is dry and the rains are late [Key Informant 17]. Another participant spoke about changes in the way they cultivate, for example, observing soil decline in some plots of cultivated land [Key Informant 15]. Regardless of their role, many participants held knowledge about experienced changes in the incidence and seasonality of vector-borne and diarrhoeal diseases, including malaria and cholera [Key Informants 1, 3,6, 9, 10.1, 10.2, 14]. One health assistant mentioned behaviours and health promotion activities that needed to occur seasonally, such as deworming and vaccination campaigns in preparation for the rainy season (i.e. March and April; September and October) [Key Informant 1].

Participatory mapping identified 35 different knowledge holders. Identified individuals represented a diverse range of knowledges and influences including subsistence community members, appointed chairpersons, elected councillors, clinical health professionals, public health outreach personnel, village extension health workers, district officials, administrative chiefs, non-governmental organisations, researchers, as well as educational and religious representatives. Knowledge holders engaged either directly or indirectly with information relating to local health and subsistence food systems. For example, NGOs and development partners were viewed as knowledgeable about subsistence food and farming systems by the training and expertise they provided, while clinical and public health care professionals were recognised as knowledgeable by the point-of-care treatment and preventative outreach they provided. Politically-oriented knowledge holders, such as elected area councillors and administrative chiefs, engaged indirectly with both health and subsistence information networks. They were considered to have influence through their ability to liaise and mobilise those who had knowledge and monitored information. To define this cohort of knowledge holders we used a flow of categorical attributes: (1) the monitoring of information they engage in; (2) the knowledge networks that they are embedded in; and (3) the administrative levels that they operate within (Figure 3.3). Several community "systems" emerged throughout participant discussion (i.e. political, council, administrative, religious, traditional, health, medical, research, agricultural) and were thematically

grouped into knowledge networks: western-scientific, political, administrative, Indigenous, local. The different administrative levels are widely used classifications in this context.

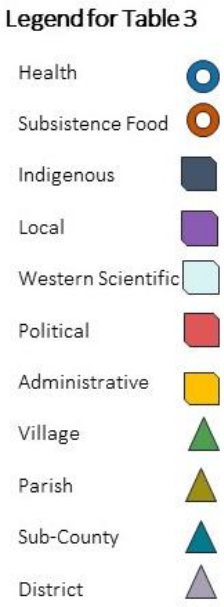
Table 3.3 breaks down how the attributes map onto each of the different knowledge holders. The final column indicates the numbers of times a knowledge holder was identified during the participatory mapping and interview processes. In general, these networks show a density of information diffusion and knowledge exchange between all members. Knowledge holders identified more frequently were largely from local knowledge, Indigenous knowledge, and western scientific knowledge networks that operated across village, parish, and sub-county administrative levels. Knowledge holders operating at the district level were largely categorised as administrative and scientific knowledge holders, they were not identified as frequently, with less central and connecting roles. Notably, there was no explicit evidence of climate-specific information present in these networks.

LEVEL 1 MONITORING INFORMATION	LEVEL 2 KNOWLEDGE NETWORK	LEVEL 3 ADMINISTRATIVE LEVEL
Health	Political	District
		Sub-County
		Parish
		Village
	Indigenous	District
		Sub-County
		Parish
		Village
	Local	District
		Sub-County
		Parish
		Village
	Western Scientific	District
		Sub-County
		Parish
		Village
	Administrative	District
		Sub-County
		Parish
		Village
Subsistence Food	Political	District
		Sub-County
		Parish
		Village
	Indigenous	District
		Sub-County
		Parish
		Village
	Local	District
		Sub-County
		Parish
		Village
	Western Scientific	District
		Sub-County
		Parish
		Village
	Administrative	District
		Sub-County
		Parish
		Village

Figure 3.3 Flow of categorical attributes used to define knowledge holders.

Table 3.3 Identified knowledge holders of local health and subsistence food systems.

Knowledge Holder	Monitoring Information	Knowledge Network	Administrative Level	No. Times Identified
Local Councillor (LC1)	Indirect			17
NGOs Development Partner				16
In-Charge (HC II/III)				16
Chairperson / Community Leader				13
Village Health Team (VHT)				13
Community Hospital				11
Indigenous Community Member (Batwa)				11
Health Assistant				10
Community Outreach Team				9
VHT Coordinator / Health Link Facilitator				9
Local Councillor (LC5) MPs / Lawyers	Indirect			8
Local Councillor (LC2)	Indirect			8
Community Development Officer	Indirect			8
Sub-County Chief	Indirect			8
Local Councillor (LC3)	Indirect			8
District Health Team (Officer and Inspector)				7
Parish Chief	Indirect			7
Local Community Member (Bakiga)				7
Religious Leader				7
Police Security Officer	Indirect			6
Bataka				6
Chief Administrative Officer	Indirect			5
Researcher				5
Teacher / School Rep				5
District Veterinary Officer				4
District Natural Resource Officer				4
Chief Financial Officer	Indirect			4
District Agricultural Officer				4
Uganda Wildlife Authority	Indirect			4
Ancestor				4
Traditional Herbalist				3



Understanding *How* Information, Knowledge Holders, and Systems are Connected

Subsistence community members were identified as central knowledge holders in these networks and notably where information about health and subsistence food systems converge. These were members of subsistence-based farming communities, reliant on each other for generating and sharing knowledge about agricultural cycles and practices. The community chairpersons, local, and religious leaders were all seen as trusted and influential representatives situated at both the village and parish levels of administration. Leaders formed a critical connection between the community and local councillors, as well as development and research partners. They also served on different boards and committee meetings. While a lot of information came from outside of the community (i.e. NGOs, local area councillors, health assistants, etc.), important information still came from ancestral knowledge and tradition. Traditional herbalists were identified as knowledge holders for information relating to health. The Bataka, a self-organised, social welfare group devised by the community, was also identified in the network. This group meets regularly, face-to-face, to organise collective financing, loans, health insurance, and other activities based on identified need such as funerals and emergency transport to the nearest health facility.

Local councillors (LC) were identified as influential knowledge holders, engaged in decision-making processes from the village (LC1) to the district (LC5). These were elected representatives, who facilitated political links with the village, parish, sub-county, and district administrative levels of knowledge holders and systems. NGOs and development partners refer to independent organisations with programmes broadly focused in areas of development. Despite being classified as knowledge holders by numerous participants, however, they did not play a central role in the matrix depicted (i.e. there were fewer number of lines connecting these nodes). Most participants did not make a distinction between different NGOs and development partners, or their respective programmes, operating within food and health information systems (Table 3.3).

The Bwindi Community Hospital, a private health care facility in Kanungu, was also considered a central point for monitoring and responding to health information. The hospital has the resources to extend some outreach services directly into the communities through community nurses, health extension workers, and outreach teams. The health assistant (HA) was identified as playing a critical role to connect the spaces between clinic-based and community-based health monitoring and response across different levels of government administration. HAs are public health professionals concerned with health promotion and outreach. While situated at the sub-county level, they are also

seen as 'fieldworkers' in the village, for example, making seasonal household visits to monitor sanitation practices or deworming and vaccination coverage. The in-charge referred to the nurse or clinical officer 'in-charge' of the health centre (II or III). Their clinical training and responsibility identified them as knowledgeable about information relating to health management and treatment. They engage in monitoring and response at both the parish and district levels. This includes using clinical records and data to make clinical observations and decisions, as well as receiving written referrals from the community. Village health teams (VHT) were considered active community monitors and observers nested within Indigenous knowledge, local knowledge, and western scientific knowledges networks. Typically, they are members of the community themselves, appointed to carry out household visits, make written hospital referrals, and ongoing follow-up care. While mainly focussed at the village level, they connect through the VHT coordinator and link facilitator to feed health-related information into monitoring and response mechanisms such as the technical planning team meetings at the district level.

The district technical planning team (DTPT) consists of the chief administrative officer and sub-county chief, with expert representatives and officials in health (health inspector), environment (natural resource officer), agriculture (agricultural officer), social welfare (community development officer), wildlife (Uganda Wildlife Authority), security (police officer), finances (chief financial officer), and education (teacher representative). Together they are seen to provide a channel for monitoring information, relating directly and indirectly to local health and food systems, to flow into decision-making and response processes. Reports are taken directly from the village, parish, and sub-county and brought into deliberation at these meetings. Similarly, decisions are implemented by key representatives directly into sub-county, parish, and village administration and practice.

Figures 3.4 and 3.5 represents a subset of this network to elucidate the dynamics detailed above between how information, knowledge holders, and networks are connected. The centrality of the community members is observed with numerous flows of information to and from. We note the connectivity of the health assistant, the diversity of information they engaged with, across village, parish, and sub-county levels of administration. The LC is distinguished by being the only member identified from the parish administrative level (3.4) and political knowledge system (3.5). Finally, the VHT's unique position is made apparent by their bridging of diverse networks of Indigenous knowledge, local knowledge, and western scientific knowledge.

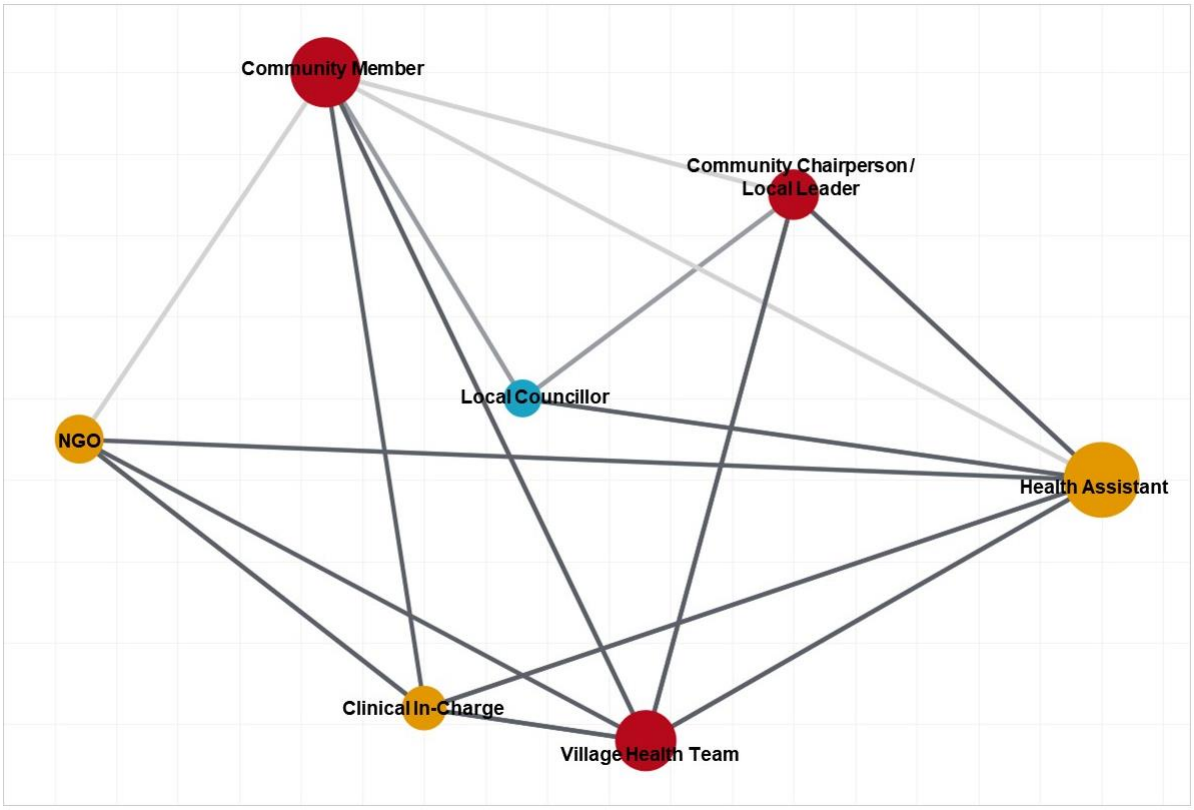


Figure 3.4 Grouped network of select identified knowledge holders and reciprocated information flows by administrative level.

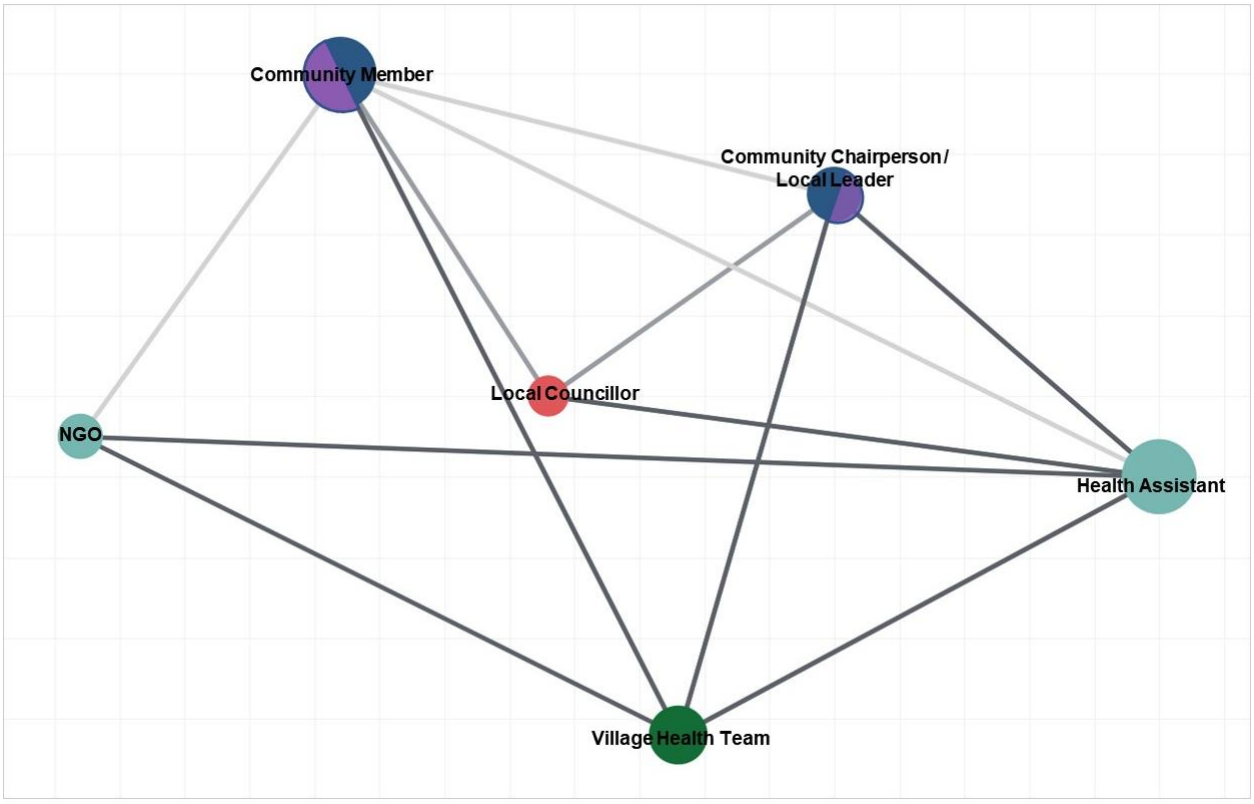
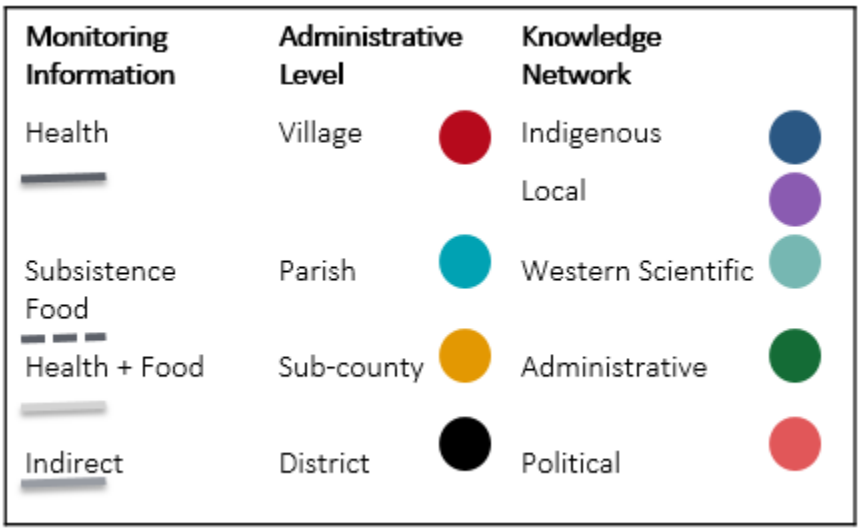


Figure 3.5 Grouped network of select identified knowledge holders and reciprocated information flows by knowledge network.



Legend. In both Figures 3.4 and 3.5 we have selected a subset of the most identified knowledge holders to visualise these network dynamics. These figures depict reciprocated monitored information flows—whereby the same set of knowledge holders send and received information from each other.

The figure also shows centrality—the size of the node and the number of times information flows to and from them. We show the connectivity of knowledge holders within and between different groupings of monitored information, administrative levels, and knowledge networks.

Contextualizing the Connectivity of Systems and Networks

Those in political or administrative positions, such as local councillors, chiefs, chairpersons, were recognised by most informants as being key to monitoring information networks, having the ability to liaise and mobilise across information networks [Key Informants 1, 6, 7, 9]. As one clinical officer explained,

> *If you want something to come out properly, then the political structure backed by administrative structures, then things can be, what, be pushed... because these political leaders, once they give voice, once involved everything is implemented…the political system helps the community own it...but once we leave [the political leaders] behind [sighs] then we are lost completely [Key Informant 6].*

This same informant also identified four systems of stakeholders (health, political, administrative, and religious), suggesting that by combining these systems and stakeholders meant that "whatever you wanted can be implemented". Local area councillors (LC1, LC2, LC3) were recognised as influential and authoritative individuals that can link between administrative levels (1-village, 2-parish, 3-sub-county). As two VHTs suggested, "they have the authority to command" [Key Informant 10.1, 10.2]. Regarding the communication channels and mobilisation within these information networks numerous participants considered "the LC system [to be] very helpful" [Key Informant 2, 4, 7,9, 10.1, 10.2]. Community leaders, such as designated chairpersons and elected councillors, provide links for subsistence communities to political and health networks [Key Informant 16].

Information flows within and between neighbouring Batwa and Bakiga subsistence communities were identified as a key pathway for adaptive learning and sharing information about food, farming, as well as resulting changes in subsistence practices [Key Informants 11, 12, 14, 15, 16, 19, 20]. For example, drought and resulting challenges with food security and farming adjustments experienced in one subsistence community were also raised by a member of a neighbouring community that was concerned about potential threats to their water security [Key Informant 14].

VHTs were identified as active community monitors and observers. They described how they were "responsible for knowing every household in their catchment area" [Key Informants 10.1, 10.2]. Here, information flows between households and health centres to identify health issues, deliver and

receive care, educate, and promote health-related behaviours. Rather than relying on individual households to initiate information flows, focal persons (with a supported level of training and expertise) are identified from within the community to take on the responsibilities of actively monitoring households. VHTs are trusted representatives that link necessary health information to, and from, communities.

At the community level, several platforms exist for facilitating information flow within health and subsistence food networks. An interesting example of an existing community information-sharing channel is the Bataka—a community-led social welfare group. For both Batwa and Bakiga communities, these groups "have power at the community level" by helping subsistence communities organise collective financing, loans, and insurance themselves [Key Informants 8.1, 8.2, 13, 15, 15, 17, 20]. Several informants considered intergenerational knowledge transfer as a useful mechanism of information flow. Examples of this included teachings and transfers of herbal and medicinal knowledge, how to 'dig', when to plant, when to harvest, and observations of long-term seasonal and environmental cues [Key Informant 11, 15, 17, 19, 20]. Another example of a community information-sharing platform was through religious leaders and groups, "because they have a good platform to *give* information" … "to preach the gospel of environmental health and sanitation… and the followers listen to them" [Key Informants 1, 2, 3, 6, 8.1, 8.2, 13]. The radio was also considered a channel for facilitating information-sharing with community members from weather forecasts, agricultural updates, health promotion, and outreach [Key Informants 10.1, 10.2, 11, 15, 18]. It is an established platform used to "teach the whole of Kanungu" [Key Informants 10.1, 10.2]. Face-to-face meetings are also used as channel for sharing and processing information. From the Technical Planning Team Meetings held at the District, to quarterly meetings in the communities mobilised through VHTs, Coordinators, and HAs. VHTs explained how, in the event of a localised outbreak identified by presentations to the health centre, they would trace symptoms back into the communities to initiate primary and secondary treatment plans [Key Informant 10.1, 10.2].

While there was no explicit evidence (or perhaps recognition) of 'Climate Information Holders', it was still a category that appeared inherently in local health and subsistence food information systems. At this level of local experience, the easiest way to talk about and understand climate is in terms of weather. There was no mention of local, regional, or nationally recognised climate and weather affiliated organisations. It seemed that knowledge about climate and seasonal change was not recognised (either formally or informally) in the same manners as other knowledge about health and

food, for example, in the way that people had control over it or could 'hold' it. One key informant mentioned that while they may rely on information from other knowledge holders, both inside and outside of their immediate networks, they cannot blame people when this information is wrong since the weather has been so unpredictable [Key Informant 11]. For example, when unexpected amounts and/or duration of rain spoil the crops, disrupt the harvest, and lower the yields. Or similarly, when a delayed onset of rain, or prolonged period of drought, prevents the crops from germinating and people cannot cultivate enough food for the season. Informants stated that people would often plant in accordance with seasonal timeframes that they have learned and have been passed down for generations. It was also disclosed that no adjustments to these timeframes were being made, even despite the weather being so unpredictable, "we just leave it up to God" [Key Informant 13]. For knowledge holders, particularly health affiliated knowledge holders, climate-related information was considered in relation to seasonality (i.e. how malaria incidences increase in the rainy season), or simply environmental determinants of health (i.e. water, sanitation, and hygiene), and not across longer temporal frames of seasonal variability and change.

Discussion

This research maps existing networks of trusted relationships already used for integrating diverse knowledges, information, and administrative action. As researchers and public health practitioners, we tend to focus on the implementation stage of surveillance as being an easy entry point for opening the process up to others (28,32,41,90). In this way, we allow for extractive approaches in practice that disregard alternative, and sometimes divergent, ways of knowing embedded in diverse (non-western scientific) knowledge systems (33,40). Applying conventional approaches to surveillance in this way, without deliberate consideration of the broader contextual, cultural, historical, social and political processes, can lead to the re-marginalisation of peoples and the reproduction of inequalities in power between groups of people (22–24). We present some of the core insights that have emerged from this case study and how this work moves to fill the practice gap of meaningfully engaging local communities, Indigenous peoples, and diverse knowledge holders to drive equitable and integrated surveillance initiation. We anticipate that our findings can be used to inform the initiation stage of a place-based integrated climate-food-health surveillance system, both in Kanungu District, Uganda, and other local contexts rich in a diversity of knowledges as well as existing forms of monitoring and response.

Information Needs

The networks of local health and subsistence food systems that we investigated were not supported by distinct systems of climate and meteorological information. The diversity of perspectives within the networks we investigated, however, means there will be a difference in climate and meteorological information needs (35). This includes differences in how information is evaluated and used to make decisions. For example, take the perspective of a public health professional deciding to conduct community health promotion activities, or a clinical health professional managing referrals at a health centre, or a smallholder famer deciding when to plant their crops. While different knowledge holders may engage in different information and knowledge networks, regardless of whether they are a health practitioner or subsistence farmer, there is a need for specific information about the risks of climate change, how they are changing, and adjustable action pathways for reducing those risks (9). Ebi and colleagues suggest initiating surveillance systems that not only monitor and respond to the impacts of climate change in standard health outcomes, but also consider indicators for vulnerability, exposures, health system resilience, adaptive learning, and knowledge management (17). How the definitions and measures of climate-related surveillance thresholds and indicators are chosen will impact the knowledge holders and networks engaged in this process as well as the ensuing surveillance response (22,74). An important part of developing a just place-based climate-food-health integrated surveillance system, one that precipitates action, will be to determine what is considered accurate, relevant, and reliable climate-related information in accordance with the diversity of knowledge holders represented (35). Integrating climate information will affect the structure, content, and context of existing health and subsistence food surveillance response in terms of what, who, how, and why (Figure 3.2). *How* we build on existing relationships to produce new forms of knowledge and provide needed climate-weather information in community systems is a key way forward; with the possible added-value of this information depending on how equitably new knowledge forms converge, or diverge, to create positive synergies with existing knowledges (35). This will also apply if we are to understand *how* the monitoring of information and knowledge networks are changing relationally in response to climatic and environmental changes.

Knowledge Bridges

In the valuing of diverse worldviews there is opportunity to create new epidemiologies and equitable forms of surveillance that can respond to the impacts of climate change on health through food systems (23). Knowledge co-production has also been used as a lens to illustrate the relational

processes that link communication pathways (in our case reciprocal information flows) and knowledge systems with adaptive forms of learning and decision making (91). Equally, the relational bridges of information and knowledges identified within our networks are important for facilitating iterative decision making and adaptive learning in local health and subsistence food systems given the context of changing and inequitable vulnerabilities, exposures, and hazards associated with climate change (9,17). Using the number and reciprocity of relational processes in a network as a proxy to determine the efficiency of knowledge transfer and information diffusion (92), we suggest that most of the transfer and diffusion is happening within and between Indigenous, local, and western scientific knowledge networks, as well as village, parish, and sub-county administrative levels. In contrast, the reciprocal diffusion and exchange from, and to, district levels and administrative systems was less apparent. Furthermore, we found that identifying the flows of information between groups in our network allowed us to see the specific knowledge holders responsible for bridging between more than one knowledge network (n=9) and between more than one administration level (n=11) (Table 3.3). For example, there were only two knowledge holders, VHT coordinator and sub-county chief, who bridged both administration levels and knowledge networks. Perhaps a focus on these weaker bridging points could help improve adaptive forms of knowledge transfer and information diffusion necessary for monitoring and responding to changes in local health and subsistence food systems (87,93).

Knowledge Brokers

If a bridge is a method by which information is diffused or knowledge is transferred between groups (87), then *who* is positioned to bridge that information and knowledge is also important for initiating equitable and integrated surveillance systems. From the identification of influential knowledge holders within these systems, we found that not all knowledge holders needed to be directly associated with health and subsistence food information to be identified in the network (n=11) (Table 3.3). This highlights that there may be an important distinction between those who bridge networks through power and influence, and those who bridge networks through knowledge and expertise. A knowledge broker is not necessarily the expert who is the most knowledgeable, however, they can be well situated to connect the people who are (94). For example, politically-oriented knowledge holders, such as elected area councillors and administrative chiefs, were noted for their ability to liaise with and mobilise people, not necessarily for the technical knowledge and capacity they had in health and subsistence food systems. We can apply a similar rationale, based on how knowledge holders

were identified, to determine “proxies” for what is needed when establishing new network connections that broker the production and use of climate and meteorological information (95). Having trusted intermediary knowledge brokers will be an important part of integrating a climate-food-health surveillance system.

Positioning Knowledges and Power

The relationships within knowledge systems shape the flows of knowledge, information, credibility, and power within those systems (96). We reflect on how numerous participants with various characteristics (Table 3.2), all outside the political system (Table 3.3), viewed those within the political system as having the power to influence decisions that concerned them. Furthermore, while all identified knowledge holders were considered “knowledgeable” in ways, some were referenced as having “more” knowledge (i.e. VHT coordinators or link facilitators compared to VHTs; a clinical officer or health assistant with many years of experience and education). However, experience alone was not a determining factor for being considered “more” knowledgeable, with many subsistence community members and chairpersons having decades of experience and intergenerational knowledge. Formal education and training might also be criteria that influence how knowledgeable a person was considered, as well as their access to knowledge systems and use of information. We note how highly dispersed knowledge can be at the local level, with different knowledge holders having access to different forms of information and knowledge. For example, the role that ethnicity has in accessing knowledge systems and monitoring information networks (both existing and potential). Those identified as having influential connecting roles were non-Indigenous knowledge holders. This must be a consideration in the future integration of a place-based surveillance system in a context whereby power can influence access to new forms of knowledge and information within communities. In this same context, land dispossession, lacking reparations, forced relocation, and shifting from forest-based to agriculture-based livelihoods inflict barriers to Indigenous knowledge transmission and generation. Therefore, sharing examples of Indigenous leadership and relationships in knowledge networks, such as connectedness of the Bataka, neighbouring settlements, and VHTs, becomes pertinent for informing research processes as well as future monitoring and response efforts. We cannot separate the research of existing knowledge networks from the politics that (re)produce inequalities of power within and between groups of people (68). Local hierarchies in health and subsistence food systems became apparent throughout the research process. For example, how any essential information needed to pass through the appropriate channels (i.e. DHT, DTPT), by specific

persons or gatekeepers (i.e. VHT coordinators, HAs, LCs) to enact a community response. There is a risk that we as researchers engaged in place- and community-based research need to be aware of, which is that our methods reemphasise pre-existing inequalities and power dynamics, consolidating the position of people and gatekeepers within local hierarchies. Particularly when the diffusion of information and production of knowledge is so deeply rooted in power and influence. Discerning where influence is, and how power is distributed, within knowledge production processes will help to understand the context, and constraints, in which knowledges are being produced (91) and will be another critical part in the initiation of a place-based integrated surveillance system.

Next Steps

The surveillance of complex and uncertain interactions, like the impacts of climate change on health through food systems, requires us to disrupt our existing methods of inquiry and create space for multiple knowledge systems and diverse knowledge holders to produce new forms of knowledge (68,91,97–100). Effectively monitoring and responding to the impacts of climate change on health through subsistence food systems also means engaging across sectors and disciplines, like agriculture and meteorology, whose policies and programmes may also affect human health (1,9). While there may be limited climate change adaptation action planned in the Ugandan health sector, a focus on improving access to climate and weather information may be happening in other sectors, like agriculture, the benefits of which could be extended into health information and knowledge networks through partnerships (21,101). Brokering and bridging between agencies (like health, hydrological, and meteorological services) and communities (like the ones mapped here) can strengthen networks and help connect information and resources across sectors and disciplines (9,87,93). In the context of Kanungu District, potential collaborating bodies could be the national meteorological association (UNMA), or the Intergovernmental Authority on Development Climate Predictions and Applications Centre (ICPAC), or the Greater Horn of Africa Climate Outlook Forum (*GHACOF*). These organisations produce information on a range of scales from climate predictions, to seasonal forecasts, and daily weather forecasts. Bridging can also occur across different knowledge systems and cultural complexes to help establish long-term collaborative partnerships between knowledge holders in different groups (42). For example, VHTs, members of the local community with training in community health, can help bridge understanding and access between households and providers. Financing this bridging is another consideration for initiating and maintaining a place-based integrated climate-food-health

surveillance system where health facilities and services, both government and private, struggle to finance targeted outreach services that extend into communities (102).

Study Limitations

The data collection for this case study was conducted over a period of 3 months and may not be well positioned to account for changes in networks over time. The analyses presented here are still representations of real, changing, and complex systems. Since networks are dynamic, much of what we investigate in this type of analyses is trying to understand how individuals are embedded within larger structures (85,88). Some flows of information may change depending on the individual occupying the position. This is particularly the case for more formally derived administrative or political positions and fixed-terms positions in which there might be high turn-over rates. We tried to account for some level of variation by including data sources from different sub-counties within the district. However, we recognise that similar analyses conducted over longer periods of time can provide deeper, more contextualised, understandings of network dynamics (92).

We also consider the bias inherent in the iterative snowball identification method and recruitment process of key informants. Using the support of other key informants has the potential to skew the composition of representation that reflects both the researchers' positionalities and key informants' subjective definitions of *who* is considered a focal group or individual, as well as bias the understanding of power and inequalities between groups (77,80). We observed that some knowledge holders had fewer reciprocal relationships (i.e. teachers, traditional healers, researchers). This may have been shaped by the perspective of our key informants and the experience they used to define these knowledge holders. Alternatively, the knowledge holders with the highest number of reciprocal relationships (i.e. subsistence community members, chairpersons, health assistant) were often roles occupied by key informants themselves.

Conclusion

Integrating place-based climate-food-health surveillance systems is not just about *what* types of information we monitor, but also *how* and *who* connects it through existing information monitoring and knowledge networks. Our findings emphasised the need to understand the unique contributions of diverse knowledge systems and holders as we prepare for and manage climate-food-health problems and impact pathways that are both evidence-based and locally relevant. Understanding

existing network dynamics, boundaries, and interactions are an important part of the process in initiating and designing the integration of usable climate-food-health surveillance systems. A deep contextualised and relational understanding of existing community health and subsistence food systems will enable us to recognise existing and potential opportunities for bridging diverse knowledges and equitably integrating the information necessary for monitoring and responding to the impacts of climate change.

List of Abbreviations

DHT—District Health Team

DTPT—Technical Planning Team

GHACOF—Greater Horn of Africa Climate Outlook Forum

HA—Health Assistant

HCII—Level 2 Health Centre

HCIII—Level 3 Health Centre

ICPAC—Intergovernmental Authority on Development Climate Predictions and Applications Centre

IPBES—Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

LC—Local Councillor

LC1—Level 1 Village Local Councillor

LC2—Level 2 Parish Local Councillor

LC3—Level 3 Sub-County Local Councillor

LC5—Level 5 District Local Councillor

MAMJJ—March, April, May, June, July

NGO—Non-Governmental Organisation

VHT—Village Health Team

Declarations

Ethics Approval and Consent to Participate

This study was submitted to and approved by the Business, Environment, and Social Sciences (AREA) Faculty Research Ethics Committee, University of Leeds, United Kingdom, and the Makerere School of Social Sciences (MAKSS) Research Ethics Committee, Makerere University, Uganda. Written informed consent for data collection and publication was given by all participants. Identifying features were removed from the original data and not specified in reporting to respect participant confidentiality. For example, an informant's role and sub-county were not linked to protect and prevent the reverse identification of an individual.

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Authors' Contributions

Conceptualisation, BvB; Data curation, BvB; Formal analysis, BvB; Funding acquisition, BvB, LBF, SL, DN, SLH; Investigation, BvB, ST; Methodology, BvB; Project administration, BvB, ST; Supervision, LBF, RK, HE; Visualisation, BvB, LBF, SLH; Writing – original draft, BvB, LBF; Writing – review & editing, BvB, LBF, RK, SL, DN, HE, SLH. All authors have read and approved the final manuscript.

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Authors' Information

The authors of this paper are informed by diverse interdisciplinary backgrounds—global public health, epidemiology, geography, ethnography. While each are informed by different geographic and institutional contexts—academic, government, community—they share commonalities in place-and community-based research methodologies that seek to address greater societal challenges.

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Chapter 4—Indigenous knowledges in the IPCC assessment process: Time for a reboot

This chapter responds to answers the guiding question set out in Chapter 1: (how) can climate change assessments equitably and meaningfully bring together diverse knowledges? This work considers the mandate of the UN Framework Convention on Climate Change (UNFCCC) that calls on the western scientific community to engage meaningfully with Indigenous and local experts and knowledge holders. The aim of this chapter is to assess the Intergovernmental Panel on Climate Change (IPCC)'s formal mechanisms for equitably considering diverse knowledges, specifically Indigenous knowledges, in a global climate change evidence assessment process. It presents a review and synthesis of IPCC procedures and principles, the sixth assessment cycle Special Reports, expert reviewer comments from drafted versions of Special Reports, as well as in-depth interviews with expert advisors. The findings from this work have significant implications for realising procedural justice in the next generation of global climate change evidence assessments, which in turn feed global climate adaptation responses. This chapter provides guidance for reforming IPCC procedures and principles to achieve a necessary standard of procedural justice for engaging Indigenous knowledges and knowledge holders.

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Bianca van Bavel[1], Lea Berrang Ford[1,2], Jennifer Rubis[3], Sherilee L. Harper[4], James Ford[1]

1. Priestley International Centre for Climate, University of Leeds, Leeds, West Yorkshire, UK

2. Nuffield Centre for International Health & Development, University of Leeds, Leeds, West Yorkshire, UK

3. Green Climate Fund, Incheon, Republic of Korea

4. School of Public Health, University of Alberta, Edmonton, Alberta, Canada

Abstract

The Intergovernmental Panel on Climate Change (IPCC) exists as an independent institutional process to assesses the state of evidence and knowledge on climate change. In recognizing the importance of different types of knowledge for understanding and responding to climate change, there has been increasing calls for the IPCC to evolve its procedures to provide a comprehensive assessment of all knowledge relevant to climate change. As such, this paper aims to assesses formal IPCC mechanisms for equitably considering diverse sources of knowledge, specifically Indigenous knowledges, along a path of evidence assessment. We begin by reviewing the different processes, and critiques, of the IPCC assessment cycle to examine how the IPCC defines and mandates the curation of knowledge to determine what information becomes the evidence that feeds into global, national, and local climate change responses. We examine how Indigenous-focused content has been evidenced into IPCC assessments—paying specific attention to its evolution over time from AR4 up to, and including, the sixth assessment cycle Special Reports. We analyse expert reviewer comments from drafted versions of IPCC Special Reports to assess the gaps between expectations and existing mechanisms within the IPCC assessment process to evidence Indigenous knowledges and engage knowledge holders. We add depth to our analysis by conducting interviews with a range of experts. We find that while Indigenous-focussed content and sources of Indigenous knowledge are increasing, the mechanisms for meeting expectations of equitable engagement lie largely outside the limits the current IPCC process. Ultimately, we find that within the parameters of its current mandate and governing principles, the IPCC process cannot achieve a standard of procedural justice necessary for working with diverse knowledges and knowledge holders. We propose potential mechanisms for facilitating the equitable consideration of Indigenous knowledges within the existing IPCC process, as well as beyond it. Unless mechanisms are designed to safeguard and facilitate equitable and meaningful consideration of diverse knowledges as evidence, 'business-as-usual' will be insufficient for the next generation of climate assessments.

Introduction

The Intergovernmental Panel on Climate Change (IPCC) is an independent, institutional process of knowledge assessment aimed at providing a "clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts" (1). IPCC assessments are themselves a response to the uncertainties of climate change and the need to understand and assess the best-available evidence when making decisions at global, national, and local scales. Amid changing environmental, political, and societal contexts, there are increasing calls for the IPCC to reflect the epistemic and geopolitical diversity necessary to provide a comprehensive assessment of *all* evidence relevant to climate change today (2). However, the current IPCC governance structures and organizing principles, including the boundaries of its very mandate and the scientific integrity of its evidence valuation process, complicate these calls to be more inclusive of diverse forms of evidence and knowledge.

There is growing recognition of the ways in which a diversity of knowledge systems offer alternative ways of knowing that can help us better understand, respond to, and govern climate change (3–9). The IPCC itself has acknowledged the importance and value of evidence offered by diverse and multiple ways of knowing in understanding and responding to climate change. Furthermore, this acknowledgement comes with a recognition that "some forms of IK and LK are also not amenable to being captured in peer-reviewed articles or published reports, and efforts to translate IK and LK into qualitative or quantitative data may mute the multidimensional, dynamic and nuanced features that give IK and LK meaning" (10). As such, it is not simply more diverse peer-reviewed literature that is needed in evidence assessments, rather mechanisms that can equitably consider diverse forms of knowledge. For example, Indigenous sciences highlight protocols and methodologies that belong to the worldviews and paradigms of Indigenous knowledge systems (11–16). If the IPCC wants to diversify their evidence-base, then they will need to diversify how they assess evidence. How knowledges are evidenced and considered in global assessment processes, like the IPCC, will determine how priorities are shaped, decisions are made, and actions are taken in the future (17,18).

In this paper, we aim to assess formal IPCC mechanisms for equitably considering diverse sources of knowledge, specifically Indigenous knowledges, along a path of evidence assessment. To do this, we examine how the IPCC defines and mandates the curation the knowledge and sources of evidence that feed global, national, and local climate change responses by reviewing the different procedures, and

critiques, of the IPCC assessment cycle. We extend the work of Smith and Sharp (9) and Ford et al (19,20) to examine how Indigenous-focused content has been evidenced into IPCC assessments—paying specific attention to its evolution over time from AR4 up to, and including, the sixth assessment cycle special reports (SR1.5, SROCC, and SRCCL). We assess the gaps between expectations and existing mechanisms within the IPCC assessment process to evidence Indigenous knowledge, and engage knowledge holders, by analysing expert reviewer comments from drafted versions of IPCC special reports. We add depth to our analysis by conducting interviews with a range of experts. Finally, we propose potential mechanisms for facilitating the equitable consideration of Indigenous knowledges within, and beyond, the existing IPCC assessment process.

Context and Framework

Defining Evidence and Governing Knowledge with the IPCC

IPCC assessment processes create a structure for the prioritisation, mobilisation, and consumption of climate knowledge (2,18). In other words, knowledge about climate change is shaped through the procedures and principles that govern IPCC assessments. For example, the decisions to exclude or include literature as evidence, choices about how much or how little emphasis is given to a topic or area of research, approaches to managing conflicting perspectives about evidence, mechanisms for communicating findings based on evidence, and prioritisation of high-level statements where confidence is formally assessed (19,21). In turn, these processes and principles also play vital roles in identifying knowledge gaps, dictating the direction of, and catalysing new knowledge. This knowledge simultaneously shapes how we respond to climate change by influencing decisions, policies, negotiations, and agendas at international, national, and local scales (19,22–24), including informing the United Nations Framework Convention on Climate Change (1992), the Berlin-Mandate (1995), the Kyoto-Protocol (2005), and the Paris-Agreement (2016).

Using evidence assessment processes as a window into how we value and mobilise knowledge, we start by reviewing the different processes of the IPCC assessment cycle alongside the principles governing the IPCC's work (Table 4.1)(1). We do so to unpack how the IPCC's mechanisms for defining and curating knowledge to determine what information becomes the evidence that informs global, national, and local climate change responses.

Table 4.1 The IPCC mandate per the 'Principles Governing IPCC Work'*.

What is the IPCC and what is its mandate?	The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.
	IPCC reports should be neutral with respect to policy, although they may need to deal objectively with scientific, technical and socio-economic factors relevant to the application of particular policies.
	[IPCC] concentrates its activities on the tasks allotted to it by the relevant WMO Executive Council and UNEP Governing Council resolutions and decisions as well as on actions in support of the UN Framework Convention on Climate Change process.
	Review is an essential part of the IPCC process. Since the IPCC is an intergovernmental body, review of IPCC documents should involve both peer review by experts and review by governments

**First approved in 1998 (14th Session), last amended in 2013 (37th Session). Principles are reviewed a minimum of every 5 years and amended accordingly.*

Comprised of 195 member governments, the Intergovernmental Panel has the first and the last say in the assessment process. For example, the Panel elect the Chairs of the Working Groups (WG) and Task Forces (TF) that will provide technical and scientific guidance throughout the assessment cycle, defining the focus and function of the report in an initial outline, as well as determining the composition of authors who will contribute to each chapter. Thousands of experts from academia, government, industry, and non-profit organisations are nominated by IPCC member governments and observer organisations, or by other experts known through their publications and work (25). Based on these nominations, hundreds of experts are selected to become coordinating lead authors (CLAs), lead authors (LAs) and review editors (REs), while those who are not selected may still contribute as expert reviewers or contributing authors later in the process. Collectively, CLAs and LAs are responsible for framing the content and focus of their respective chapters; however, the content and focus of the chapter must still follow the outline approved by the Intergovernmental Panel.

Chapter teams are tasked with assessing evidence relevant for understanding climate change, impacts, future risks, adaptation, and mitigation as it aligns with the focus of their WG chapter. Evidence includes those from peer-reviewed and internationally available literature and selected non-peer reviewed, 'grey', literature. The assessment of evidence is ongoing and adaptive to include new submissions of relevant information during both the preparation and review of the report. If more

specific knowledge or expertise are needed, then additional experts are recruited as contributing authors (CAs) to "ensure that the full range of views held in the *scientific community* is reflected in the report" (25). Chapter teams are responsible for ensuring the quality and validity of contributing sources of evidence. Reports undergo three rounds of expert-peer review. The first-order draft report is reviewed by independent experts encompassing a "range of views, expertise, and geographic representation". A diverse group of experts are sought in an open call for reviewers issued by the Bureau. Any expert can sign up to be a reviewer. This includes experts previously nominated for CLAs, LAs, REs, and CAs, experts suggested by current authors, as well as experts not previously known to the IPCC process. The review process is facilitated by designated Government Focal Points (GFPs). The revised second-order draft report and summary for policy makers (SPM) are then reviewed by experts, governments, and non-government observer organisations. This review is open to all experts wishing to engage. The final government draft report and SPM are reviewed by member governments. The Panel and WGs give the final approval for publication in a plenary meeting, where select authors and member governments meet to discuss the SPM line-by-line. After the line-by-line review and discussion, the member governments approve the SPM and the Panel officially accepts the findings from the underlying report (1). This interface between authors and member governments is a critical step in the IPCC assessment process. All comments from experts, governments, and non-government observer organisations, as well as author responses to each reviewer comment, are made publicly available following the report publication. Reports are produced in English and translated into Arabic, Chinese, Russian, Spanish, and French. Member Governments also summarise and translate sections of the report into national languages for tailored dissemination through existing government channels.

Critiques of Existing Evidence Assessment Processes

We present a summary of critiques about existing mechanisms to equitably consider diverse sources of knowledge along a path of evidence assessment, from evidence framing to evaluation, acceptance, and translation (Figure 4.1).

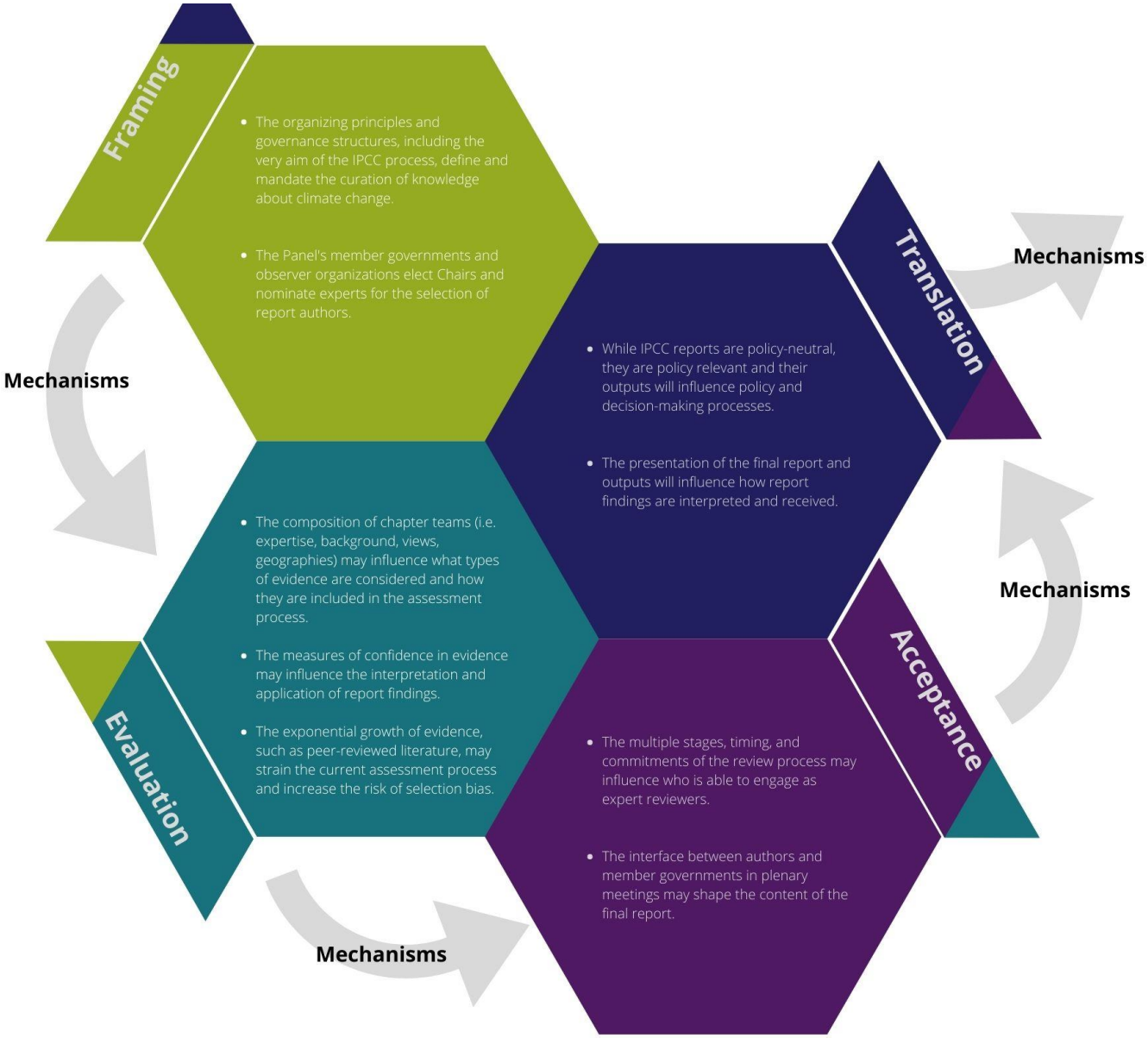

Figure 4.1 Summary of critiques of existing mechanisms to equitably consider diverse sources of knowledge along a path of evidence assessment.

The focus and function of an IPCC assessment process begins with 195 member governments of the Panel electing WG and TF Chairs. These elected experts are intended to reflect a balanced geographical representation that meets scientific and technical requirements (1,26). They are not expected to represent the views of governments, or likewise, have governments endorse their views. The existing method of chapter team selection is meant to safeguard against biases in reports that favour the perspective of one country or region over another, while also ensuring that the voices and experiences of certain regions are not overlooked (25). Despite an intention to protect this selection process from the influence of political interests, some critiques suggest that the relationship and role of governments may bias the selection of authors in support of certain policies, controlled messaging, and marginalisation of dissenting views (2,17–19). Some scholars note that the compositions of IPCC authors, and their views and backgrounds, will influence what evidence is considered and how it is included in the assessment process (18,20,21).

In practice, there is no explicit criteria for member governments and observer organisations to follow in nominating CLAs, LAs, or REs apart from the aim to reflect a balance of gender, career stage, and geographic representation that captures a range of scientific, technical and socio-economic views and backgrounds (27). An analysis of the 721 AR6 chapter authors (CLAs, LAs, and REs) revealed 56% of authors are from UN classified 'industrialised countries' (down from 68% in AR5) and 44% are from 'developing countries' including small island states and least developed countries, with over half of experts being new to the IPCC process and a third of all authors women (up from 21% in AR5) (28). Another analysis of Indigenous expertise in AR5 WGII chapter authors (CLAs, LAs, and REs) revealed only six chapters (out of 30) had authors with expertise on Indigenous issues and climate change with no Indigenous experts as CLAs, LAs, or REs involved in regional chapters for Australia, Asia, Central and South America (20).

The introduction of REs and review guidelines made space in the assessment process to accept non-peer-reviewed, or grey, literature (i.e. conference proceedings, reports produced by governments, industry, research institutions, international and other relevant organisations). Despite this early recognition that other sources can also contribute evidence to the assessment process (Annex 2), critics suggest that the prioritisation of peer-reviewed scientific, technical, and socio-economic literature as the most valid form of evidence can disadvantage potentially pertinent contributions from non-western scientifically-validated knowledge (29,30). The IPCC continues to develop and refine its guidance for undertaking evidence evaluation in assessment reports, including measures of confidence (i.e. level of agreement and

quality of evidence), as well as probabilistic quantification of uncertainty (27,31–34). These processes have been primarily designed for the evaluation of quantitative evidence, often making it less applicable to qualitative evidence, and often irrelevant to some forms of non-western scientific evidence. The weight given to these quantitative expressions of the quality of evidence, however, will influence how others interpret and apply report findings (18).

The amount of peer-reviewed and internationally available scientific literature related to climate change is exponentially expanding with rapid emergence patterns of novel topics (35), such as the emergence and spread of infectious diseases (36) like Zika virus (37,38) and SARS-coV-2 (39–41). The challenges of accurately capturing this "exploding literature base" means that existing assessment mechanisms are no longer fit for purpose even in the context of peer-reviewed literature only, and subject to an increasing risk of selection bias (35). The challenge of considering diverse knowledges is thus superimposed upon an already increasingly strained scientific assessment process.

Final IPCC assessment reports aim to present an objective, comprehensive, and balanced scientific review of the state of climate knowledges with multiple rounds of expert review are meant to support the rigour of IPCC reports and protect the assessment process from biases (27,42). Like authors, reviewers volunteer their time to the assessment process. Unfortunately, the timing of and commitments required for undertaking the review may prevent independent experts and governments from being able to engage in this stage of the assessment process. Just as with chapter teams, the composition of independent expert and government reviewers, their expertise, geographies, backgrounds, and interests, will have an influence on the outcome of these multiple review stages that feed into the final report product and dissemination to policy and other decision makers. Scholars caution that translating the evidence of IPCC reports with universal authority influences how it will be interpreted, and received, by different stakeholders and decision-makers (18,22,43). These limitations echo criticisms that, overall, the IPCC process lacks diverse stakeholder involvement and knowledge inclusion (29,30). The IPCC assessment process will only experience more (not fewer) challenges to its outlined goal and principles unless mechanisms are designed to safeguard and facilitate the equitable consideration of diverse knowledges as evidence.

Methods

Here, we provide an overview of the research methodologies as they relate to the objectives of the study (Table 4.2). Details are given for each source: IPCC Special Reports; Expert Reviewer Comments; Interviews with experts.

Table 4.2 Overview of research methodologies to investigate IK in the IPCC evidence assessment process.

Objective	Source	Methods (Criteria)
To take stock of Indigenous-focused content in the IPCC over time from AR4 up to, and including, the sixth assessment cycle special reports.	IPCC Special Reports within the sixth assessment cycle: SR1.5, SROCC, SRCCL	Keyword search; surrounding text extraction; thematic coding and content analysis.
To assess the gap between expert expectations and existing mechanisms within the IPCC assessment process to evidence Indigenous knowledges and engage knowledge holders.	Expert Reviewer Comments on the sixth assessment cycle Special Reports (SR1.5 and SROCC: FOD, SOD, SPM) Interviews with Indigenous knowledge holders and experts, as well as IPCC experts engaged in Indigenous research	Framework—Figure 4.1—application; text extraction; thematic coding and iterative analysis.
To propose potential mechanisms and future opportunities for change within, and beyond, the IPCC assessment process.	Expert Reviewer Comments on the sixth assessment cycle Special Reports (SR1.5 and SROCC: FOD, SOD, SPM) Interviews with Indigenous knowledge holders and experts, as well as IPCC experts engaged in Indigenous research	Framework—Figure 4.1—application; thematic coding and iterative analysis.
SR1.5—Special Report on Global Warming of 1.5°C; SROCC—Special Report on the Ocean and Cryosphere in a Changing Climate; SRCCL—Special Report on Climate Change and Land; FOD—First Order Draft; SOD—Second Order Draft; SPM—Summary for Policy Makers; AR4—Fourth Assessment Report; AR6—Sixth Assessment Report		

IPCC Special Reports

A document review of the IPCC Special Reports within the sixth assessment cycle (i.e. Global Warming of 1.5°C (SR1.5) (44), The Ocean and Cryosphere in a Changing Climate (SROCC) (10), and Climate Change and Lange (SRCCL) (45)) was conducted to examine how Indigenous-focused content has been evidenced into IPCC assessments over time. We reviewed the extent to which content in these reports was focused

on Indigenous Peoples, places, ways of knowing, being, doing, and accounting. To do this, we adapted a list of keywords developed from an analysis of Indigenous-focused content in the IPCC AR5 WGII (19). Keywords included 'Indigenous'; 'Indigeneity'; 'Traditional Knowledge'; 'Traditional Ecological Knowledge'; 'Traditional' (including other referents); 'IK'; 'ILK'; 'IKLK' (abbreviations). We searched and extracted surrounding text to code the focused content. Content was considered 'ambiguous' or 'general' when Indigenous Peoples (and practices) were not explicitly referred to, such as in an undifferentiated list of vulnerable groups or communities, also when Indigenous knowledges were referenced without any context or meaning provided in the surrounding text, such as undifferentiated local and traditional ways of knowing. Content was considered 'specific' when explicit references were made to Indigenous Peoples, places, and knowledges as well as when they were contextualised. When specific content contained four or more sentences, this was considered 'substantive'. In addition to the manifest analysis of keywords, latent analysis was applied to explore *a priori* themes of knowledge ownership and self-generation, knowledge as situated, knowledge recognition (9)—how Indigenous knowledge systems are, themselves, "verified, implemented, challenged and applied within their own processes of validation and their own conceptualizations" (46)—as well as knowledge sovereignty, expression, and contextual factors that hinder/promote these realisations (47). Themes were identified using Smith and Sharp's (9) assessment of respectful and ethical inclusion of Indigenous knowledges in AR4, Ford et al.'s (19) inclusion and framing of Indigenous knowledges in AR5 WGII, and Latulippe and Klenk's (47) Indigenous knowledge sovereignty framework. Initial themes were also validated during a review of expert reviewer comments. Focused content was then coded into categories and grouped into themes using guiding questions (Table 4.3).

We recognise that distinguishing Indigenous-focused content using keywords does not mean the text was developed using Indigenous knowledge paradigms (11). This analysis thus assesses explicit references to Indigenous knowledges in reports, but not whether Indigenous knowledges have been incorporated into reports. For example, our methodology is not able to capture attempts to 'mainstream' Indigenous knowledges throughout the report such as having Indigenous science citations referenced alongside western science references. In this way, Indigenous knowledges may not be explicitly stated, however, the statement is based on Indigenous evidence. This is a recognised limitation of our study.

Table 4.3 Overview of coding scheme with themes, guiding questions, and coded categories applied in analysis.

Themes	Guiding Questions	Categories
Knowledge ownership and self-generation[1,3,4]	*Are knowledges presented as Indigenous Peoples' generated knowledge?*	Indigenous Peoples, Indigenous Peoples' organisation, diversity, and complexity
Knowledge as situated[1]	*Are knowledges connected to place? Are there references to specific regions, territories, and land?*	UNPFII Regions, Indigenous territory, reservation, land, ecosystems, resources, and relational accountability
Knowledge recognition / Knowledge as an end[1,3,4]	*How/are knowledges recognised? What values are assigned? Who assigns values?*	Knowledge system, valuing, processes of validation, verification, confidence, evidence, importance, and co-production
Knowledge recognition / Knowledge as a means to understanding and responding to climate change[1,2,4]	*In what context are knowledges recognised or assigned a value?*	Impact pathways, risks—vulnerability, hazard, exposure, response options, mitigation strategies, adaptation strategies, decision making, learning, and co-benefits
Knowledge sovereignty[3]	*Are knowledges connected to the realisation of rights? Are there references to autonomy, self-determination, and self-governance?*	Rights, self-determination, governance, institutions (traditional community/decentralised), leadership, and research
Knowledge transmission and expression[3,4]	*Are knowledges connected to past, present, and future forms of expression?*	Approaches, methods, practices, activities, ceremonies, traditions, culture, technologies, tools, and livelihoods
Knowledge in context[2,3]	*How/are knowledges positioned within a wider context? Are there references to histories of colonialism and acculturation?*	Colonialism, oppression, discrimination, and dispossession

[1] Assessment of respectful and ethical inclusion of IK in AR4; [2] Inclusion and framing of IK in AR5 WGII; [3] Indigenous Knowledge Sovereignty Framework; [4] Expert Reviewer Comments SR1.5 and SROCC: FOD, SOD, SPM

Expert Reviewer Comments

All comments from experts, governments, and non-government observer organisations, as well as author responses to each reviewer comment, are made publicly available following the report publication. We conducted a review of the first and second order drafts as well as the SPM for SR1.5 and SROCC (SRCCL comments were not publicly available at the time of analysis) applying the same set of keywords that were used to search the IPCC Special Reports (above). We extracted, coded, and analysed the reviewer comments (including affiliated author responses). We used this process to familiarise ourselves with expert discussion and expectations around how Indigenous knowledges and focused content are engaged and evidenced. We assessed the gap between these expectations and existing mechanisms within the IPCC assessment process to evidence Indigenous knowledges and engage knowledge holders, using the framework developed in Figure 4.1.

Interviews With Experts

In addition to analysing the reviewer comments on the Special Reports, we also conducted in-depth interviews with expert advisors. Expert advisors were considered actors spanning knowledge system boundaries, from Indigenous knowledge holders and experts, to experts engaging with Indigenous knowledges in climate change research, as well as those with institutional experience of the IPCC. A similar typology of actors was used by Hill et al. (46) for working with diverse knowledges in evidence assessments. To identify interviewees, we began by deriving a list of IPCC expert reviewers who were affiliated with Indigenous Peoples Organisations (IPOs) and engaged in Indigenous scholarship and research. Since only five out of the 82 distinct reviewers identified were affiliated with an IPO, we also triangulated the list of expert reviewers annexed in each Special Report (SR1.5, SROCC, SRCCL) using a list of organisations affiliated with the International Indigenous Peoples Forum on Climate Change (IIPFCC), the UN Permanent Forum on Indigenous Issues (UNPFII 2017-2022), the Local Communities and Indigenous Peoples Platform (LCIPP Facilitative Working Group) of the UN Framework Convention on Climate Change (UNFCCC). We continued to identify expert advisors throughout the interview process using snowballing. Table 4.4 provides details for each expert advisor interviewed. Identifying information has been included with informed consent. In doing so we acknowledge the diversity of axiologies, from the valuing of anonymity in western sciences to the principles of knowledge ownership, information control, and source attribution in Indigenous sciences (12,48,49).

Interviews took place remotely using a video conferencing application over the course of four months (June—September, 2020). Discussions covered experiences of engaging with the IPCC process, as well as

solutions for strengthening the expression, transmission, exchange, and valuing of Indigenous knowledges in future IPCC assessments. The precise focus of the discussion was adjusted to each expert advisor's unique characteristics, geographic, background, and expertise. The interview transcripts were analysed to further explore what opportunities exist within the IPCC process and governance structures to improve the diversity of evidence. Transcripts and notes of recorded interviews were coded under broad themes based on the interview guide (Appendix 3). Using the framework developed (Figure 4.1), we identified gaps (and associated opportunities) between expert expectations and existing mechanisms in the IPCC evidence assessment process to diversify evidence and engage Indigenous knowledges and knowledge holders. Ethical approval was granted by the University of Leeds Research Ethics Committee (AREA 19-133).

Table 4.4 Details, affiliations, and experience of expert advisors. *Permission was given with informed consent to include identifying information.

Expert Advisors		Affiliation	IPCC Experience
Advisor 1	Expert in Inuit knowledge and climate change in the Arctic.	Indigenous Peoples Organisation	Reviewer (SR1.5, SROCC)
Advisor 2	Expert in local knowledge, Indigenous knowledge, and human rights in Asia.	Indigenous Peoples Organisation	Reviewer (SR1.5, SRCCL)
Advisor 3	Indigenous knowledge expert in land rights and natural resource management in Africa.	Indigenous Peoples Organisation(s)	Reviewer (AR6)
Advisor 4	Mbororo Fulani knowledge holder and Indigenous knowledge expert in advocacy and climate change.	Indigenous Peoples Organisation(s)	Reviewer (AR6)
Advisor 5	Karelian knowledge holder and Indigenous knowledge expert in language and rights of Indigenous Peoples.	Indigenous Peoples Organisation	n/a
Advisor 6	Expert in climate change observations and Indigenous knowledge.	Academic Institution	1 or more SRs/ARs
Advisor 7	Expert in climate change adaptation, Indigenous knowledge, local knowledge, and practitioner knowledge.	Academic Institution	1 or more SRs/ARs
Advisor 8	Expert in culture, heritage, and climate change in North America.	Academic Institution	Reviewer (SR1.5, AR6)
Advisor 9	Expert in global climate knowledge governance and UN institutional processes.	UNFCCC	Governance
Advisor 10	Expert in local knowledge, Indigenous knowledge, and climate change in the Arctic.	Academic Institution	Author (AR6)

Advisor 11	Rosebud Sioux knowledge holder and Indigenous knowledge expert in earth systems science.	Indigenous Peoples Organisation and Academic Institution	n/a
Advisor 12	Mopan Mayan knowledge holder and Indigenous knowledge expert in land tenure and natural resource management.	Indigenous Peoples Organisation	n/a

*All experts have consented to the above information being included with varying levels of identity/anonymity. For example, some advisors have suggested that their names be added to give information credibility and recognise ownership. Other advisors have preferred to maintain anonymity. A final version of this table will be confirmed by advisors, along with the option of co-authorship, prior to publication.

Findings

Taking Stock of Indigenous-Focused Content in IPCC Special Reports

Increases in Indigenous-Focused Content from AR4 to AR6

We reviewed the extent to which content in the IPCC sixth assessment cycle Special Reports was focused on Indigenous Peoples, places, ways of knowing, being, doing, and accounting. From our search of relevant keywords only, we found increases in the Indigenous-focused content evidenced in IPCC assessments from AR4 WGII and AR5 (Ford et al. 2016) into the sixth assessment cycle, most notably with SROCC and SRCCL (Figure 4.2). To account for some of the differences in between ARs (comprised of 30 chapters) and SRs (comprised of 5-7 chapters each), the total number of pages in each report were used to calculate percentages. In addition to length, we also note differences in comparing the content of the quadrennial Assessment Reports and the Special Reports. SRs, for instance, aim to assess evidence on a more general scope with a focus on high level questions (i.e. is a target of 1.5°C of warming possible, what this means, and the policy implications) and are conducted over a shorter time frame (i.e. 18 months). Even between the SRs we reviewed, there are differences in how general or specific, global or regional, the assessments are framed. For example, SR1.5 was the most general of the Special Reports, having only 5 chapters, it lacks the regional and natural system specific chapters of SROCC and SRCCL. Both SRCCL and SROCC, for example, included a much greater regional focus with chapters on specific regions and systems (i.e. polar regions, food systems) where more specificity could be built into the assessment process. As such, our findings should be interpreted with caution, and are intended to focus on the level of formal mechanisms for the IPCC process, which do not differ between ARs and SRs.

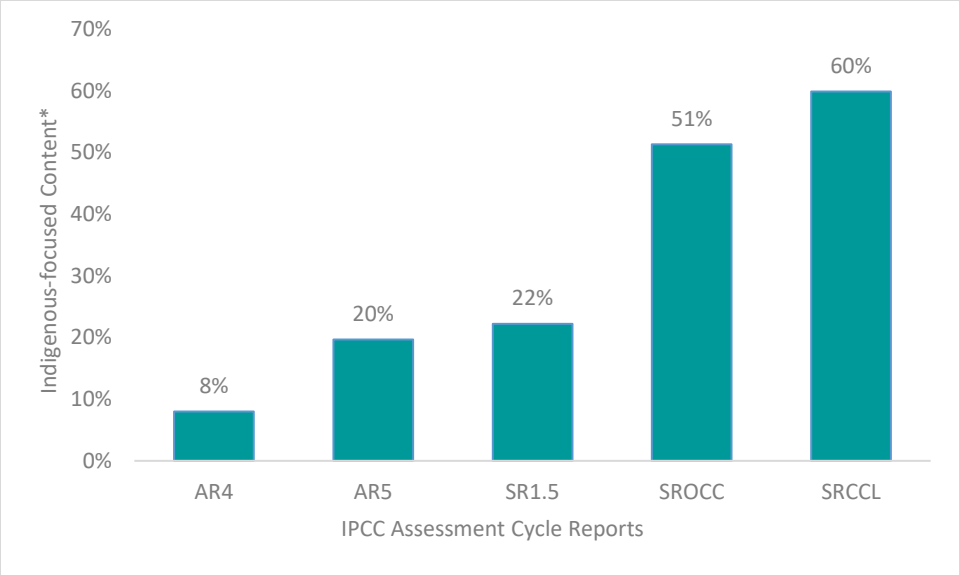

Figure 4.2 Indigenous-focused content evidenced in IPCC assessments from 2007 with the IPCC 4th Assessment Report (AR4) to 2019 with the sixth assessment cycle Special Reports. *Given the differences in between ARs and SRs the total number of pages in each report were used to calculate percentages.

We compared whether there was a change in how Indigenous-focused content was characterised. First we coded whether the extracts of text surrounding keywords were ambiguous/general, specific, and substantive. Table 4.5 presents examples of ambiguous/general and specific Indigenous-focused content. Increasingly since AR5, Indigenous-focused content is cited using specific examples, most notable within SROCC, rather than ambiguous or undifferentiated references (Figure 4.3). Of the Indigenous-focused content coded, 15% (SR1.5), 18% (SROCC), and 22% (SRCCL) were categorised as 'substantive'.

Table 4.5 Examples of ambiguous/general and specific Indigenous-focused content from IPCC Special Reports 1.5, SROCC, SRCCL.

	Examples	Location

Ambiguous / General / Undifferentiated	"Coordinated action is required across a range of actors, including business, producers, consumers, land managers, indigenous peoples and local communities and policymakers to create enabling conditions for adoption of response options."	SRCCL: p.554
	"Such risks are particularly large for top predators and for human communities that have high consumption on these organisms, including coastal Indigenous communities."	SROCC: p.66
	"A wide range of adaptation options are available to reduce the risks to natural and managed ecosystems (e.g., ecosystem based adaptation, ecosystem restoration and avoided degradation and deforestation, biodiversity management, sustainable aquaculture, and local knowledge and indigenous knowledge)."	SR1.5: p. 10
	"Local benefits, especially for indigenous communities, will only be accrued if land tenure is respected and legally protected, which is not often the case (Sunderlin et al., 2014; Brugnach et al., 2017). Although payments for reduced rates of deforestation may benefit the poor, the most vulnerable populations could have limited, uneven access (Atela et al., 2014) and face lower opportunity costs from deforestation (Ickowitz et al., 2017)."	SR1.5: p.330
	"Local food systems are embedded in culture, beliefs and values, and ILK can contribute to enhancing food system resilience to climate change."	SRCCL: p.475
	"Food sovereignty is a framing developed to conceptualise these issues (Reuter 2015). They directly relate to the ability of local communities and nations to build their food systems, based, among other aspects, on diversified crops and ILK."	p.508
Specific	"Environmental valuation literature uses a range of techniques to assign monetary values to environmental outcomes where no market exists (Atkinson et al. 2018; Dallimer et al. 2018), but some values remain inestimable. For some indigenous cultures and peoples, land is not considered something that can be sold and bought, so economic valuations are not meaningful even as proxy approaches (Boillat and Berkes 2013; Kumpula et al. 2011; Pert et al. 2015; Xu et al. 2005)."	SRCCL: p.693
	"IK and LK holders in the Himalayas have conducted long-term systematic observations in these remote areas for centuries. Contemporary IK details change in phenology, weather patterns, and flora and fauna species, which enriches scientific knowledge of glacial retreat and potential glacial lake outbursts (Sherpa, 2014)."	SROCC: p.105
	"IK and LK stand on their own, and also enrich and complement each other and scientific knowledge. For example, Australian Aboriginal groups' Indigenous oral history provides empirical corroboration of the sea level rise 7,000 years ago (Nunn and Reid, 2016), and their seasonal calendars direct hunting, fishing, planting, conservation and detection of unusual changes today (Green et al., 2010)."	SROCC: p.102

	"In forest management, encouraging responsible sourcing of forest products and securing indigenous land tenure has the potential to increase economic benefits by creating decent jobs (SDG 8), maintaining biodiversity (SDG 15), facilitating innovation and upgrading technology (SDG 9), and encouraging responsible and just decision-making (SDG 16) (medium evidence, high agreement) (Ding et al., 2016; WWF, 2017)."	SR1.5: p.462
	"Climate change is an important concern for the Maya, who depend on climate knowledge for their livelihood. In Guatemala, the collaboration between the Mayan K'iché population of the Nahualate river basin and the Climate Change Institute has resulted in a catalogue of indigenous knowledge, used to identify indicators for watershed meteorological forecasts (López and Álvarez, 2016). These indicators are relevant but would need continuous assessment if their continued reliability is to be confirmed (Nyong et al., 2007; Alexander et al., 2011; Mistry and Berardi, 2016). For more than ten years, Guatemala has maintained an 'Indigenous Table for Climate Change', to enable the consideration of indigenous knowledge in disaster management and adaptation development."	SR1.5: p.360

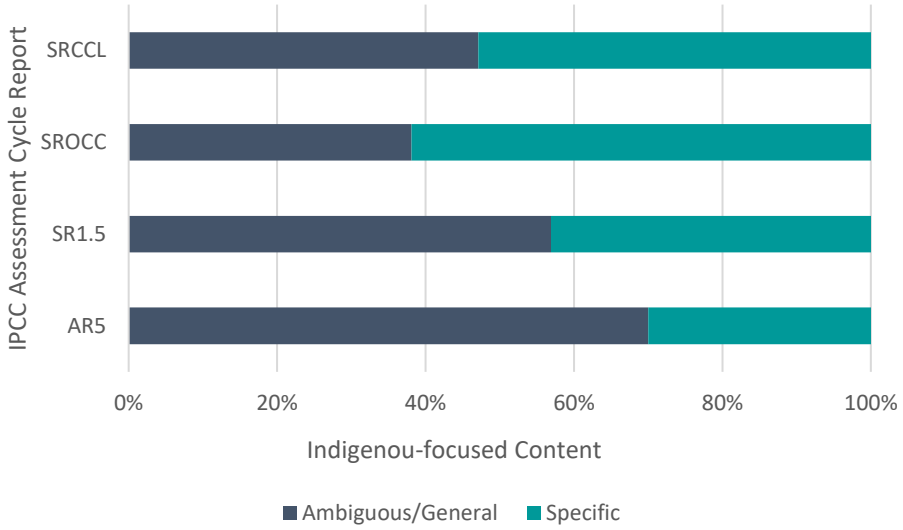

Figure 4.3 Proportion of Indigenous focused content characterised as ambiguous/general and specific. *Given the differences in between ARs and SRs the total number of pages in each report were used to calculate percentages.

Our search results indicated 27% (SR1.5), 32% (SROCC), and 20% (SRCCL) of Indigenous-focused content contained references to specific Indigenous cultural regions, land, and/or ecosystems. Specific regional examples were most notable in SROCC, with numerous examples from the Arctic, Pacific, Americas, and Asia. Regional examples from Africa (North Africa, West Africa, African Sahel, Horn of Africa, Southern Africa) featured more in SRCCL. There were no *specific* examples of Indigenous-focused content from Eastern Europe, Russian Federation, Central Asia and Transcaucasia in any of the SRs. SROCC's Chapter 3

on polar regions is not included in these counts since it is explicitly stated that published Indigenous knowledge and local knowledge were incorporated directly into its assessment process (50). Again, we acknowledge the limitations in our methods and that Indigenous content is not always distinguishable using keywords and, in some cases, will be referenced no differently than forms of western scientific evidence.

There was a smaller proportion of Indigenous-focused content in each of the SRs that referenced specific Indigenous Peoples—4.5% in SR1.5; 5% in SROCC; and 6% in SRCCL. Indigenous-focused content was often written about without referring to specific Indigenous Peoples. For example, SR1.5 refers to 'Indigenous peoples in the Arctic' or 'the Arctic and its Indigenous peoples', however, rarely with specific identification of a Nation or group of peoples despite supporting references evidencing Inuit people and places. In SRCCL, Indigenous Peoples are often grouped into an all-encompassing category of "those most vulnerable to climate change", including women, poor, local communities, and marginalised. In SR1.5, fewer than 5% of Indigenous-focused content includes specific in-text reference to Indigenous Peoples, with only four Indigenous Peoples explicitly included in the report. Across the IPCC SRs specific references are made to the Aymara, Beni-Amer, Berber, Ewenkī, Fulɓe, Guna, Gwich'in, Inuit, iTaukei, Kurukh, Manangi, Māori, Maya, Mayan K'iché, Mi'kmaq, Ni-Vanuatu, Quechua, Saami, and Tsleil-Waututh (Coast Salish) Indigenous Peoples. We note that Indigenous Peoples of focus in a referenced article may not be named. This may be the case in contexts where the definition of Indigenous is considered contentious (i.e. Africa) or in contexts when Indigenous Peoples are the majority population (i.e. Fiji).

Evidencing Indigenous Knowledges in Special Reports

We found few instances where Indigenous content was presented as belonging to a source or where Indigenous Peoples are presented as the generators and owners of the knowledge being referenced. We identified references to how Indigenous knowledges are accessed and attributed that emphasised the direct engagement with knowledge holders, "when interpreted and applied properly, IK comes directly from research by Inuit and from an Inuit perspective (ICC, 2018) … by working with Inuit on scoping and methodology for assessments and supporting inclusion of Inuit experts in research, analysis, and results dissemination" (SROCC: p. 105 Cross Chapter Box 4). SROCC also included knowledge holders' recommendations for engaging with Indigenous knowledges in assessment reports. Table 4.6 outlines examples of Indigenous-focused content organised by themes and coded language.

Table 4.6 Illustrative examples of Indigenous-focused content organised by themes and coded language.

Theme	Examples	Location
Knowledge ownership and self-generation	"There is high confidence that pastoralists have created formal and informal institutions based on [IK] for regulating grazing, collection and cutting of herbs and wood, and use of forests across the Middle East and North Africa (Louhaichi and Tastad 2010; Domínguez 2014; Auclair et al. 2011), Mongolia (Fernandez-Gimenez 2000), the Horn of Africa (Oba 2013) and the Sahel (Krätli and Schareika 2010)." "There are various approaches for utilising multiple knowledge systems. For example, the Mi'kmaw Elders' concept of Two Eyed Seeing: which is 'learning to see from one eye with the strengths of Indigenous knowledges, and from the other eye with the strengths of Western [scientific] knowledges, and to use both together, for the benefit of all' (Bartlett et al., 2012), to preserve the distinctiveness of each, while allowing for fuller understandings and actions (Bartlett et al., 2012: 334)."	SRCCL: pp.746-48 SROCC: p.103
Knowledge as situated	"Customary resource management systems based on IK and elders' leadership – for instance, Rahui in French Polynesia (Gharasian, 2016), or Mo in the Marshall Islands (Bridges and McClatchey, 2009) – also allow communities to diversify access to marine and terrestrial resources using seasonal calendars, to ensure collective food and water security, and to maintain ecological integrity (McMillen et al., 2014). In rural Pacific atolls, traditional food preservation and storage (e.g., storing germinated coconuts or drying fish) still play a role in anticipating disruptions in natural resource availability (Campbell, 2015; Lazrus, 2015). Such practices have enabled the survival of isolated communities from the Arctic to tropical islands in constraining sea environments for centuries to millennia (McMillen et al., 2014; Nunn et al., 2017a)." "There are abundant examples of how indigenous and local knowledge, which are an important part of broader agroecological knowledge (Altieri 2018), have allowed livelihood systems in drylands to be maintained despite environmental constraints. An example is the numerous traditional water harvesting techniques that are used across the drylands to adapt to dry spells and climate change. These include creating planting pits (zai, ngoro) and micro-basins, contouring hill slopes and terracing (Biazin et al. 2012) (Section 3.6.1). Traditional ndiva water harvesting systems in Tanzania enable the capture of runoff water from highland areas to downstream community-managed micro-dams for subsequent farm delivery through small-scale canal networks (Enfors and Gordon 2008). A further example are pastoralist communities located in drylands who have developed numerous methods to sustainably manage rangelands. Pastoralist communities in Morocco developed the agdal system of seasonally alternating use of rangelands to limit overgrazing (Dominguez 2014) as well as to manage forests in the Moroccan High Atlas Mountains (Auclair et al. 2011). Across the Arabian Peninsula and North Africa, a rotational grazing system, hema, was historically practiced by the Bedouin communities (Hussein 2011; Louhaichi and Tastad 2010). The Beni-Amer herders in the Horn of Africa have developed complex livestock breeding and selection systems (Fre 2018)."	SROCC: p.373 SRCCL: p.284
Knowledge as a means to understanding	"IK and LK holders in the Himalayas have conducted long-term systematic observations in these remote areas for centuries. Contemporary IK details change in phenology, weather patterns, and flora and fauna species, which enriches scientific knowledge of glacial retreat and potential glacial lake outbursts (Sherpa, 2014). The scientific community can close many	SROCC: p.105

climate change	knowledge gaps by engaging IK and LK holders as counterparts. Suggestions towards this objective are to work with affected communities to elicit their knowledge of change, especially IK and LK holders with more specialised knowledge (farmers, herders, mountain guides, etc.), and use location- and culture-specific approaches to share scientific knowledge and use it with IK and LK." "In Tanzania, increased variability of rainfall is challenging indigenous and local communities (Mahoo et al., 2015; Sewando et al., 2016). The majority of agro-pastoralists use indigenous knowledge to forecast seasonal rainfall, relying on observations of plant phenology, bird, animal, and insect behaviour, the sun and moon, and wind (Chang'a et al., 2010; Elia et al., 2014; Shaffer, 2014). Increased climate variability has raised concerns about the reliability of these indicators (Shaffer, 2014); therefore, initiatives have focused on the co-production of knowledge by involving local communities in monitoring and discussing the implications of indigenous knowledge and meteorological forecasts (Shaffer, 2014), and creating local forecasts by utilizing the two sources of knowledge (Mahoo et al., 2013). This has resulted in increased documentation of indigenous knowledge, understanding of relevant climate information amongst stakeholders, and adaptive capacity at the community level (Mahoo et al., 2013, 2015; Shaffer, 2014)."	SR1.5: p.360
Knowledge as a means to respond to climate change	"[IK] can be used in decision-making at various scales and levels, and exchange of experiences with adaptation and mitigation that include [IK] is both a requirement and an entry strategy for participatory climate communication and action." "In forest management, encouraging responsible sourcing of forest products and securing indigenous land tenure has the potential to increase economic benefits by creating decent jobs (SDG 8), maintaining biodiversity (SDG 15), facilitating innovation and upgrading technology (SDG 9), and encouraging responsible and just decision-making (SDG 16) (medium evidence, high agreement) (Ding et al., 2016; WWF, 2017)." "Diverse stakeholders have a particularly important role to play in defining problems, assessing knowledge and proposing solutions (Stokes et al. 2006; Phillipson et al. 2012). Lack of connection between science knowledge and on-the-ground practice has hampered adoption of many response options in the past; simply presenting 'scientifically' derived response options is not enough (Marques et al. 2016). For example, the importance of recognising and incorporating local knowledge and indigenous knowledge is increasingly emphasised in successful policy implementation (see Cross-Chapter Box 13 in Chapter 7), as local practices of water management, soil fertility management, improved grazing, restoration and sustainable management of forests are often well-aligned with response options assessed by scientists (Marques et al. 2016)."	SRCCL: p.676 SR1.5: p.462 SRCCL: p.638
Knowledge recognition / Knowledge as an end	"[The] process of knowledge co-production is complex (Jasanoff, 2004) and IK and LK possess uncertainties of a different nature from those of scientific knowledge (Kahneman and Egan, 2011), often resulting in the dominance of scientific knowledge over IK and LK in policy, governance and management (Mistry and Berardi, 2016)." "IK and LK provide case specific information that may not be easily extrapolated to the scales of disturbance that humans exert on natural systems (Wohling, 2009). Some forms of IK and LK are also not amenable to being captured in peer-reviewed articles or published reports, and efforts to translate IK and LK into qualitative or quantitative data may mute the multidimensional, dynamic and nuanced features that give IK and LK meaning (DeWalt, 1994; Roncoli et al., 2009; Goldman and Lovell, 2017). Nonetheless, efforts to collaborate with IK	SROCC: p.103 SROCC: p.102

	and LK knowledge holders (Baptiste et al., 2017; Karki et al., 2017; Lavrillier and Gabyshev, 2017; Roué et al., 2017; David-Chavez and Gavin, 2018) and to systematically assess published IK and LK literature in parallel with scientific knowledge result in increasingly effective usage of the multiple knowledge systems to better characterise and address ocean and cryosphere change (Huntington et al., 2017; Nalau et al., 2018; Ford et al., 2019)." "[IK] can play a key role in climate change adaptation (high confidence) (Mapfumo et al. 2017; Nyong et al. 2007; Green and Raygorodetsky 2010; Speranza et al. 2010; Alexander et al. 2011; Leonard et al. 2013; Nakashima et al. 2013; Tschakert 2007). The Summary for Policymakers of the Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2014b, p. 26) states that 'Indigenous, local, and traditional knowledge systems and practices, including indigenous peoples' holistic view of community and environment, are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts. Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation' (see also Ford et al. 2016)."	SRCCL: pp.746-48
Knowledge sovereignty	"Customary land rights can extend across many categories of land, but are difficult to assess properly due to poor reporting, lack of legal recognition, and lack of access to reporting systems by indigenous and rural peoples (Rights and Resources Initiative 2018a) …securing of these land tenure regimes vital in land and climate protection. These lands are estimated to hold at least 293 GtC of carbon, of which around one-third (72 GtC) is located in areas where indigenous peoples and local communities lack formal recognition of their tenure rights (Frechette et al. 2018)." "Inuit seek to achieve self-determination in all aspects of research carried out in Inuit homeland (e.g., Nickels et al., 2005). Inuit actively produce and use climate research (e.g., ITK, 2005; ICC, 2015) and lead approaches to address climate challenges spurred by great incentive to develop innovative solutions. Engaging Inuit representative organisations and governments as partners in research recognises that the best available knowledge includes IK, enabling more robust climate research that in turn informs climate policy."	SRCCL: p.749 SROCC: p.105
Knowledge transmission and expression	"Local drivers of exposure and vulnerability include, for example, coastal squeeze, inadequate land use planning, changes in construction modes, sand mining and unsustainable resource extraction (e.g., in the Comoros; Betzold and Mohamed, 2016; Ratter et al., 2016), as well as loss of Indigenous Knowledge and Local Knowledge (IK and LK; Cross-Chapter Box 4 in Chapter 1). For example, the loss of IK and LK-based practices and associated cultural heritage limits both the ability to recognise and respond to ocean and cryosphere related risk and the empowerment of local communities." "Importantly, health adaptation is occurring at the local scale in the Arctic (Ford et al., 2014a; Ford et al., 2014b). Adaptation at the local-scale is broad, ranging from community freezers to increase food security, to community-based monitoring programs to detect and respond to climate health events, to Elders mentoring youth in cultural activities to promote mental health when people are 'stuck' in the communities due to unsafe travel conditions (Pearce et al., 2010; Brubaker et al., 2011; Harper et al., 2012; Brubaker et al., 2013; Douglas et al., 2014; Austin et al., 2015; Bunce et al., 2016; Cunsolo et al., 2017)."	SROCC: p.662 SROCC: p.267
	"In Fiji and Vanuatu, strategies used to prepare for cyclones include building reserve emergency supplies and utilizing farming techniques to ensure adequate crop yield to combat potential losses from a cyclone or drought (McNamara and Prasad, 2014; Granderson, 2017;	SR1.5: p.360

	Pearce et al., 2017). Social cohesion and kinship are important in responding and preparing for climate-related hazards, including the role of resource sharing, communal labour, and remittances (McMillen et al., 2014; Gawith et al., 2016; Granderson, 2017). There is a concern that indigenous knowledge will weaken, a process driven by westernization and disruptions in established bioclimatic indicators and traditional planning calendars (Granderson, 2017)."	
	"In the case of food security, abrupt and protracted events of food insecurity might occur. There is a distinction between 'hunger months' and longer-term food insecurity. Some indigenous practices already incorporate hunger months whereas structural food deficits have to be addressed differently (Bacon et al. 2014). Governance mechanisms that facilitate rapid response to crises are quite different from those aimed at monitoring slower changes and responding with longer-term measures."	SRCCL: p.738
Knowledge in context	"Understanding the interactions between land tenure and climate change has to be based on underlying understanding of land tenure and land policy and how they relate to sustainable development, especially in low- and middle-income countries: such understandings have changed considerably over the last three decades, and now show that informal or customary systems can provide secure tenure (Toulmin and Quan 2000) ... However, where customary systems are unrecognised or weakened by governments, or the rights from them are undocumented or unenforced, tenure insecurity may result (Lane 1998; Toulmin and Quan 2000). There is strong empirical evidence of the links between secure communal tenure and lower deforestation rates, particularly for intact forests (Nepstad et al. 2006; Persha et al. 2011; Vergara-Asenjo and Potvin 2014). Securing and recognising tenure for indigenous communities (such as through revisions to legal or policy frameworks) has been shown to be highly cost effective in reducing deforestation and improving land management in certain contexts, and is therefore also apt to help improve indigenous communities' ability to adapt to climate changes (Suzuki 2012; Balooni et al. 2008; Ceddia et al. 2015; Pacheco et al. 2012; Holland et al. 2017)."	SRCCL: p.749
	"Indigenous knowledge is threatened by acculturation, dispossession of land rights and land grabbing, rapid environmental changes, colonization and social change, resulting in increasing vulnerability to climate change – which climate policy can exacerbate if based on limited understanding of indigenous worldviews (Thornton and Manasfi, 2010; Ford, 2012; Nakashima et al., 2012; McNamara and Prasad, 2014). Many scholars argue that recognition of indigenous rights, governance systems and laws is central to adaptation, mitigation and sustainable development (Magni, 2017; Thornton and Comberti, 2017; Pearce, 2018)."	SR1.5: p.337

In all three Special Reports, we see Indigenous ways of knowing as a means—having a role in understanding risks and impact pathways, as well as adaptation and mitigation response options. There are references to Indigenous ways of managing the land sustainably in the face of climate change, including desertification, land degradation, and food insecurity (SRCCL) as well as specific contexts such as mountain, polar, low-lying islands and coastal regions (SROCC). Specific examples of how Indigenous knowledges underpinned adaptive capacity included agro-ecological and forest management systems, as well as social networks, collective memory, and shared repository of multi-generational experiences (SR1.5: p.337).

In addition to being a means of understanding and responding to climate change, Indigenous ways of knowing, being, doing and accounting are also a valued end. Despite this, there were few instances in SR1.5 which contained recognition of the intrinsic value of Indigenous knowledge systems; often it was still in relation to western scientific knowledge or desired response options. In both SROCC and SRCCL, there were more overt examples recognizing the validity and independence of Indigenous knowledges, the complexity of knowledge co-production processes to create new understandings for decision making, as well as existing challenges such as the hierarchical treatment of diverse knowledge systems (SRCCL: pp.104; 512; 558; 565; 736; 738; Cross-Chapter Box 13). For example, excerpts from the reports referred to Indigenous knowledges as part of a system with intrinsic processes of validation and "need not be viewed as needing confirmation or disapproval by formal science, but rather [they] can complement scientific knowledge (Klein et al. 2014)" (SRCCL: p. 104). In the first chapter of SROCC, Section 1.8: Knowledge systems for understanding and responding to change, describes how Indigenous knowledges are not only meant to "complement scientific knowledge" (as stated in SRCCL: p. 104), but that Indigenous knowledges holds distinct and critical systems for observing, responding to, and governing the ocean and cryosphere in a changing climate. Indeed, Figure CB4.1 illustrates how the "knowledge from different systems can enrich the body of relevant knowledge while continuing *independently* or can be combined to co-produce new knowledge" (emphasis added; SROCC: p. 104 Cross Chapter Box 4), and makes clear that Indigenous knowledges can "stand on their own" as a form of evidence (SROCC: p. 102). SRCCL's chapter 6 and cross-chapter box 13 also provided space in which to recognised the intrinsic value and validation processes of Indigenous Peoples and systems. SRCCL includes content referring to the role that diverse stakeholder engagement—Indigenous Peoples, local communities, scientists, policymakers—can have for successful land, agricultural and environmental policy, as well as implementing response options through meaningful problem definition, knowledge assessment, and solution generation; "simply presenting 'scientifically' derived response options is not enough (Marques et al. 2016)" (SRCCL: p. 638).

We observed when the recognition of Indigenous knowledge holders and systems was also connected to content about Indigenous self-determination and governance. One such example from SROCC describes how "Inuit actively produce and use climate research (e.g., ITK, 2005; ICC, 2015) and lead approaches to address climate challenges spurred by great incentive to develop innovative solutions" (SROCC: p. 105 Cross Chapter Box). In terms of Indigenous governance, there was mention of non-state and local actors governing themselves through customary law, such as the creation of entitlements or norms to regulate shared and sustainable use of scarce resources (SROCC: pp. 97-98). In SRCCL, Indigenous forms of governance are included in a reference to customary land rights and systems of tenure.

Indigenous knowledge transmission and expression were present in the teachings of Elders being passed down to youth through shared activities and practices (SROCC), as well as in the social cohesion of sharing labour, resources, and remittances when responding and preparing to climate-related hazards like cyclones and drought (SR1.5). Reference to techniques like traditional rain water harvesting (SRCCL) and tools like traditional planning calendars (SRCCL) are indicators of how situated knowledge has been (and continues to be) shared for centuries. We also identified content that addressed potential constraints (SROCC: Section 4.3.2.2) and drivers of Indigenous knowledge loss. Examples included increased climate variability and 'westernisation', both of which continue to disrupt the transmission and expression of Indigenous knowledges (SR1.5: p.360).

Aligned with knowledge transmission and expression is understanding the wider historical, political, social, and cultural contexts of Indigenous knowledge. In SRCCL, there is mention of changing legal and policy frameworks to recognise and secure land tenure for Indigenous Peoples (and the benefit that can have for reducing deforestation and land management, SRCCL p. 749), however, there are few references to customary rights (i.e. land rights: pp 106, 749), with one paragraph mentioning the Amazonian colonisation and forced migration of people. In SR1.5, there is one paragraph that presents the argument for recognizing Indigenous rights, governance systems, and customary laws to support the realisation of climate adaptation and mitigation (SR1.5: p.337). This refers to the mutual economic, social, and ecological co-benefits of securing Indigenous land tenure and ownership (SR1.5: pp.330, 462, 477), while at the same time, explicitly naming root causes that hamper the realisation of Indigenous knowledges and self-determination such as colonisation, acculturation, dispossession of land, land grabbing, rapid environmental change, and social change.

Assessing the Gap: Dissonance Between Expectations and Existing Mechanisms

We present findings from our assessment of the gap between expectations —reflecting perceptions of the minimum standard—and existing mechanisms within the IPCC assessment process to diversify evidence and engage Indigenous knowledges and knowledge holders. Our assessment uses the framework previously developed (Figure 4.1).

Gaps in How Evidence is Framed

Experts unanimously called for direction from, and partnership with, Indigenous Peoples and organisations throughout the entire assessment process. Examples of present and previous experiences of Indigenous engagement included being asked after the text was already drafted (below), or ad-hoc

opportunities for co-authorship that arose through existing relationships and being known to IPCC author teams (i.e. writing cross-chapter boxes in SROCC and SRCCL, as well as a page for the polar regions cross-chapter paper in AR6). While enabling Indigenous co-authorship is taking a step in one direction, the present mechanism for doing so was reported to be neither timely nor determined by Indigenous Peoples, nor is it widely available to voices and groups less familiar to the IPCC. As one expert reviewer commented:

> *Ideally, Indigenous knowledge holders should participate in the development of these reports so that they stand as an example of HOW to be engaging with Indigenous knowledge…there are many communities and individuals from this population whose voices, knowledge, and experience would have strengthened the writing of this report had they been brought in from the beginning*—Expert Reviewer 9604 SR1.5

Another expert reviewer commented:

> *While the information included here is accurate and we're happy to have it in, we were surprised to see it included without having been contacted to have a discussion or even be notified that the IPCC report would like to showcase this work. While we understand the intention was to highlight this as a good example, we are very disappointed not to have had the opportunity to contribute to preparations and drafting of text about an ICC project. This is a good example where the importance of partnership with Indigenous Peoples and Indigenous Organisations could have been demonstrated through co-authorship but falls short*—Expert Reviewer 6068 SROCC

Self-determined opportunities for Indigenous knowledge holders and experts to contribute to the framing of IPCC assessments, such as authoring content or having a direct voice in Panel proceedings, was also emphasised. Here, the current mechanism for engagement was described as fitting Indigenous knowledge holders and experts within the IPCC's scientific and bureaucratic process and was not perceived as respecting and promoting Indigenous rights (i.e. under UNDRIP). For example, one expert reviewer commented:

> *The importance of partnership and self-determination for [Indigenous Peoples] in research and global assessments like the IPCC is emphasised. As such, we would like to see a point in the SPM when IK is mentioned that notes the importance of understanding and engaging with IK in a way that understands, respects, and promotes Indigenous rights*—Expert Reviewer 3088 SROCC

These comments repeatedly point to the absence of approaches—including formal guidance and standards of practice—for how knowledge holders and experts become a part of the overall process: from determining their own contributions and developing content, to the analysis and verification of findings.

Gaps in How Evidence is Evaluated

The existing mechanism of reviewing evidence in the IPCC process is predicated on peer-reviewed scientific literature. Some experts viewed this as a way of 'safeguarding' the IPCC from threats taken to undermine its credibility (i.e. as was previously seen in AR4). As one expert interviewee explained "it's much easier to defend [the inclusion of evidence] that has been in the peer-reviewed literature" [Expert Advisor 7]. Continuing from this, experts shared the view that "the IPCC has no methodology to include Traditional Local Knowledge in its works"—Expert Reviewer 9356 SR 1.5. Here, the expectation is that Indigenous protocols are used to identify and access the scope of "available and relevant" Indigenous knowledge sources and supporting evidence. References were made to missing Indigenous peer-reviewed sources, including oral evidences and testimonies (published and otherwise). Expectations aligned with a critical understanding that Indigenous knowledge research and scholarship be evaluated based on its congruency with Indigenous paradigms, perspectives, and peers. This included expectations that Indigenous knowledge generation, information ownership, Indigenous-led research, and self-determination be recognised within the IPCC evaluation of evidence in assessments. These expectations were included in reviewer comments as well as in the expert interviews; for example:

> *'Integrating' IK via publications from non-Indigenous authors is not appropriate. Nor is referencing how IK has been integrated in past assessment reports as well as other reports, like IPBES, which only serve to provide weak and poor examples*—Expert Reviewer 6062 SROCC

> *There's a lot of research being done in Indigenous groups...I think there is quite a bit going on. That's not necessarily through the academic system that we don't see because if you don't look for it you won't find it*—Expert Advisor 6, Academia

> *The challenge for the IPCC is, how do we use that information directly and not have to process it through a peer-reviewed journal, which is the way it's currently all set up, and I just got a deep gut level of that it's wrong to have to process that through a peer-reviewed journal because there is no one who will peer review that article who is actually genuinely qualified to review it*—Expert Advisor 8, Academia

> *Most of Indigenous Knowledge at community level will be important in a 1.5-degree world; the question is how this body of knowledge is integrated in IPCC assessments as a holistic body of knowledge and what other lessons can be drawn from it than just weather and climate indicator focused knowledge*—Expert Reviewer 12963 SR1.5

One IPCC author acknowledged that "there has been a lot more progress, I think, in terms of understanding the kind of breadth of knowledge but also different kinds of forms that communities can themselves also use to [store] traditional and Indigenous knowledge for their own kind of future generations" [Expert Advisor 7]. Despite a sense of 'progress' from some, Indigenous methods for

attributing knowledges and sources directly, with significant complexity and clarity to avoid misinterpretation and misrepresentation, are both missing. As one expert reviewer noted, “it is somewhat difficult to use ‘published’ Indigenous knowledge - first of all because very little is published, second, because it can easily be taken out of context and be misinterpreted, since it is very complex. The context/analysis should ideally always be confirmed by the knowledge holders” [Expert Reviewer 22590 SROCC]. Due to not having appropriate ways for evaluating evidence from non-western scientific sources, IPCC assessments have key gaps in knowledges from evidence that are either absent or over-simplified in arguments. For example, a section in Section 4.3.2.2 (SROCC) addressing the drivers of Indigenous knowledge loss or sources containing Inuit knowledge on sea ice in Chapter 3 (SROCC) [Expert Reviewers 6796; 18742]. Other resulting examples included how Indigenous knowledges were divided up into focused-content to fit specific sub-sections of the report (i.e. Section 4.3.3.2 on ecosystems and forest SR1.5; cross-chapter boxes SROCC and SRCCL; Chapter 3 SROCC; implementation of adaptation and mitigation response SR1.5: Chapter 4, Box 4.3, etc.). One interviewee explained:

> *A lot of reports always want you to "go give us examples of adaptation in the Arctic and how we are adapting"...and I think there's much less willingness on our organisations part to just kind of fit into the existing structure...it can't really work within the packaged structure that is IPCC. There's going to have to be, ideally I mean, I think it'll take a long time to get there, but ideally you'd have to kind of have some sort of a change in, or flexibility in, the process. I just don't see how you can just have an "Indigenous knowledge chapter", that's just not...that just wouldn't work*—Expert Advisor 1, IPO

Gaps in How Evidence is Accepted

Out of the 82 distinct expert reviewers identified as engaging with Indigenous knowledges and focused content, 79% were affiliated with an academic institution, while the remaining non-academic and non-governmental affiliations included only 2 IPOs. Right now, existing relationships with persons affiliated to the IPCC process raise and/or mentor possible engagement opportunities for Indigenous organisations and experts within the review process. Experts shared examples, which included guidance for how to approach conducting a review as well as learning from those embedded in the IPCC process the potential impact that their comments can have on the actual report. As one interviewee explained:

> *I don't know if they're aware…if you're an Indigenous person living in an island and [if] they review comments, because we have to look at every single comment and answer every single comment. And, that's a massive opportunity for influence. This is really difficult to even assess the literature, but it's really difficult to cover every angle and perception and, you know, and also if they know references because there's so many people who just write a comment, and say, ‘Well, I don't agree and there's so much literature on this’. Then that's it, and it's really difficult for us to then say ‘what are the papers that really demonstrate this point well’...I think that review comments in*

> *particular are really impactful, especially if they can kind of, you know, be able to show the authors another perspective, and help them to formulate that perspective as well...although we've got people who write paragraphs and tell us to insert them which we can't do*—Expert Advisor 7, Academia

Experts also voiced the need for more deliberate and widespread invitations to participate, along with being supported to do so. For example, one interviewee commented:

> *The biggest problem I've seen with bringing in different knowledges, it's just the fact that if you're not connected to the network you don't know what they're doing, necessarily. So, for example, there's a lot of open calls for people to participate, but if you're not on the list, you won't necessarily get to find out about the calls until maybe it's too late or you won't find out ever... I think if these processes want to include [Indigenous Peoples] they have to actively seek them out…to make them feel welcomed to participate...If you want to include Indigenous People then you would have to make sure that they are aware that they're welcome... It goes further than that, obviously, but once, if you approach them you have to include them in a way where indigenous knowledge is treated in a correct manner, you know you can't try to fit things into it…You have to give it space to be what it is itself.*—Expert Advisor 6, Academia

Gaps in How Evidence is Translated

Further gaps were assessed in how evidence is being translated, whereby final assessment products were not always accessible or relevant to those outside an academic audience. Existing mechanisms to translate evidence include high level government briefings of report summary findings; however, the reach of these does not extend to Indigenous organisations and councils. One expectation was that the IPCC promote opportunities that make the knowledge and science accessible by bringing them to relevant parties and groups in between assessments. Furthermore, experts spoke to how many Indigenous organisations and platforms already have an interest, as a part of their own mandate, to engage with the IPCC process. For example, one interviewee shared:

> *In our current mandate—it's called the Utigavik declaration—there's a whole section on Indigenous knowledge and it kind of calls on [our IPO] to promote the use of Indigenous knowledge in [western] scientific initiatives, and I think actually names the IPCC… So I guess in that sense the work of doing the reviews is fulfilling our mandate, it's benefiting us, and that we can report back on say we did participate in this... another benefit [for our IPO] is signalling as an Indigenous organisation, signalling to scientists and the co-authors and even sometimes there are policymakers...signalling that [we're] interested, Indigenous knowledge is important, this is how it should be done*—Expert Advisor 1, IPO

While the IPCC assessment process has already been recognised as relevant to what they do, their engagement still needs to be supported. Given that the IPCC provides an evidence base from which action is/should be taken, some experts questioned whether the process could shift from its declared 'policy-neutral' in principle to become more 'policy-reciprocal' in practice. One interviewee explained,

The IPCC is obviously the recognised scientific input. And their assessment reports and special reports and recognised central processes: the basis from which action should be taken. But there's actually a sort of...the opportunity to bring the science and knowledge to the parties in sort of between reports and it brings the most up to date information there. But it also has the ability to bring the knowledge that's needed in the exchange with the gaps as well around sort of research—Expert Advisor 9, UNFCCC

Proposing Solution Spaces: Potential Mechanisms and Future Opportunities

Drawing from discussion with expert advisors and comments made by expert reviewers—representing a variety of types of actors required for working with Indigenous knowledges in assessments—we propose potential mechanisms for facilitating the equitable consideration of Indigenous knowledges within the existing IPCC process, as well as those that may extend beyond it. Table 4.7 is based on the findings from our analysis of reviewer comments and interviews with experts. The first column represents the process as outline in our guiding framework (Figure 4.1). The questions can be used to navigate the text that follows. By assessing the gap, we focus on 'what is expected' and look at 'what exists to meet those expectations'. After which we present more findings from the interviews with experts and reviewer comments that focus directly on 'what more could be done'. Figure 4.4 positions potential mechanisms in relation to the existing assessment process. 'Existing mechanism' and 'priming mechanisms' fall within the core areas of assessment found in figure 4.1, while 'reaching mechanisms' and 'aspiring mechanisms' are positioned away from the centre in terms of their feasibility.

Table 4.7 Gaps between expert expectations and existing mechanisms within IPCC assessment process.

Process	What is expected?	What exists to meet expectations?	What more could be done?
Overall Process and Framing Evidence	Direction from, and partnership with, Indigenous Peoples and organisations throughout the assessment process.	Relying on existing relationships/history of engagement to facilitate ad-hoc engagement.	Indigenous councils/governing organisations invited to become observers/members of the Panel.
	Self-determined opportunities for Indigenous knowledge holders and experts to contribute/ author content / direct voice in sessions of the Panel, WGs, TFs, workshops, and plenary meetings.	Fitting Indigenous knowledge holders and experts within a (western) scientific and bureaucratic process.	Training for WGs to promote an understanding of what are Indigenous knowledges and protocols for the ethical engagement of Indigenous knowledge. Indigenous expert meeting(s) via IPCC WG executive committees in partnership with IPOs. Resources and funding to support Indigenous self-determination in assessment process.
Evaluating Evidence	IK research and scholarship should be evaluated based on its congruency with Indigenous paradigms, perspectives, and peers, not western scientific.	Report content begins to recognise Indigenous Peoples and their knowledge; however, there are currently no Indigenous protocols or methodologies to do so, and there is no formal guidance for assessing different types of knowledge.	Consultation on methods and protocols to find and promote Indigenous scholarship with IPOs, IPBES, CBD, LCIPP, IUNC. Indigenous expert meeting via IPCC WG executive committee, in partnership with IPOs.
	Indigenous protocols for identifying and accessing the scope of "available and relevant" Indigenous knowledge sources and supporting evidence.	IPCC assessment based on a scope of (western) scientific literature, already prone to selection-bias, and does not have mechanisms for assessing the Indigenous-knowledge base.	New executive structure or coordinating group to develop IPCC framework/guidelines/methods for knowledge engagement.

	Indigenous methods for attributing knowledges and sources directly and with significant complexity and clarity to avoid misinterpretation and misrepresentation. Recognition of Indigenous knowledge generation, information ownership, Indigenous-led research, and self-determination.	Fitting Indigenous knowledges within a (western) scientific knowledge form; without proper accreditation of where/who the knowledge comes from. IK divided up into focused-content and specific sub-sections of the report.	Cross reference Indigenous sources consistently and in depth throughout report. Allow more space and depth for relevant non-western scientific knowledge systems and sources within the main text of report. Communicate Indigenous leadership and partnerships behind the evidenced examples.
Accepting Evidence	Deliberate invitation and support to participate in expert review activities. IPOs see the IPCC process as relevant to what they already do and want to engage. IPOs have their own mandate to engage with the IPCC process.	Existing relationships mentor ad-hoc engagement opportunities for IPOs and the impact potential of participating in the review.	Indigenous councils/governing organisations invited to become observers/members of the Panel. Align process with IPOs that are already keen to engage with the IPCC.
	Process needs to become policy-reciprocal and relevant.	IPCC assessments provide an evidence base from which to action is/should be taken. Assessments should be neutral with respect to policy.	Reciprocal and targeted science-policy statements and dialogues.
Translating Evidence	Final assessment products need to be accessible and made relevant to IPOs and Indigenous communities. Opportunities in between assessments to bring the knowledge and the science to parties.	High level government briefings of report summary findings.	New executive structure or coordination group to develop framework/guidelines/methods for knowledge dissemination and follow up. Targeted dissemination/policy briefings of findings to IPOs; engage IPOs to make findings accessible and relevant at local levels of governance and implementation.

Beyond the IPCC Process	The IPCC is one of many platforms that IPOs want to engage with and there are limited capacity and resources to do it.	IPCC is an independent process from the UNFCCC; however, flow back from IPCC is used to inform their mandate and engagement.	Resources and funding to facilitate ongoing conversations and collaborations with IPOs and Indigenous Peoples. Align process with IPOs that have mandate to engage with the IPCC. Align IPCC's process with UNFCCC's process, which has a mandate to engage with IK. Connect IK learning/engagement across CBD, IPBES, IUCN; UNFCCC, IPCC.

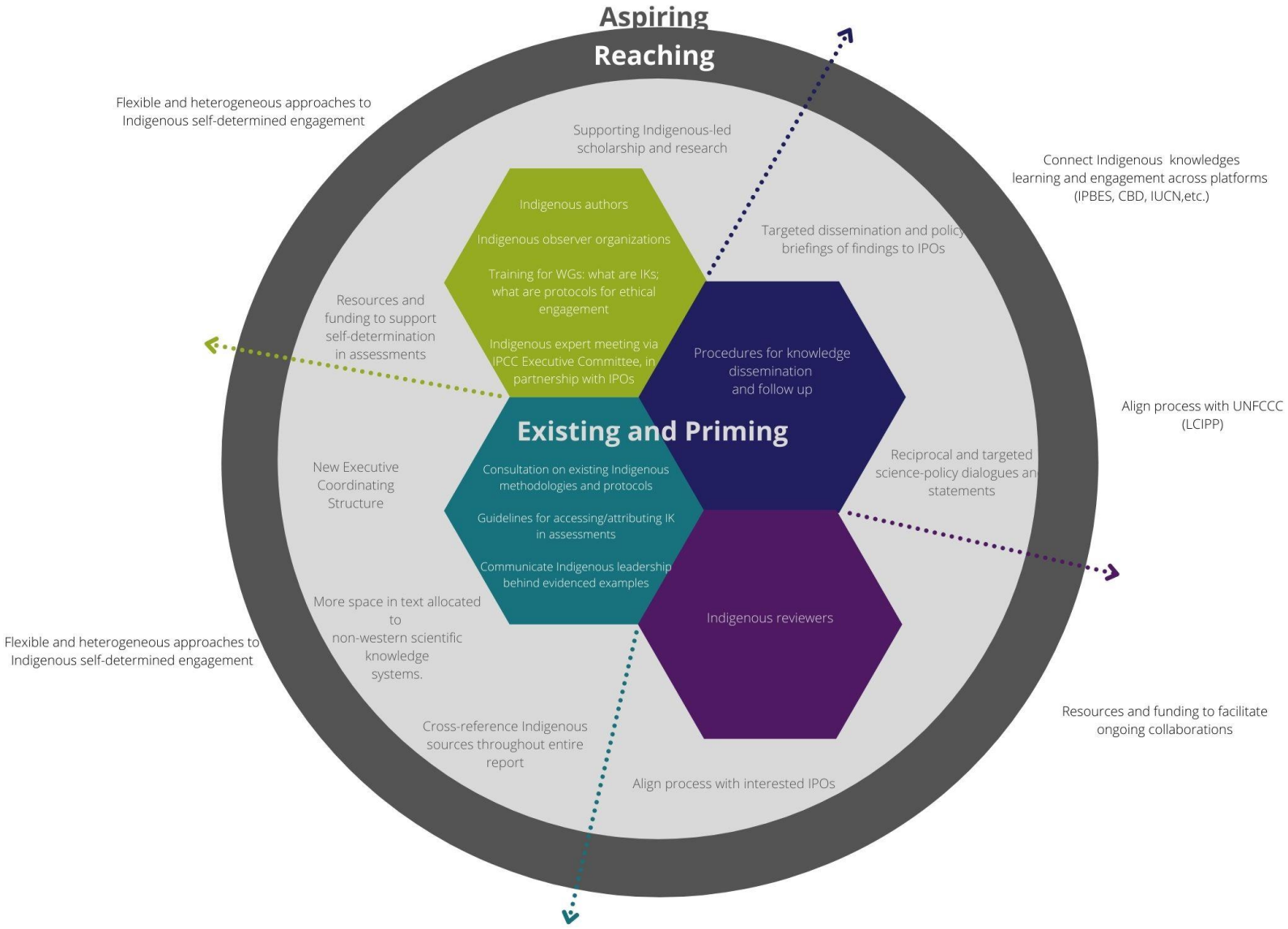

Figure 4.4 Potential mechanisms to facilitate the equitable consideration of Indigenous knowledges within, and beyond, the IPCC assessment process.

Potential Mechanisms for Framing Evidence

We propose developing mechanisms to explicitly define what counts as 'knowledge' and 'evidence'. As previously assessed, there is a gap in partnering with Indigenous Peoples and organisations, with calls for early and ongoing participation in report development and throughout the entire assessment process. In addition to Indigenous authorship, Indigenous observers or members of the Panel would enable a direct channel for Indigenous voices to open and frame the evidence assessment process from the beginning (i.e. the outline and selection of topics as well as nominations of experts) through to the final approval sessions (i.e. the deliberations and dissemination of the report). As one interviewee suggested:

> *If the process stays as it is for the next assessment…what I said about bringing the Indigenous voices in is to try to get more Indigenous authors. I'm really pleased with the chapter team we have in this assessment because it's half people who have a long history of working on these issues on the Islands and half of them are from those Islands. I think we have a really good balance in that chapter team...Having Indigenous authors being part of the writing team and writing things that can then be decided and that represents the knowledge in a way that they are comfortable with*—Expert Advisor 7, Academia

One coordinating mechanism that emerged was to go through existing channels of the IPCC Executive Committee to convene an expert meeting in partnership with–or led by–Indigenous Peoples. Previous models were described for specific topics such as cities (2018) as well as culture and heritage (2021). As one interviewee shared:

> *Through conversations with the IPCC, what we understood that the first major step was to ask the IPCC essentially to sponsor an expert meeting, and that would really be an official part of the IPCC taking on the issue and saying sort of where are we, what is our state of knowledge around this topic, and then what comes out of that expert meeting is basically a formal report that has some recommendations and then the IPCC can take some steps from that. And our model for this is, there was an expert meeting on climate change and cities that was held in early March of 2018*—Expert Advisor 8, Academia

For the IPCC to revise how topics are framed and evidence engaged also means training authors in how to do the work. For example, such training opportunities could raise awareness about the value and importance of evidencing Indigenous knowledges and engaging Indigenous knowledges holders in the assessment process. Experts shared how training could be facilitated for individuals from each Chapter Team (secretariat, working group executive committees, technical support units) about "what is Indigenous knowledge and how do you ethically engage with Indigenous knowledge, and why is self-

determination in research important for Indigenous Peoples"—Expert Advisor 1. Critically, this would help to build an awareness to recognise when knowledge is being inappropriately made to "fit" scientific paradigms and structures. Meaningful partnerships with IPOs and platforms could help facilitate these trainings and workshops along with adequate resources and financial support for trainers and authors to attend [Expert Advisors 1, 2, 4, 8, 9, 10, 12].

Potential Mechanisms for Evaluating Evidence

We propose developing mechanisms to explicitly define how to access, attribute, and synthesise different forms of knowledge, as well as how to assess confidence in diverse evidences. Guidelines and protocols, developed by Indigenous knowledge holders and experts, exist that can guide the ethical engagement of Indigenous knowledge—key references: Inuit Tapiriit Kanatami (12), Utigavik Declaration (51), Our Knowledge Our Way (16), Local Biodiversity Outlooks 2 (52), EMRIP. However, critical dialogue and consultation with Indigenous organisations and scholars is needed to determine how these methodologies may be applied respectfully within the context of the IPCC. One potential mechanism would be the development of an executive structure or coordinating group within the IPCC could catalyse the formalisation of guidelines for accessing and attributing Indigenous knowledge sources [Expert Advisor 9, 1]. One interviewee suggested,

> *The only way I can perhaps see it [changing how the IPCC model is predicated on peer-review / bringing in diverse knowledges] happening is to have some sort of collaborative or coordination group across scientists to try and develop some sort of better understanding of how it can happen and start seeding this idea moving forward in with small, even online, groups…these days, we're all used to it. So bringing friends of this idea together to start looking at how it can be done and start to propose these ideas…And, ultimately writing a letter to the to the IPCC Chair to say we are a bunch of people that would suggest the following and perhaps that's one way of bringing things forward as well...you need to be able to sort of present the idea, either to the Secretariat: this is an idea how do we populate it? Or can we bring it into the discussions that the Secretariat is organizing on extra work, and then if you want to bring it to the process level, you have to go to the chair of that process, so that the IPCC chair…Or you can also write to the heads of the Secretariat, and say we'd like to have an informal discussion*—Expert Advisor 9, UNFCCC

Furthermore, experts recommended that Indigenous knowledge, if considered a knowledge source used to inform IPCC reports, be cross-cutting throughout the whole report and not only divided up into Indigenous-focused content and discussion across multiple report chapters and sections [Expert Reviewers 2639 SROCC; 55504 SR1.5]. This would support the appropriate evidencing of Indigenous knowledges and focused content throughout the entire report, rather than it only being highlighted in

chapter-boxes or singular stand-alone paragraphs. As SROCC authors highlight in their response to a reviewer comment:

> *Considering that IPCC has been founded upon scientific knowledge from its beginning and we are in SROCC framing and formally introducing IK & LK for the first time, it needs space—* Author Response SROCC

As indicated by both IPCC authors and reviewers, non-western scientific knowledge systems and sources require more relevance and depth of information within the main text of report as well as in cross-chapter boxes as opposed to in sub-sections, as has been done previously [Expert Reviewers 16042, 22548 SROCC; 55504, 40410 SR1.5]. This includes communicating the Indigenous leadership and partnerships behind the examples being evidenced in text, such as adaptation responses and mitigation options.

Potential Mechanisms for Accepting Evidence

We propose developing mechanisms to explicitly define how evidence is reviewed and then confirmed. Opening the process to Indigenous expert reviewers, particularly individuals with targeted expertise who may not be already known to the Bureau or in the IPCC's list maintained from previous reports and nomination processes, is another option that can be readily implemented. This will require coordinated efforts to specifically invite and/or support Indigenous reviewers to participate in the process by moving from a passive invitation to active efforts to ensure representation. Once again, having Indigenous observers or members of the Panel would ensure a direct channel for Indigenous voices in the final approval sessions. As one interviewee explained,

> *If the process stays as it is for the next assessment…I think it is about bringing in more Indigenous authors but also making authors more aware of the imbalance of the sources that we might be citing and trying to look for, but it's really difficult to look for. You don't stumble across that and then specifically go to each country and try to find Indigenous papers...So I think for Indigenous authors to actually then publish papers about the knowledge that they want to share or, you know, that's coming through their research. I think that's, that's really a key. Because then there is material available for IPCC to cite and it's not just the grey literature—* Expert Advisor 7, Academia

Potential Mechanisms for Translating Evidence

We propose developing mechanisms to explicitly define how to disseminate and share the resulting information. For people and organisations that are connected to local forms of governance and realising solutions on the ground, the IPCC needs to meaningfully extend the reaches of their findings

[A.2, A.4, A.12]. This would mean a bringing a focus to the targeted dissemination such as delivering policy briefings of findings to IPOs, even translating content into Indigenous languages.

> *When the IPCC land report was released in August 2019 in Geneva, we also released a host of case studies based on land forests and communities to show how do we see the relevance of land and forest to climate mitigation and adaptation...it's not only the review of IPCC, how do we relate our work on the review of IPCC and the IPCC reports, in tandem with how do we see the realisation of those through case studies where communities land and forest are involved*—Expert Advisor 2, IPO

Furthermore, using the same engagement channels (i.e. executive structure or coordination group within the IPCC) to consult with Indigenous organisations and councils to determine how to make findings relevant and co-develop procedures for knowledge dissemination and follow-up.

Clarifying Feasibility: Stretching Beyond the IPCC Process

Despite the potential mechanisms, proposed above, many are challenging in practice and would not be possible without reformation of the IPCC evidence assessment process. Therefore, in proposing potential mechanisms, we also considered what the limitations of implementing changes to the existing process may be as well as the stretch required to extend beyond the current process (Figure 4.4). For example, report authors responded to expectations and potential mechanisms by presenting the limitations of the process and wider system within which they too were situated. As IPCC authors and interviewees commented,

> *IPCC authors must assess credible knowledge from published sources and free of specific interest or 'knowledge ownership and control' issues. However, we agree very much that Indigenous knowledge holders should be involved in integrated assessments including on global climate change such as the IPCC. Indeed, our efforts in SROCC are intended to prepare for improved engagement in the AR6 and beyond. It was time pressure that did not allow us to seek Indigenous co-authorship*—Author Response 6068 SROCC

> *I'm concerned that we are jumping too quickly, not only in the context of IPCC, and politely inviting contributing authors and Indigenous authors, which we of course should do. That's an important step but it's a multitude of steps that we need, and any Indigenous person becoming a PhD level or professor level scholar today has had to undergo a certain process of becoming a scientist… There are nuances of tokenism: if we are saying that the solution lies in only getting more numbers of Indigenous scholars, but we don't discuss how does the whole field of what's known as 'Indigenous climate change studies' look like*—Expert Advisor 10, AR6

Some advisors questioned whether it is even possible to meaningfully engage Indigenous knowledges without changes to existing fundamental structures. For instance, interviewees shared:

> *The structure, as is, you can't just insert in knowledge holders or Indigenous Peoples into it... so how then can that structure change and I think that there's probably lots of answers to that too*—Expert Advisor 1, IPO

> *Sometimes in trying to do good…or trying to do the right thing at a certain pace…that we sometimes end up creating more problems than solving*—Expert Advisor 12, IPO

We propose looking beyond the existing IPCC process to clarify the feasibility of developing mechanisms for the equitable consideration of diverse knowledges. Most experts acknowledged that change of this magnitude, a shift in paradigm, takes time and shared stories of the enduring efforts by people and communities determined to make this shift happen. Indeed, one interviewee explained:

> *Why are you coming to these end of the earth meetings, that was in Cambridge at the time, and why are you coming here from New Zealand when nothing, ultimately, will change this week. Aroha [Mead] answered to me by saying that the Māori, in this case, were the collective of trying to advance the Māori knowledge and engagement with these particular structures, and said that it's a decade view, sometimes a century view, that by going into every committee meeting, and always repeating the same: Indigenous rights, Indigenous knowledge, Indigenous women, work with us. And sending out these…almost like ambassadors to all of the UN groups, all of the UN processes, the Māori were conceptualizing, as she was saying, that one day there will be shifts*—Expert Advisor 10, AR6

Some experts looked to Indigenous organisations and platforms that themselves have determined mandates to promote the use of Indigenous knowledges in scientific initiatives. Examples include the UNFCCC's Local Communities and Indigenous Peoples Platform and their Facilitative Working Group, as well as the Working Group on Article 8 (j) within the Convention on Biological Diversity (CBD). As one interviewee suggested,

> *So there are things already there, I only think that somehow they need to recognise and prioritise also that you need to have...you need to attempt to include those as part of your methodology and collecting evidence...one way of getting that into the process, is perhaps the involvement or getting feedback from the now recognised LCIP platform in the UNFCCC, and the article 8(j) working group of the CBD, I think that those two will be a good enough thing to start somewhere down the line*—Expert Advisor 2, IPO

Other experts were on board with channelling the work of Indigenous knowledge engagement through Indigenous organisations and governance bodies, such as the Inuit Circumpolar Council, who already have developed protocols and ways of working with relevant intergovernmental and research initiatives that suited them (Utigavik Declaration). As one interviewee commented,

> *There could be an opportunity there [with the LCIPP], but that being said, I don't think the IPCC should go to the UNFCCC to answer this question of how to improve Indigenous participation, they should go directly to Indigenous organisations*—Expert Advisor 1, IPO

The IPCC is one of multiple intergovernmental platforms that IPOs wish to engage with and there are limited capacities and finite resources for them to do so. Some Indigenous experts and organisations are already making the decisions on whether to spend the time feeding into other assessment processes like IPBES and national or regional assessments such as the Snow, Water, Ice and Permafrost in the Arctic (SWIPA) [Expert Advisors 1, 2, 5, 6, 10]. Furthermore, significant contributions go towards participating in the UN Conference of the Parties (COP)—either within the UNFCCC or the CBD as well as the Expert Mechanism on the Rights of Indigenous Peoples (EMRIP) within the Human Rights Council [Expert Advisors 3, 4, 5]. Many expert advisors expressed that it might be possible to connect the learning and engagement of Indigenous knowledges across these different UN bodies. This idea emerged both from a concern about their capacity to engage as well as an interconnected and relational ways of knowing. As one interviewee suggested:

> *Why the UN system of knowledge cannot come together [instead of] having the CBD separately, climate change separately...why not having all of them together because in the reality and on the ground, there is no climate change solution in one square meter; and biodiversity in one square meter. All are part of the same environment and same climate*—Expert Advisor 4, IPO

While the UNFCCC has its own governance structures, organizing principles, and processes, there are resourced priorities and positions dedicated to "bring the science and Indigenous knowledge together under the process, which includes trying do a little bit from our side…sort of engaging a little bit further with how the scientific community, including the IPCC look at this"—Expert Advisor 9, UNFCCC. Under its own mandate, the IPCC includes looking at ways to support the UNFCCC process (Table 4.1). For example, under an existing mandate, the UNFCCC invites the scientific community to engage further with Indigenous experts and knowledge holders and equitably consider different knowledge systems.

> *The flow back [from the UNFCCC to the IPCC] really comes in terms of physically people being in the same room at the conferences [COP] and getting the ideas of what happens, but actually the flow back is usually in the form of mandates...under our process, there's something called the joint working group, which is a discussion group between the SBSTA and the IPCC sort of the Secretariats and the presiding officers and that meeting also includes those representatives*

> *of the constituted bodies, which includes the LCIPP now, so there is sort of an exchange of information at this high level*—Expert Advisor 9, UNFCCC

Still, Indigenous knowledge holders and experts continue to voice their opposition to the (re)institutionalisation of knowledges, and knowledge holders, within a non-Indigenous process and wider system reminiscent of colonial regimes. For instance, interviewees commented:

> *The successful system is one where people like me, who look like me, do not challenge. We accept. As this is the only narrative, is the only game in town, and I am a part I don't even question it. And sometimes I feel like that same thing also happens within the narrative of the UN family, you know, because it's very bureaucratic, isn't it? It's very professional. You will never have an Indigenous Elder in the UN getting it*—Expert Advisor 12, IPO

> *Those of us who are able to become the elites and join the mission, become the IPCC authors or otherwise recognised authors in science on Indigenous issues, often wield a position of power and we can either make or break certain nuanced and emphasised ways of doing things and this position is a very dangerous one because it has, not huge power, but it has power that is very significant to the discussion of how Indigenous knowledge is allowed*—Expert Advisor 10, AR6

Discussion

In this paper, we aimed to assess formal IPCC mechanisms for equitably considering diverse sources of knowledge, specifically Indigenous knowledges, along a path of evidence assessment. To do this, we examined how the IPCC defines and mandates the curation the knowledge and sources of evidence that feed global, national, and local climate change responses by reviewing the different processes, and critiques, of the IPCC assessment cycle. We extended the work of Smith and Sharp (2012) and Ford et al (2016, 2012) to examine how Indigenous-focused content has been evidenced into IPCC assessments—paying specific attention to its evolution over time from AR4 up to, and including, the sixth assessment cycle special reports (SR1.5, SROCC, and SRCCL). We assessed the gaps between expectations and existing mechanisms within the IPCC assessment process to evidence Indigenous knowledges, and engage knowledge holders, by analysing expert reviewer comments from drafted versions of IPCC special reports. We added depth to our analysis by conducting interviews with a range of experts. Finally, we proposed potential mechanisms for facilitating the equitable consideration of Indigenous knowledges within, and beyond, the existing IPCC assessment process.

Our findings revealed a substantial dissonance between the limits of existing mechanisms, expert expectations, and the feasibility of meeting those expectations within the existing process. Table 4.7 presents findings from both expert review comments and interviews with experts and offers a

framework for moving forward. Furthermore, this dissonance converged with our review of Indigenous-focussed content. Whereby Indigenous-focussed content and evidenced Indigenous knowledge are increasing, the mechanisms for meeting expectations of equitable engagement lie largely outside the limits the current IPCC process (Figure 4.4). The review of the sixth assessment cycle Special Reports here, as well as the review of AR5, rely heavily on analysing the content identified by keywords, rather than the actual epistemology, ontology, methodology, and axiology underlying each concept and its presentation. We acknowledge the limitations in our methods and that attempts to 'mainstream' Indigenous-focused content and knowledges may not be captured. While this reflects the limit of our methodology, it also indicates the limit of the IPCC's methodology to consider the Indigenous-knowledge base. For example, SROCC's Chapter 3 on polar regions explicitly states that Indigenous knowledge, local knowledge, and practitioner knowledge have been considered in parallel with western scientific knowledge when framing and evaluating the scope of best-available evidence (50). It is possible that other chapters in SROCC, SRCCL, and SR1.5 also did this. We consider this a proposal for working *within* the existing assessment process and perhaps a starting point for developing and building on mechanisms earlier in the evaluation of evidence. In addition to mainstreaming the evidencing of Indigenous knowledges in reports, explicit and in-depth examples of Indigenous knowledges, like those seen in cross-chapters boxes, is another mechanism that already exists and is being put into practice (i.e. cross-chapter box 13 in SRCCL; cross-chapter box 4 in SROCC). Cross-chapter boxes are positioned to attract readership and elevate topics of critical importance by making them more visible.

In reviewing the potential mechanisms, we also considered the stretch required to extend beyond the current process and what the limitations of implementing changes to the existing process may be (Figure 4.4). One thing that became evident was that before being able to develop mechanisms to fill existing gaps in the assessment process there are potential 'priming' approaches that can be taken within the governance structures of the IPCC (i.e. the Secretariat and WG Executive Committees). Following existing models and growing interest, these mechanisms could begin to take shape immediately and would make room for more interim ideas to grow—such as developing guidelines for accessing and attributing Indigenous knowledge sources and procedures for targeted knowledge dissemination. We also note that most potential mechanisms are either concentrated on the framing and evaluation of evidence. This could be signalling where there is most dissonance in the process and underscoring that evidencing diverse knowledges equitably begins with embedding change from the beginning in process goals and principles (7,11,53,54).

As one expert said, “the IPCC very clearly holds its reputation, a very good reputation, in the UNFCCC process…but they need to find a way of moving forward” [Expert Advisor 9]. There may be many ways to move, some within and others beyond, the existing IPCC process. Regardless, to achieve procedural justice in IPCC assessments and ensure reciprocal responsibilities and benefits of engagement with diverse knowledges and knowledge holders (46,47,55), the IPCC process will need to change. The role of the IPCC is not to answer all the questions, rather to figure out ways to assess—on a comprehensive, objective, open, and transparent basis—what is the current state of knowledge / available information relevant to understanding and responding to climate change (Table 4.1). Given the ever-growing base of available peer-reviewed scientific literature (35), to diversify their evidence-base the IPCC will need to diversify how they assess evidence. This means honestly reflecting on the dissonance between the function of the IPCC as well as its fundamental structure moving forward. This is a problem that arises before we even get to diversifying our knowledge base; perhaps it is an entry point for the wider revision. More diversified knowledge-bases and actors can better shape how we assess evidence, gather information, and solve problems (2–4,46,53,56–58). The equitable consideration of diverse forms of evidence relevant to climate change risks, impacts, and potential responses seeks to enhance the legitimacy of the assessment process as well as who this process has relevance for.

The IPCC has persistently argued that climate policy must be forward-thinking, anticipating future pathways and making decisions now to ensure just transitions. For its own process of evidence assessment, the IPCC must be as forward-thinking in planning for a process within AR7 that responds to increasing calls for equitable diversity of knowledge in a just process of evidence assessment. Like climate policy, ‘business-as-usual’ is insufficient for the next generation of climate assessments. The IPCC assessment process will only experience more (not fewer) challenges to its outlined goal and principles unless mechanisms are designed to safeguard and facilitate the equitable consideration of diverse knowledges as evidence.

List of Abbreviations and Acronyms

AR4—Fourth Assessment Report

AR6—Sixth Assessment Report

AR7—Seventh Assessment Report

CA—Contributing Author

CBD—Convention on Biological Diversity

CLA—Coordinating Lead Author

FOD—First Order Draft

GFP—Government Focal Point

IPBES— Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC—Intergovernmental Panel on Climate Change

IPO—Indigenous Peoples Organisation

LA—Lead Author

RE—Review Editor

SOD—Second Order Draft

SPM—Summary for Policy Makers

SR—Special Report

SR1.5—Special Report on Global Warming of 1.5°C

SROCC—Special Report on the Ocean and Cryosphere in a Changing Climate

SRCCL—Special Report on Climate Change and Land

TF—Task Force

UNDRIP—United Nations Declaration on the Rights of Indigenous Peoples

UNFCCC—United Nations Framework Convention on Climate Change

WG—Working Group

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Chapter 5—Conclusion

This chapter concludes the thesis and reviews the aim, objectives, and guiding questions set out in Chapter 1. Here, we return to the key concepts that have been used to braid this work together and explore equitable mechanisms and just processes for diversifying knowledges to advance climate-health responses. Chapter 5 outlines the key contributions of the thesis towards answering: why diverse knowledges matter for effective adaptation responses (Chapter 2); what procedural justice means for initiating adaptation responses in practice (Chapter 3); how climate change assessments can equitably and meaningfully bring together diverse knowledges (Chapter 4). As a whole, this thesis aims to provide empirical evidence that examines the critiques of existing processes, questions the limitations of conventional approaches, and builds confidence in the possibilities of knowledge diversity and procedural justice.

Recap of Thesis Aim and Structure

Research Aim and Objectives

From Chapter 1, the thesis set out to explore equitable mechanisms and just processes for diversifying knowledges to advance climate-health responses. This aim guided the design and application of appropriate research objectives, methodology, and scope in each of the three empirical chapters (Table 1.1—Chapter 1).

Table 1.1. Overall research aim and objectives with associated methodology and scope corresponding to empirical thesis chapters.

Aim: To explore equitable mechanisms and just processes for diversifying knowledges to advance climate responses.

Objective	Methodology	Scope—Source	Chapter—Output
Guiding Question: Why do diverse knowledges matter for effective adaptation responses?			
1. To critically appraise contributions and mechanisms for engaging diverse knowledges in integrated climate-health monitoring and response systems globally.	Systematic literature review, evidence synthesis, and confidence assessment of published empirical papers on integrated climate-health monitoring and response systems	Global— Theoretical and empirical secondary evidence	Chapter 2 Published Manuscript
Guiding Question: What does procedural justice mean for initiating adaptation responses in practice?			
2. To contextualise mechanisms for initiating integrated climate responses within existing knowledge networks of community health and subsistence food systems in Uganda.	Place-based key informant interviews, participatory knowledge holder mapping, social network theory and analysis	Local— Place-based empirical primary evidence	Chapter 3 Published Manuscript
Guiding Question: (How) Can climate change evidence assessments equitably and meaningfully bring together diverse knowledges?			
3. To assess mechanisms for equitably considering diverse knowledges in global climate change evidence assessments.	Targeted review and synthesis of IPCC procedures and principles, IPCC Special Reports (sixth assessment cycle), IPCC expert reviewer comments, and interviews with expert advisors	Global— Science-Intergovernmental secondary and primary evidence	Chapter 4 Prepared Manuscript

Thesis Structure

Here, I identify how the empirical work contributes to answering each of the guiding questions set out in Chapter 1 (Table 1.1). I also return to the core concepts of effective adaptation response—as a mandate for targeting the empirical work; knowledge diversity—as an entry point for inquiry; and equitable and just process—as a frame for investigation.

Chapter 2 contributed to answering why Indigenous knowledges and local knowledges matter for effective climate adaptation responses. This chapter presented a systematic literature review, evidence synthesis, and confidence assessment of published empirical papers on integrated climate-health monitoring and response systems. The methodology responded to objective (1) by critically appraising the contributions and mechanisms of engaging diverse knowledges.

Chapter 3 contributed to answering what procedural just means for initiating an adaptation response in practice. This chapter presented a case study from southwestern Uganda using place-based key informant interviews and participatory knowledge holder mapping with diverse knowledge holders of community health and subsistence food systems. The methodology responded to objective (2) by contextualizing mechanisms for initiating integrated climate responses within existing knowledge networks.

Chapter 4 contributed to answering (how) can climate change evidence assessments, like the Intergovernmental Panel on Climate Change (IPCC), equitably and meaningfully bring together diverse knowledges. This chapter presented a targeted review and synthesis of IPCC principles and procedures, the sixth assessment cycle Special Reports, expert reviewer comments from drafted versions of Special Reports, as well as in-depth interviews with expert advisors. The methodology responded to objective (3) by assessing formal IPCC mechanisms for equitably considering diverse knowledges, specifically Indigenous knowledges, in a global climate change evidence assessment process.

Key Contributions of the Thesis

Why do Indigenous knowledges and local knowledges matter for effective adaptation responses?

Chapter 2 provides empirical evidence (and confidence) to show that Indigenous knowledges and local knowledges matter to climate-health adaptation responses. This has significant implications for global climate change discourse and policy where arguments about the value of diverse knowledges persist. To be clear, this uncertainty of value and recognition has nothing to do with the significance that knowledges have for the generators, holders, and communities themselves. As Kyle Powys Whyte highlights, there is immeasurable meaning in what Indigenous knowledges do for Indigenous peoples in their own ways of governance and the self-determination of rights and responsibilities (1). It is unfortunate, however the case, that external recognition (by western scientists and policymakers) of what diverse knowledges contribute to climate adaptation responses is an essential part in the realisation of procedural justice in global discourse, policy, and future planning—both within and outside of the IPCC. In terms of recognition at the level of global discourse and policy, my work aligns with the UN Framework Convention on Climate Change (UNFCCC) mandate, which calls for the western scientific community to engage further with Indigenous and local experts and knowledge holders. It does so by building confidence—specifically for the western scientific climate community—in the possibilities of knowledge diversity, equity, and procedural justice.

Chapter 2 uses an evidence synthesis approach (GRADE-CERQual (2)) to support four key insights about how Indigenous knowledges and local knowledges advance climate-health responses—through detection, attribution, action, and divergence. Systematic reviews and meta-analyses/syntheses in global health have applied such approaches to help answer questions about interventions, systems complexity, as well as guideline development and decision frameworks at local and global scales (3–6). The purpose of taking this approach to evidence synthesis is to catalyse understanding about complex systems and inform evidence-based policy decisions about the development and implementation of interventions (3,4). Despite its suitability, to my knowledge, applying a confidence assessment to systematic review findings from participatory and mixed-methodological research has yet to be applied in the assessment of climate adaptation responses.

As it was applied in Chapter 2, the evidence synthesis approach enabled a critical examination of adaptation response effectiveness, in terms of knowledge diversity, equity, and procedural justice.

The confidence gained from applying this approach to mixed evidence synthesis is, however, still rooted in a western-scientific paradigm and any adaptation response by non-western scientific knowledge holders will undoubtedly undergo Indigenous-and or local-generated forms of effectiveness assessment (i.e. to determine why and how a response works; for who and in what circumstances; how does it change human, environment, and health systems over time). Still, this is an example of how distinct and diverse ways of knowing not only create but also evaluate effective climate-health responses.

In the context of advancing our responses to climate change, one thing that became evident through using knowledge diversity as an entry point for inquiry was an expanded, interconnected, and relational understanding of health. Human systems are a part of ecological systems, making the health of human and more-than-human beings within these systems interdependent, if not one and the same. Calls for the integration across western knowledge domains of ecological, health, and social sciences are mounting against the backdrop of today's global pandemic along with the pressures of climate change and biodiversity loss (7). This work attempts to hold space for relational and dynamic climate-health boundaries. Such space is motivated by connecting learning from Indigenous knowledge holders and experts who have long recognised and defended an interdependence and intimacy of the health and wellbeing of all living beings(1,8–12). For example, a vital part of how Inuit conceptualise their health and wellbeing is rooted in a connection they feel with the land itself (13). This connection is not unique to Inuit, nor is it shared by all, as it can be realised differently by different people through acts of reciprocity—land-based practices, ceremonies, stories, teach-ins, land-based medicine—and is therefore contextual and specific to place and being—mind, body, emotion, and spirit (1,8,9). Mohawk teachings, for example, disintegrate boundaries completely by considering the waters of the earth and our bodies to be from the same source, reminding us that violence to one is violence to the other (12). Recognising how context-dependent and diverse conceptualisations of health can be then similarly how health is affected or impacted will differ from person to person and place to place. Broadening our understandings of the interdependence and intimacy of environment and health creates a space where we can understand and respond to the realised impacts of climate change on health in just and equitable ways.

Far more than the equitable benefits of adaptation responses, procedural justice speaks to the autonomy and equity of diverse knowledge engagement throughout the entire process informing response (14–16). Given that the findings from Chapter 2 can be considered a reasonable

representation of climate-health adaptation responses, this work provides evidence to support the terms of autonomous engagement of non-western scientific knowledge holders—local communities, Indigenous peoples—in ongoing and initiating response processes. The existing practice-gaps identified—such as local and Indigenous-led initiation and definition of responses, non-western-scientific knowledge ownership and information control—can be used to develop guidelines for initial calls in adaptation response funding or indicators of response effectiveness used in (western-scientific and non-western scientific) evaluations of responses.

What does procedural justice mean for initiating adaptation responses in practice?

Chapter 3 provides a case study for *how* procedural justice might be used to guide the first stage of adaptation initiation in practice. Intentional and equitable consideration of existing networks of diverse knowledges, trusted relationships, power imbalances, and agency is a crucial, and perhaps overlooked, place to begin before we develop, design, and implement climate adaptation responses (17). This is particularly critical in contexts like Kanungu District, where the inequities of disease and poverty produce differentiated vulnerabilities, exposures, and adaption capacities to the impacts of climate change (18–20).

Without a process to account for the reality of changing and inequitable risks within and between communities our responses may amplify existing inequities by silencing diverse and disenfranchised voices. Taking a relational approach, such as applying social network theory and analysis, can be helpful for thinking about placed-based systems—how they experience and respond to the risks and impacts of climate change—as dynamic and evolving. One application of this work could be to understand *how* information flows and knowledge networks are changing relationally in response to climatic and environmental changes.

Chapter 3 realises the interdependence of climate-food-health systems as they exist on the ground. Despite how informal community systems operate and exist in practice, formal adaptation responses initiated externally by multilateral NGOs and governments can be disconnected in their separate sectors and funding siloes. For example, desegregating adaptation planning and financing in Uganda across agriculture and health sectors could provide benefit across health and food systems at local levels of response (21). The methodological approach and findings from this chapter can be used to guide partnerships and knowledge exchange about procedurally just ways to build on existing

relationships, locally, and integrate climate information (and funds) that are fit for specific people, purpose, and response (22).

The justice and equity dimensions explored in my research are relevant to determining effective response across the entire process of adaptation, including climate policy and governance (14–16). There is growing recognition and experimentation of the ways in which the redistribution of decision-making power to many diverse and interconnected centres of governance can shape climate policy and response (23–26). Considering that the implementation of climate policy in practice occurs locally, through place-based processes, then the development of climate-policy occurring in connection with those implementing networks would be also be appropriate. This work can be used to improve the process of how people, and knowledges, are being brought into deliberate and democratic networks of climate governance (23,24). Again, returning to a fundamental finding from this research: how responses are developed, who they are designed for and by, as well as the context in which they are intended to be implemented are likely to influence their effectiveness (17).

While huge sums of global financing are being rolled out to support climate change responses worldwide, adaptation is still under-funded with large gaps remaining in terms of who and how climate finance flows are allocated (22,27–29). This is another facet of understanding what procedural justice means in practice. In low and middle income countries, for example, accountability and access to adaptation financing is premised on evidence-based prioritisation of adaptation responses that are likely to be the most effective in reducing climate risk. Sometimes this is without any consideration of existing local capacity and human resources of implementing responses. This 'absorptive capacity' is particularly relevant in determining whether health systems have the capacity to manage increases in the frequency and intensity of extreme weather and climate events and changing burdens of climate-sensitive health outcomes (30). One suggestion would be to use this work as a framework for how partnerships could apply and account for adaptation financing. For example, when submitting funding applications and updates, partners could provide a roadmap with examples of key initial stages of procedurally just and equitable adaptation response with diverse knowledges and holders. Accounting for contextual, relational, and non-climatic factors can not only contribute to the initiation of effective climate-health responses, but also the ongoing implementation, monitoring, and evaluation of them. This work can be used to inform a process for developing just and equitable climate-health thresholds and indicators for adaptation as process (30–32). For example, defining

what measures matter is another important stage of initiating a climate-health adaptation response, and one in which leadership from local and Indigenous communities is essential (13,33).

(How) Can climate change evidence assessments equitably and meaningfully bring together diverse knowledges?

Chapter 4 provides a baseline to guide the reform of IPCC evidence assessment procedures and principles to achieve a necessary standard of procedural justice for engaging Indigenous knowledges and knowledge holders. Despite proposing ways within the IPCC process that procedural justice can begin, this work uses a different rationale while still adding to the growing body of literature calling for an overhaul of the IPCC process and that it is no longer 'fit for purpose' (34). For example, scholars have problematised the IPCC's inability to meet the demands of an exploding literature base, as well as how it informs policy deliberations, and how it engages experts and evidence from different disciplines, backgrounds, and geographies (35–40). Using these practical critiques as an entry point, along with the review and synthesis of sixth assessment cycle Special Reports and expert reviewer comments of drafted Special Reports, we offer a critical window into the assessment process by conducting interviews with expert advisors. In doing so, this work is able to demonstrate a substantial dissonance between the driving purpose and formal mechanisms of the assessment process, existing expectations of expert communities, and the feasibility of implementing changes to the fundamental structure of the IPCC process. Ultimately, we find that within the parameters of its current mandate and governing principles, the IPCC process cannot achieve a standard of procedural justice necessary for working with diverse knowledges and knowledge holders.

In supporting the need for reform that would enhance the legitimacy and relevance of the evidence assessment process and outcomes, Chapter 4 attempts to move beyond the critiques to propose new pathways for safeguarding and facilitating equitable knowledge diversification in the context of climate change evidence assessments. For example, we proposed working with direction from, and partnership, with Indigenous Peoples Organisations to developing guidelines for accessing and attributing Indigenous knowledge sources and procedures for targeted knowledge dissemination, such as using existing Indigenous protocols to identify the scope of 'available and relevant' evidence (41–44). Another proposal would be to have the Panel invite Indigenous councils and governing organisations to become members or observer organisations. These are both examples of how making space for Indigenous knowledge holders and experts to determine, themselves, the parameters by

which they want to engage not only safeguards the equitable and meaningful consideration of Indigenous knowledges, it also promotes the rights of Indigenous Peoples. Our findings underscored that the greatest potential for reform is in the framing and evaluation of evidence. Aligned with findings from Chapters 2 and 3, I demonstrate how evidencing diverse knowledges equitably and meaningfully begins with embedding justice into the initiation of process; within its very goals and principles (45–48).

Once again, this work responds to an existing UNFCCC mandate, inviting the western scientific community to engage further with Indigenous and local experts and knowledge holders in the equitable consideration of different knowledge systems (UNFCCC). This work indicates a growing appetite from participating parties to find ways of working together with diverse knowledges to inform adaptation responses. This work also aligns with the functions of the newly established (2018) Local Communities and Indigenous Peoples Platform (LCIPP) Facilitative Working Group of the UN, in particular, their mandates: to promote Indigenous knowledges and local knowledges in addressing and responding to climate change; as well as to facilitate the bridging of diverse knowledges in designing and implementing international and national actions, programmes and policies. While the IPCC is an independent body, there are established channels of feedback between its processes and those of the UNFCCC. For example, flow back from the IPCC process is used to inform the UNFCCC mandate and engagement process. Therefore, it was no surprise that a few of the expert advisors who engaged in this research were also connected to the UNFCCC either through their secretariat or their LCIPP Facilitative Working Group. At a more regional level, the findings from Chapter 4 can be harnessed to develop recommendations by Indigenous Peoples Organisations, many of whom similarly have a mandate to engage with UN bodies and scientific processes related to climate change. Combined with the LCIPP's work to build the capacity of Indigenous peoples and local communities to engage in UNFCCC processes, there could be scope to have these findings support bids for funding that would facilitate the dialogue of diverse knowledges and longer-term collaborations of experts needed.

Undeniably, the framing of knowledges and evidence in the IPCC still matters for shaping priorities, making decisions, and taking actions across global and local settings (39,49). Changing the entire paradigm of a system, which feeds our global and local responses to the impacts of climate change on health, is not an easy feat. It takes work and time. Similar work is taking shape in biodiversity related evidence assessments, the IPBES for instance (50–52). This is about creating a space, at the interfaces,

where that work can take place and where multiple ways of understanding and responding to the impacts of climate change on health can be seen, heard, and accepted. It is in this 'solution space' where Chapter 4 is positioned to contribute.

Holding Myself Accountable

> *Be very careful with your words. Your actions. Think it through. Then think it through again | Think it ahead through time | Think it backwards through time—Leanne Betasamosake Simpson, 2015 (Preface, p. xvii)*

Here, I would like to take a step back from the thesis and reflect on a journey of learning that has taken shape over the course of my doctoral studies—learning how to hold myself accountable as a researcher. The empirical chapters of my thesis are presented in chronological order and very much reflect this trajectory of self-evolution, as researcher, through time. From adopting an almost 'IPCC-style' approach in the framing and assessment of contributions and engagement of diverse knowledges (Chapter 2). To presenting a critique of these approaches and their inherent limitations for equitably and meaningfully considering diverse knowledges (Chapter 4).

> *Remember that words carry the ability to impact the chemistry of brains and the beating of hearts | Calls should be whispers—Leanne Betasamosake Simpson, 2015 (Preface, p. xvii)*

Margaret Noodin, an Anishinaabe poet, has described how the Ojibwe word for *listening* and *peace* are related. In the context of oral cultures and methodologies, a peaceful listener can internalise their own understandings and share them with others, at a different time and place, in a way that still holds true to how the ideas were originally offered and received. For me, holding myself accountable as a researcher means seeking out methodologies that *see* and *listen* to people in a way that they wish to be seen and heard. Over the past three and half years, I have observed myself several times transitioning through the research process. What I grapple to understand most is when, in that process, knowledges and lived experiences become data and information. I have often returned to the analogy of a *cadaver*—when does something with breath and meaning becomes lifeless and dissectible? I find myself pausing, trying to resuscitate the breath and meaning of the original offering. What a peculiar and privileged position to be able to listen and see people so intimately and yet retain such a distance in understanding their reality. Moreover, it is also a 'dangerous' position to occupy

because, as one Expert Advisor expressed, it has the power to shape the wider discourse of how knowledges are *allowed* and evidences are considered (p.155).

> *The only one you can hold accountable is yourself | That really is your only job—Leanne Betasamosake Simpson, 2015 (Preface, p. xvii)*

Reflecting on my own work, Chapter 2 attains the greatest distance from the research process. This is likely been because the work was based on 'secondary data' to begin with—a position that is also afforded in the process of global evidence assessments. However, this is the same distance that allows us to 'fit' the contributions and engagement of diverse knowledges into frameworks where they do not belong (i.e. using public health surveillance quality and outcome measures in Table 2.5, p.50-51). In Chapter 3, despite being closer to, drawing guidance from, and sharing experiences within the research process, there is still a distance—made more apparent in the analysis—which leaves me with residual discomfort. Here, the *danger* of distancing enables us to confound meaning and create arbitrary boundaries (i.e. the labelling of knowledge networks in Figure 3.3, p. 90; Table 3.3, p.91). Learning from my own missteps, the process and proposals of Chapter 4 attempt to regain a closeness of understanding. Such proximity can only be afforded through relationships with Indigenous Peoples and local communities, which will in turn promote and guide the ethical engagement and self-determination of knowledges within the research process. As a researcher, this includes learning how to hold myself accountable within the research process—in a way that upholds the animacy and diversity of the world we are seeking to understand.

Conclusion

Overall, my thesis aims to provide empirical evidence that examines the critiques of existing processes, questions the limitations of conventional approaches, and builds confidence in the possibilities of knowledge diversity and procedural justice (10,47,53–55). From the ways that diverse knowledges contribute to adaptation responses, to what procedural justice looks like in practice, and pathways to reform autonomous engagement in evidence assessments—this concluding chapter presents insightful responses to those questions guiding my research:

> Why do Indigenous knowledges and local knowledges matter for effective adaptation responses?

What does procedural justice mean for initiating adaptation responses in practice?

(How) Can climate change evidence assessments equitably and meaningfully bring together diverse knowledges?

Teachings of transparent, critically reflexive, collective, dialectic, and contextually adapted approaches for bringing together diverse knowledges also guided my research (46,47,55–62). This work makes contributions towards understanding how we bring together diverse knowledges to advance climate adaptation responses, locally and globally.

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Appendices

Appendix 1—Supplementary Material for Chapter 2

1. Mixed Methods Appraisal Tool (version 2018) adapted and applied to 24 studies included in the systematic literature review

Supplementary Data Chapter 2 (85 KB, xlsx)

2. CERQual Qualitative evidence profiles and metadata

In general, there were moderate concerns about the design or conduct of the primary studies that contributed evidence to our key insights. Figure 6 shows the extent of methodological limitations in the underlying evidence for each of the 10 review findings (see contributions to MSS processes in Table 5). More in depth than applying an appraisal tool, this assessment required us to review each study and make a judgement about, as well as provide an explanation for, any methodological issues likely to affect the overall confidence in a review finding. While most studies (n=17) had no or minor concerns, the remaining (n=5) that had identified moderate and (n=2) serious concerns had an influence when we aggregated supporting data across studies at the level of findings and key insights. Issues that arose either because they were absent or too ambiguous to extract enough detail related to sampling strategies, triangulation in the interpretation and verification of findings, incongruence in the application of mixed methods, adherence to quality criteria, critical reflexivity or exploration of limitations. The judged extent of these limitations resulted in the reduction of overall confidence in some of our review findings (1.1, 1.3, 1.4, 2.2, 3.1, 3.2, 3.4), and thus the broader key insights as well (1 and 2).

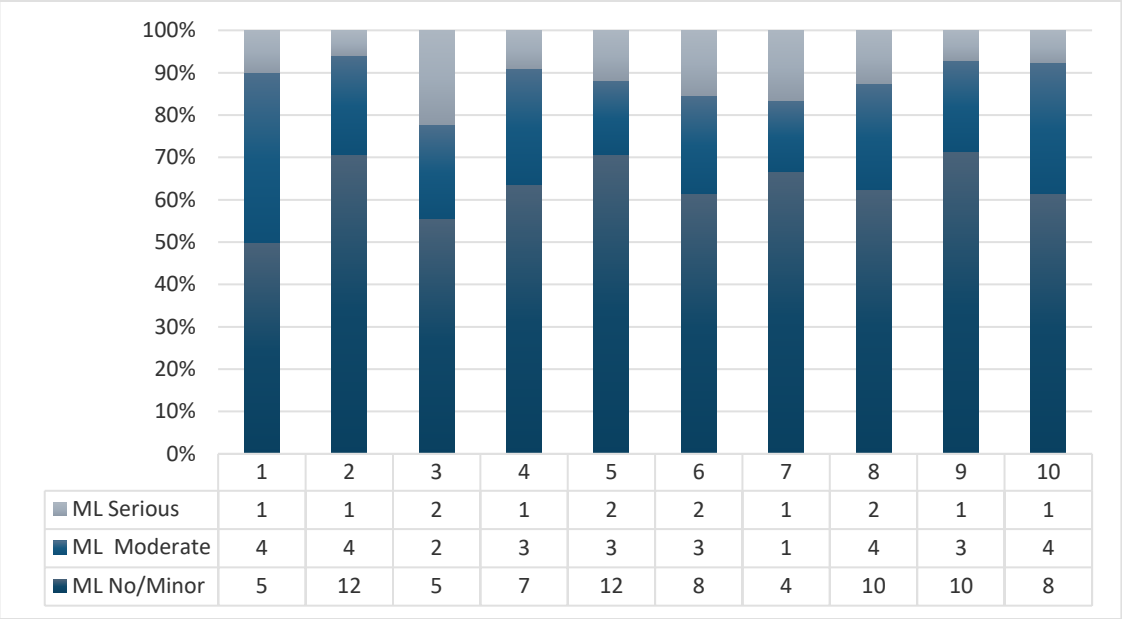
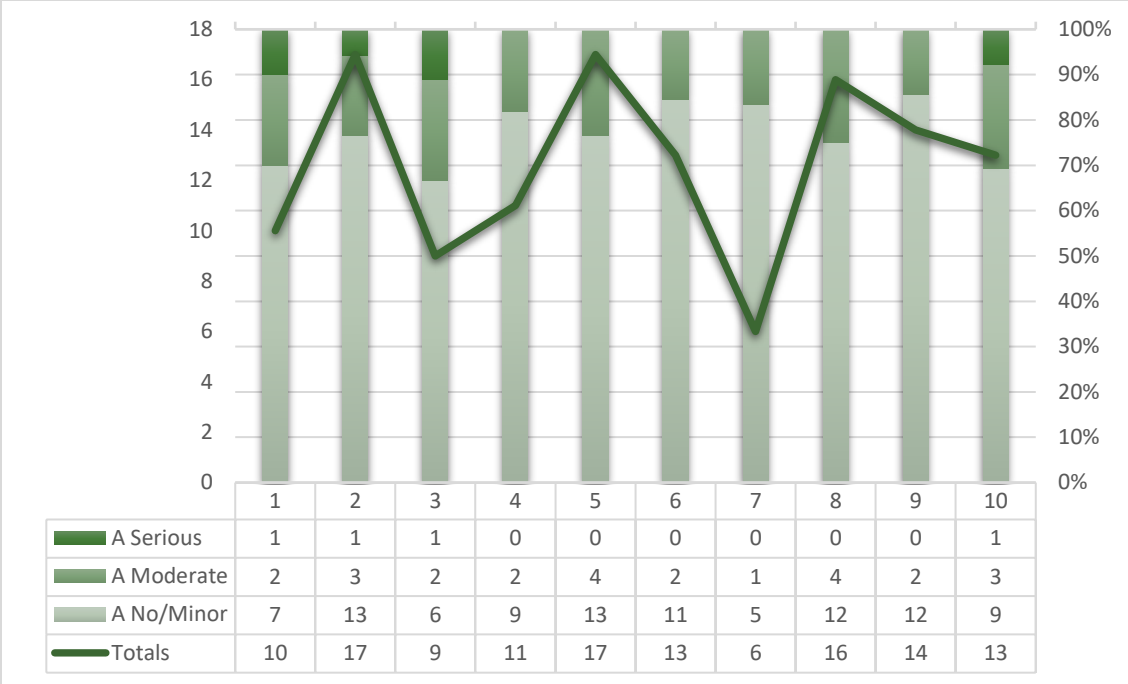


Figure A: Concerns about the methodological limitations in the primary studies supporting review findings 1-10.

Adequacy and Confidence

Overall, we had minor to no concerns about the degree of richness and quantity of supporting data across each of the 10 review findings. Figure 7 shows concerns about the adequacy in, and of, the underlying evidence for each of the 10 review findings (see contributions to MSS processes in Table 5). This assessment required us to make a judgement about adequacy both at the level of individual study as well as the total number of studies supporting each finding (as indicated by the trend line). At the level of individual study, most employed a mixed methodology that resulted in a depth and diversity of information, as well as repeated observations that spanned large temporal and geographical scales. Seven out of our 10 findings were supported by more than half of the reviewed evidence base (i.e. 13 or more individual studies). As such, any issues in adequacy were unlikely to affect the overall confidence in our review findings and key insights.

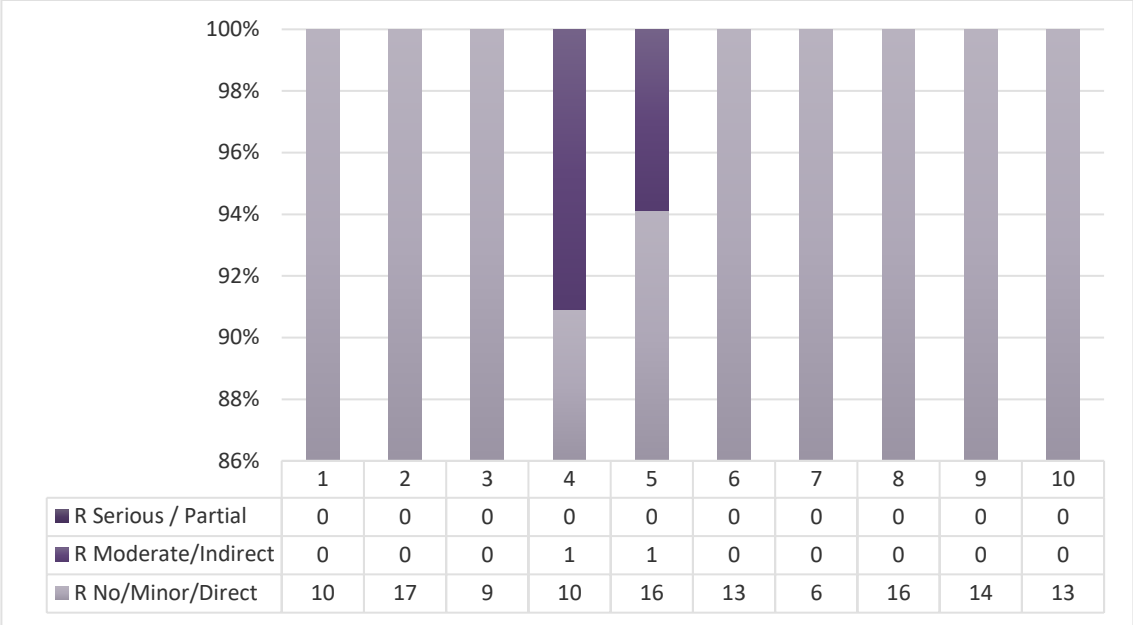


	1	2	3	4	5	6	7	8	9	10
A Serious	1	1	1	0	0	0	0	0	0	1
A Moderate	2	3	2	2	4	2	1	4	2	3
A No/Minor	7	13	6	9	13	11	5	12	12	9
Totals	10	17	9	11	17	13	6	16	14	13

Figure B: Concerns about the adequacy in, and of, the primary studies supporting review findings 1-10.

Relevance and Confidence

There were little to no concerns about the extent to which the supporting body of evidence from the primary studies was applicable to the context specified in the wider review objective. Figure 8 shows the concerns about relevance of underlying evidence for each of the 10 review findings (see contributions to MSS processes in Table 5). The selection process undertaken in this review resulted in high amounts of similarities between the context of the studies supporting each review finding and the context specified in the review question. As such, there were minimal to no concerns threatening the relevance of supporting data, which did not affect the overall confidence in our review findings and key insights. Please see continued discussion relating to publication and dissemination biases in the review.



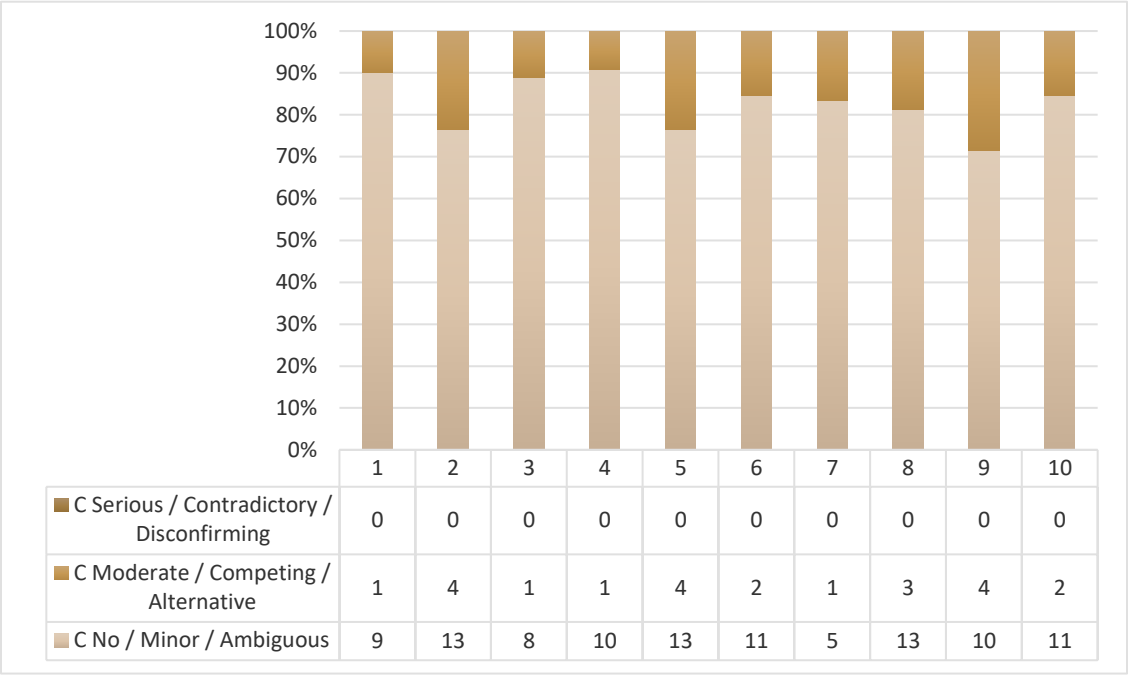
	1	2	3	4	5	6	7	8	9	10
R Serious / Partial	0	0	0	0	0	0	0	0	0	0
R Moderate/Indirect	0	0	0	1	1	0	0	0	0	0
R No/Minor/Direct	10	17	9	10	16	13	6	16	14	13

Figure C: Concerns about relevance of the primary studies supporting review findings 1-10.

Coherence and Confidence

Overall, we had minor or no concerns about how clear and compelling or supportive the fit was between the data from the primary studies and the review findings that synthesized that data. Figure 9 shows the concerns about coherence between underlying evidence and each of the 10 review findings (see contributions to MSS processes in Table 5). The few instances where minor concerns were assessed was either because it was not clear if some of the underlying data supported the specific review finding, or there could have been plausible alternative descriptions, interpretations or explanations used to synthesise the underlying data. As such, any issues in coherence were

considered unlikely to affect the overall confidence in our review findings and key insights.



	1	2	3	4	5	6	7	8	9	10
C Serious / Contradictory / Disconfirming	0	0	0	0	0	0	0	0	0	0
C Moderate / Competing / Alternative	1	4	1	1	4	2	1	3	4	2
C No / Minor / Ambiguous	9	13	8	10	13	11	5	13	10	11

Figure D: Concerns about coherence between the primary studies and review findings 1-10.

Appendix 2—Supplementary Material for Chapter 3

1. Key informant interview guide

Interview Guide Theme	*Example Question*
Activities, roles, and functions of health and/or subsistence food system	In general, what is happening in your community right now? What activities are you engaging in?
	In general, what is your role in the [health / subsistence food] community system?
Knowledge holder identification	In your community [health/food] system, who is responsible for sharing [health / subsistence food] information with you? What is their role?
	Who do you share information with? What is their role?
	Who would you consider knowledgeable about [insert health / subsistence food activity they have mentioned]?
	Who would you consider influential in the [health / subsistence food] community system?
	Who do you recommend we speak with for more information?
Methods of information flow	How do you access the information about [insert specific health / subsistence food activity they have mentioned]?

Information, monitoring, and response	In your community [health/food] system, how is your role/activity different/similar to this time last season? And the seasons before? What makes you aware of these changes? How/do you respond?
Other	What additional information would be useful for you to have to support your role/activity?

2. Blocked asymmetric matrix of knowledge holders and information flows

(Sender = Row; Target = Col)	In-Charge (HC II/III)	NGOs Development Partners	VHTs	Community Hospital	Health Assistant	VHT Coordinator / Health Link Facilitator	CHEW / Outreach Team	Researchers	Sub-County Chief	Technical Planning Team (District Officical Body)	District Health Team	Community Development Officer	Parish Chief	Teachers / School Reps	LC1	LC2	LC3	LC5 / MPs	Community Chairpersons / Local / Religious Leaders	Bataka	Community Members (Batwa)	Neighbours (Bakiga)	Traditional Herbalist
In-Charge (HC II/III)	--	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0
NGOs Development Partners	1	--	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	0	1	1	1	1	0
VHTs	1	1	--	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1
Community Hospital	1	1	1	--	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0
Health Assistant	1	1	1	1	--	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0
VHT Coordinator / Health Link Facilitator	1	1	1	1	1	--	0	0	1	1	1	0	1	0	0	0	0	0	1	0	1	1	0
CHEW / Outreach Team	1	1	1	1	1	0	--	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
Researchers	0	1	0	1	0	0	0	--	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1
Sub-County Chief	1	1	0	0	1	0	0	0	--	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Planning Team (District Officical Body)	1	1	0	0	1	1	0	0	1	--	1	1	1	1	1	1	1	1	1	0	0	0	0
District Health Team	1	1	1	1	1	1	0	0	1	1	--	1	1	0	1	1	1	1	1	0	0	0	0
Community Development Officer	0	1	0	0	1	0	0	0	1	1	1	--	1	1	1	1	1	1	1	1	1	1	0
Parish Chief	0	0	0	0	1	0	0	0	1	1	0	1	--	0	1	1	0	0	1	0	0	0	0
Teachers / School Reps	0	0	0	0	0	0	0	0	1	1	0	0	0	--	0	0	0	0	1	0	1	1	0
LC1	0	0	0	0	1	0	0	0	1	1	1	1	1	0	--	1	1	1	1	1	1	1	0
LC2	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1	--	1	1	1	1	1	1	0
LC3	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	--	1	1	1	1	1	0
LC5 / MPs	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	--	1	1	1	1	0
Community Chairpersons / Local / Religious Leaders	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	--	1	1	1	1
Bataka	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	--	1	1	0
Community Members (Indigenous)	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	--	1	1
Neighbours (Local)	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	--	1
Traditional Herbalist	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	--

Appendix 3—Supplementary Material for Chapter 4

1. Expert advisor interview guide

Key Themes	Example Interview Questions
Experience and Expectations	*What (if any) has been your experience engaging with the IPCC?* *[For non-academics]* *(If so) How did this compare to your initial expectations of the process and being involved?* *(If not) Why is it important for you to find ways of working with the IPCC?* *In general, do you think there is a place for global assessments and syntheses of knowledges [about climate change]?*
Definitions and Destinations *Integration vs. Utilization vs. Self-Determination* *Strengthening transmission pathways (Knowledges -> Information->Action) in accordance with IK governance structures*	*In general, what does Indigenous knowledge [leadership] mean to you?* *[For Indigenous Knowledge Holders]* *Can you give specific examples of how knowledge is (expressed, transmitted, valued, synthesized) in an Indigenous context?* *In your view, are assessment reports and syntheses of non-western scientific knowledges fit-for-purpose? useful? meaningful? even possible?*

Making Room for Indigenous Knowledges *Inclusion->Leadership->Self-Determination, Sovereignty, and Governance*	*<u>Presently</u>, is there anything about the IPCC process that is working to strengthen/make space for the [leadership] (expression, exchange, transmission, value, synthesis) of Indigenous knowledges?* *In general, how would you improve on the [leadership] (expression, transmission, value, synthesis) of Indigenous knowledges in the IPCC process? Outside the process?* *Can you give <u>specific examples</u> [drawing from your previous experiences] of how [leadership] (expression, transmission, value, synthesis) of Indigenous knowledges can be [strengthened in the IPCC process]? Can they?* *Can you give specific examples of how we can remove barriers to (expression, transmission, value, synthesis) of Indigenous knowledge systems [within the IPCC process]? Can we?* **As an academic/non-Indigenous scholar engaging with Indigenous knowledge and research, what does it mean to make room for Indigenous ways of knowing, being, and doing? What does it mean to "move over" for Indigenous knowledge leadership, self-determination, and sovereignty?* • *What is the role/responsibility/obligation of non-Indigenous researchers in this process?* • *Can you give specific examples from your own research?* • *What would you consider yourself an expert in?*
Probes from the Literature	*Challenges:* • Scale of synthesis? (i.e. introduce regional panels) • Review process? (i.e. duration, sequence, number of steps) • Selection of authorship and editors? • Extent of UN and government oversight? • Confidence criteria and methods of knowledge validation? (i.e. specific to each knowledge system) • Language of process? (i.e. working groups, contact meetings, correspondence, draft texts; i.e. English, Spanish, French, Scientific, Bureaucratic) • Recognition? (i.e. non-state observer status, inequality and power imbalance in UNFCCC

	protocol, lack of agency and autonomy in decision-making which ultimately decides participation) • Non-Indigenous [narrow] interpretations of Indigenous knowledges? (i.e. determining whether Indigenous knowledges are relevant for adaptation but not mitigation) *Solutions* • Creating institutional space, collaboration, and partnership that responds to need and priorities of Indigenous researchers, students, and communities (i.e. facilitating knowledge exchange between Indigenous researchers and practitioners, sponsoring mentorship, ensuring presence and safety within the institution<-see Latulippe & Klenk for all references of "making room" • Recognizing different ways of valuing knowledges (i.e. governance and intrinsic value (Whyte), vs. extractive and supplemental value (Smith and Sharp, Latulippe, David-Chavez) • Codifying research protocols and formalizing structures of accountability (communities themselves) • Creating frameworks for the protection of intellectual property (i.e. Indigenous ownership, control, access, and possession (OCAP) principles) • Following existing guidelines or developing new ones (i.e. Guidelines for considering Traditional Knowledges (TKs) in Climate Change Initiatives) • Upholding international human rights standards in research and environmental planning (i.e. Indigenous self-determination and free, prior, and informed consent (FPIC) established by the UNDRIP) • Representatives and technical advisers who can navigate language barriers • Interpersonal relationships and appealing to the "open-mindedness" of others • Removing barriers that impede the practice of Indigenous knowledge (i.e. transfer of lands, resources, and decision-making authority over traditional and treaty territories; major social, health, and economic gaps; exposure to environmental risks and harms; burdens face by Indigenous scholars, students, staff, and knowledge

	holders to unsettle dominant institutions) <-see Latulippe & Klenk for all references of “moving over”