Opportunities for adaptation to climate change: A comparative analysis of Indigenous fisheries systems in the Canadian Arctic and Eastern Sri Lanka

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ABSTRACT

This thesis examines opportunities for climate change adaptation in Indigenous fisheries communities, using two communities in Sri Lanka and the Canadian Arctic as place-based case studies. Climate change is a significant challenge facing humanity in the 21st century. For coastal communities, this challenge includes dramatic changes in coastal resources due increased extreme weather, ocean acidification, sea-level rise, and decreased sea ice in polar areas. Worldwide, climate change has had a particularly large impact on coastal Indigenous people due to their high reliance on local aquatic systems for food security. Together, these facts make Indigenous fishing communities' ability to adapt to climate change particularly critical. In this thesis, I studied two contextually different Indigenous fisheries systems in a comparative analysis that uncovered broader climate adaptation insights. The two case studies were undertaken in the Canadian Arctic Inuit community and in the Eastern Sri Lankan Coastal Vedda community.

My aim was to identify, examine, and evaluate opportunities for building resilience and reducing vulnerability (i.e., adaptation) in social-ecological systems through the development of an in-depth understanding of how Indigenous fishing communities experience and respond to climate change. The research is guided by four overarching objectives:

1) To develop a conceptual framework to help assess community adaptations to climate change in fisheries systems,

2) To assess community adaptations to climate change among Inuit fisher communities, using a case study from Pangnirtung, Baffin Island, Nunavut,

3) To assess community adaptations to climate change among Coastal-Vedda fisher communities, using a case study from Kunjankalkulam in eastern Sri Lanka, and

4) To carry out a comparative analysis of the two case studies (i.e., Inuit of the Canadian Arctic and Coastal-Vedda of Sri Lanka) to examine the changes (shocks and stressors) they experience, as well as their adaptive responses to those changes, to develop a broader understanding of opportunities for climate adaptation policy in small-scale fisheries in wide range of settings.

To accomplish the research objectives, I used a three-tier (conceptual, empirical, and comparative) methodological approach. I have developed a conceptual framework based on a literature review and have used this framework throughout the knowledge production process to maintain conceptual consistency, maintain a place-specific focus, and provide guidance. I have used mixed qualitative data collection methods together with a community-based participatory research approach for empirical case studies. The fieldwork was conducted episodically over a period of three years, including 14 weeks in the Arctic and 24 weeks in Sri Lanka. I examined various place-specific adaptive strategies as well as broader strategies that apply to the Indigenous fisheries context. I have carried out a comparative analysis to develop a broader understanding across the case studies.

This work contributes to conceptual, empirical, and methodological advancements in climate adaptation research. I proposed a place-specific conceptual framework for assessing community adaptation in a fisheries context. I found that the implications of climate impacts affect people in mixed/interrelated ways combined with other non-climatic changes—intertwined nature (e.g., sea ice conditions, market and fish price changes in the Canadian Arctic). In terms of adaptive responses, I found three adaptive strategies and three place-specific attributes from both Inuit and Coastal-Vedda communities that allow them to effectively deal with change and build adaptive capacity. I identified eight sources of resilience that can be used to build the ability to adapt to climate change, as well as five definitive characteristics of successful adaptation in an Indigenous fisheries context. I found that the three-tier methodological approach used in this study could bring advanced insights to climate adaptation research.

Chapter 2 describe the overarching methodological approaches used to address the study objectives. This chapter provides the overall logic behind my methods, as well as defines terms used throughout the thesis so that the manuscript chapters can remain concise and focused. (This chapter is a new addition to the thesis, in response to the reviewers' request for more methodological clarity.) Chapter 3 presents the conceptual framework, which provides the conceptual tools necessary to assess community adaptations in diverse small-scale fisheries systems. With the understanding of resilience as a combined result of coping, adapting, and transformative capacities, Chapter 3 provides the theoretical foundation essential for the thesis. Chapters 4 and 5 use the framework developed in Chapter 3 to present and analyze empirical case studies of the Canadian Arctic (Inuit) and of Sri Lanka (Coastal-Vedda), respectively, to investigate how Indigenous fishers experience, respond to, and adapt to climate change.

Chapter 6 is a comparative analysis of the Inuit and Coastal-Vedda case studies; it identifies diversification and the practice of fisheries co-management as a common adaptive strategy among Inuit and Coastal-Vedda. From across these two case studies, this chapter identifies eight sources of resilience that can build adaptive capacity: i) use of diverse kinds of knowledge; ii) practice of different ways of learning; iii) use of community-based institutions; iv) efforts to improve human agency; v) unique worldviews; vi) specific cultural attributes that keep up with adaptation; vii) effective social networks; and viii) high level of flexibility. Further, this chapter identifies the definitive characteristics of a successful community adaptation process. These characteristics are: a) continuous learning through knowledge co-production; b) capacity-building to improve human agency; c) a place-specific nature (rootedness); d) collective action and partnerships through community-based institutions; and e) flexibility. Finally, Chapter 7 concludes the thesis with a reflection on key findings, knowledge contributions, policy implications, and future research directions.

RÉSUMÉ

Cette thèse examine les possibilités d'adaptation au changement climatique au sein des communautés autochtones de pêcheurs, en utilisant deux communautés, l'une du Sri Lanka et l'autre de l'Arctique canadien comme études de cas. Le changement climatique représente un défi important pour l'humanité au XXIe siècle. Pour les communautés côtières, ce défi comprend des changements spectaculaires dans les ressources côtières en raison de l'augmentation des conditions météorologiques extrêmes, de l'acidification des océans, de l'élévation du niveau de la mer et de la diminution de la banquise dans les zones polaires. À l'échelle mondiale, le changement climatique a un impact particulièrement important sur les populations indigènes côtières en raison de leur forte dépendance à l'égard des systèmes aquatiques locaux pour garantir leur sécurité alimentaire. Ces faits rassemblés font de capacité des communautés de pêche indigènes à s'adapter au changement climatique un facteur critique. Dans cette thèse, j'étudie deux systèmes de pêche indigènes contextuellement différents dans le cadre d'une analyse comparative qui met en évidence des perspectives plus larges en matière d'adaptation au climat. Les deux études de cas ont été réalisées dans la communauté inuit de l'Arctique canadien et dans la communauté vedda des côtes de l'est du Sri Lanka.

Mon objectif était d'identifier, d'examiner et d'évaluer les possibilités de renforcer la résilience et de réduire la vulnérabilité (soit la capcité d'adaptation) des systèmes socio-écologiques par le développement d'une compréhension approfondie de la manière dont les communautés de pêcheurs indigènes vivent le changement climatique et y réagissent. La recherche est guidée par quatre objectifs généraux :

1) Développer un cadre conceptuel permettant d'évaluer les adaptations communautaires au changement climatique dans les systèmes de pêche,

2) Évaluer l'adaptation des communautés de pêcheurs inuits au changement climatique, en utilisant une étude de cas à Pangnirtung, sur l'île de Baffin, dans le Nunavut,

3) Évaluer les adaptations au changement climatique parmi les communautés de pêcheurs de la région côtière où vivent les Veddas, en utilisant une étude de cas à Kunjankalkulam dans l'est du Sri Lanka, et

4) Effectuer une analyse comparative des deux études de cas (c'est-à-dire les Inuits de l'Arctique canadien et les Vedda des côtes du Sri Lanka) pour examiner les changements (chocs et facteurs de stress) qu'ils subissent, ainsi que leurs réponses adaptatives à ces changements, afin de mieux comprendre les possibilités d'une politique d'adaptation au climat dans la pêche à petite échelle dans des contextes très différents.

Pour atteindre les objectifs de la recherche, j'ai utilisé une approche méthodologique à trois niveaux (conceptuel, empirique et comparatif). J'ai développé un cadre conceptuel basé sur une analyse documentaire et j'ai utilisé ce cadre tout au long du processus de production des connaissances pour maintenir la cohérence conceptuelle et me concentrer pleinement sur chaque lieu, et fournir des conseils. J'ai utilisé des méthodes mixtes de collecte de données qualitatives ainsi qu'une approche de recherche participative communautaire pour des études de cas empiriques. Le travail sur le terrain a été effectué de manière épisodique sur une période de trois ans, dont 14 semaines dans l'Arctique et 24 semaines au Sri Lanka. J'ai examiné diverses stratégies adaptatives spécifiques à un lieu ainsi que des stratégies plus larges qui s'appliquent au contexte de la pêche autochtone. J'ai effectué une analyse comparative afin de mieux comprendre l'ensemble des études de cas.

Ce travail contribue aux avancées conceptuelles, empiriques et méthodologiques de la recherche sur l'adaptation au climat. J'ai proposé un cadre conceptuel spécifique à un lieu pour évaluer l'adaptation des communautés dans un contexte de pêche. J'ai constaté que les implications des impacts climatiques affectent les gens de manière mixte/interdépendante, en combinaison avec d'autres changements non climatiques - de nature interdépendante (par exemple, l'état de la glace de mer, les changements du marché et du prix du poisson dans l'Arctique canadien). En termes de réponses adaptatives, j'ai trouvé trois stratégies adaptatives et trois attributs spécifiques à un lieu dans les communautés inuit et de vedda des côtes, qui leur permettent de faire face efficacement au changement et de renforcer leur capacité d'adaptation. J'ai identifié huit sources de résilience qui peuvent être utilisées pour renforcer la capacité d'adaptation au changement climatique, ainsi que cinq caractéristiques définitives d'une adaptation réussie dans un contexte de pêche autochtone. J'ai constaté que l'approche méthodologique à trois niveaux utilisée dans cette étude pourrait apporter des connaissances avancées à la recherche sur l'adaptation au climat.

Le chapitre 2 décrit les approches méthodologiques globales utilisées pour atteindre les objectifs de l'étude. Ce chapitre présente la logique générale de mes méthodes, et définit les termes utilisés tout au long de la thèse afin que les chapitres du manuscrit puissent rester concis et ciblés. (Ce chapitre est un nouvel ajout à la thèse, en réponse à la demande de plus de clarté méthodologique de la part des examinateurs). Le chapitre 3 présente le cadre conceptuel, qui fournit les outils nécessaires pour évaluer les adaptations communautaires dans divers systèmes de pêche à petite échelle. Partant de la compréhension de la résilience comme résultat combiné des capacités d'adaptation et de transformation, le chapitre 3 fournit le fondement théorique essentiel à la thèse. Les chapitres 4 et 5 utilisent le cadre développé au chapitre 3 pour présenter et analyser des études de cas empiriques de l'Arctique canadien (Inuits) et du Sri Lanka (Veddas des côtes), respectivement, afin d'étudier comment les pêcheurs autochtones vivent le changement climatique, y réagissent et s'y adaptent.

Le chapitre 6 est une analyse comparative des études de cas sur les Inuits et les Veddas des côtes ; il identifie la diversification et la pratique de la cogestion des pêches comme une stratégie adaptative commune aux deux groupes. À partir de ces deux études de cas, ce chapitre identifie huit sources de résilience qui peuvent renforcer la capacité d'adaptation : i) l'utilisation de divers types de connaissances ; ii) la pratique de différents modes d'apprentissage ; iii) l'utilisation d'institutions communautaires ; iv) les efforts visant à améliorer l'action humaine ; v) des visions du monde uniques ; vi) des attributs culturels spécifiques qui suivent l'adaptation ; vii) des réseaux sociaux efficaces ; et viii) un niveau élevé de flexibilité. En outre, ce chapitre identifie les caractéristiques définitives d'un processus d'adaptation communautaire réussi. Ces caractéristiques sont : a) l'apprentissage continu par la coproduction de connaissances ; b) le renforcement des capacités pour améliorer l'action humaine ; c) une nature spécifique au lieu (enracinement) ; d) l'action collective et les partenariats par le biais d'institutions communautaires ; et e) la flexibilité. Enfin, le chapitre 7 conclut la thèse par une réflexion sur les principaux résultats, les contributions en matière de connaissances, les implications politiques et les orientations futures de la recherche.

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AUTHOR CONTRIBUTIONS

This thesis includes four manuscripts that are either published or being prepared for submission to peer-reviewed journals. These manuscripts were prepared with co-authors, whose contributions are as follows.

Chapter 3: "*A framework for assessing community adaptation to climate change in a fisheries context*" by Eranga Galappaththi (primary author), James Ford, and Elena Bennett. Eranga Galappaththi led the conceptual development of the manuscript, wrote the manuscript, and coordinated feedback among the co-authors. James Ford and Elena Bennett contributed to the conceptual development of the manuscript and provided comments, feedback, and suggestions.

Chapter 4: "*Climate change and community fisheries in the arctic: A case study from Pangnirtung, Canada*" by Eranga Galappaththi (primary author), James Ford, Elena Bennett, and Fikret Berkes. Eranga Galappaththi led the conceptual development of the manuscript, field data collection in the Canadian Arctic, and data analysis, as well as wrote the manuscript and coordinated feedback among the co-authors. James Ford, Elena Bennett, and Fikret Berkes contributed to the conceptual development of the manuscript and provided comments, feedback, and suggestions.

Chapter 5: "*Climate change and adaptation to social-ecological change: The case of Indigenous people and culture-based fisheries in Sri Lanka*" by Eranga Galappaththi (primary author), James Ford, and Elena Bennett. Eranga Galappaththi led the conceptual development of the manuscript, field data collection in Sri Lanka, and data analysis, as well as wrote the manuscript and coordinated feedback among the co-authors. James Ford and Elena Bennett contributed to the conceptual development of the manuscript and provided comments, feedback, and suggestions.

Chapter 6: "*Adapting to climate change in small-scale fisheries: Insights from Indigenous communities in the global north and south*" by Eranga Galappaththi (primary author), James Ford, Elena Bennett, and Fikret Berkes. Eranga Galappaththi led the conceptual development of the manuscript, field data collection in both the Canadian Arctic and Sri Lanka, comparative analysis, manuscript preparation, and coordination among the co-authors. James Ford, Elena Bennett, and Fikret Berkes contributed feedback throughout the research development stage and provided comments on the preparation of the manuscript.

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Chapter 1. Introduction

1.1 Background and context

Climate change has been identified as one of the biggest challenges facing humanity in the 21st century (Denis and Moser, 2015, Ford et al., 2016c, Hicks et al., 2016). An increasing average global temperature, rise in the sea level, ocean acidification, and extreme climate events are some of the climate impacts currently being experienced across the globe (Mirza, 2003, New et al., 2011, IPCC, 2012, Arkema et al., 2013, IPCC, 2014b, Frisch et al., 2015, Kench et al., 2015, Voss et al., 2015, Doney et al., 2016, Lam et al., 2016, Speers et al., 2016, IPCC, 2018b, Jayanthi et al., 2018, IPCC, 2019a, Keys et al., 2019). These climate impacts are spreading broadly across multiple regional and sectoral scales, resulting in complications in human-environment systems and challenging the wellbeing of both humans and the planet (Wheeler and Von Braun, 2013, IPCC, 2014b, IPCC, 2014a, FAO, 2015, FAO, 2016, Seggel and De Young, 2016). Climate change impacts are compromising the UN Sustainable Development Goals (SDGs) (Assembly, 2014), as some climate mitigation efforts can undermine particular SDGs (for example, using coal to improve energy access in Asian nations—goal 7) (Griggs et al., 2013, Nilsson et al., 2016). In this context, efforts to adapt to climate change require urgent attention.

Indigenous populations, in particular, have been identified as uniquely sensitive to climate change impacts, reflecting their often-close relationship to the environment and their dependence on natural resources for their livelihoods, culture, and well-being (Nakashima et al., 2012a, Ford et al., 2016a, Ford et al., 2016c, Zavaleta et al., 2018, Ford et al., 2019, Leu, 2019). Equally, the accumulated knowledge of Indigenous populations can help us better understand the challenges posed by climate change and the ways to respond to those challenges (Berkes, 2012, Boillat and Berkes, 2013, Mistry and Berardi, 2016, Fernández-Llamazares et al., 2017). Adaptation to climate impacts will be particularly important given our commitment to some degree of climate change this century, our experience with current climate change, and the likelihood that warming will exceed 2°C, with adaptation being increasingly prioritized in climate policy across scales (Adger et al., 2017, Conway et al., 2019, Galappaththi et al., 2019c), where adaptation can be defined as any action or process leading to increased community resilience *and* decreased vulnerability to adverse change.

Adaptation has become a central aspect of the climate policy agenda, as evidenced by the ever-growing number of publications, including the UN's IPCC reports (IPCC, 2014b, IPCC, 2014a, Ford et al., 2015, Adger, 2016, Ford et al., 2016c, Adger et al., 2017, Araos et al., 2017, Fernández-Llamazares et al., 2017, Forsyth, 2017, Lorenzen et al., 2017, Mees, 2017, Simonovic, 2017, Adhikari et al., 2018, Barange et al., 2018, Ford et al., 2018b, IPCC, 2018b, IPCC, 2018a, Conway et al., 2019, Galappaththi et al., 2019a, Galappaththi et al., 2019c, IPCC, 2019a, Lesnikowski, 2019, Piggott-McKellar et al., 2019), which highlight the need for more policy attention on climate adaptation in understudied areas such as fisheries and coastal regions (IPCC, 2018b, IPCC, 2019a).

Climate change has been identified as one of the main risks that small-scale fisheries (SSFs) systems face in terms of increasing stress, uncertainty, and complexity (O'Reilly et al., 2003, Johnson et al., 2019). A large body of literature highlights the growing associated impacts of global warming that drive the loss of coastal resources and reduce the productivity of aquatic systems, particularly at low latitudes (O'Reilly et al., 2003, Allison, 2009, Sumaila et al., 2011, Cinner, 2012, Jennings et al., 2016, Speers et al., 2016, Lorenzen et al., 2017, Savo et al., 2017, Barange et al., 2018, IPCC, 2018b). The UN's IPCC 1.5°C special report highlights the need for adaptation in a fisheries and aquaculture context, even at the lower levels of warming (Lesnikowski et al., 2017, IPCC, 2018a). Shedding light on global SSFs is important because it directly contributes to vulnerable fisher populations by promoting nutrition, food security, sustainable livelihoods, and poverty alleviation (Smith and Basurto, 2019). An increase in climate-driven stress, uncertainty, and the complexity of SSFs could result in various unpredictable global problems including food insecurity and hunger, human trafficking and migration, and social conflicts (for example, the World Food Program) (Hendrix and Salehyan, 2012, Brzoska and Fröhlich, 2016).

In this context, an examination of the adaptation of Indigenous fisher populations to climate change impacts is significant in many ways. First, adapting to climate change impacts is especially important among Indigenous populations, including those who rely on SSFs (IPCC, 2018b, Galappaththi et al., 2019c, IPCC, 2019b). Given that aquatic food dependence among coastal Indigenous people worldwide is much higher (15 times) than it is among non-Indigenous populations (Cisneros-Montemayor et al., 2016), Indigenous climate change adaptations are particularly important. Also, Kuhnlein et al. (2013) highlighted a major problem with food insecurity among Indigenous communities worldwide, including examples from India, Canada, Peru, Thailand, Japan, Colombia, and the Pacific islands. Second, Considering the (so far) limited attention paid to defining Indigenous fishers (or Indigenous fishery systems) (Ford et al., 2016c), an examination of how Indigenous fisher communities experience climate change impacts and their associated changes, as well as their responses, is the key focus of this study. Third, investigation of the nature of the adaptive responses of diverse SSFs communities to climate change impacts can advance and broaden the understanding of opportunities for adaptation to inform policy development. Finally, studying Indigenous climate change adaptations in a fisheries context using case studies is a major knowledge gap in both the adaptation and SSFs literature.

This thesis focuses on two remote Indigenous SSFs located in uniquely different geographical regions to examine the factors underpinning resilience to systems change, comparing and examining similarities and differences. For this thesis, the Inuit community of Pangnirtung in the Canadian Arctic and the Coastal-Vedda community of Kunjankalkulam in Eastern Sri Lanka were selected.

1.2 Research aim and objectives

The overarching aim of this thesis is to identify, examine, and evaluate opportunities for social-ecological systems resilience building and vulnerability reduction (i.e., adaptation) through the development of an in-depth understanding of how Indigenous SSFs experience and respond to change. This thesis will be structured around four objectives, which are:

1) To develop a conceptual framework to help assess community adaptations to climate change in SSFs systems,

2) To assess community adaptations to climate change among Inuit fisher communities, using a case study from Pangnirtung, Baffin Island, Nunavut,
3) To assess community adaptations to climate change among Coastal-Vedda fisher communities, using a case study from Kunjankalkulam in Eastern Sri Lanka, and
4) To perform a comparative analysis of two case studies (i.e., Inuit of Canadian Arctic and Coastal-Vedda of Sri Lanka) to examine the changes (shocks and stressors) they experience, and their adaptive responses to those changes, as well as to develop a broader understanding of opportunities for climate adaptation policy in SSFs.

1.3 Theoretical context

A social-ecological systems resilience approach is combined with scholarship on vulnerability and adaptation to examine the ways in which Indigenous fishing villages experience and respond to climate change impacts (Galappaththi et al., 2019c). This cross-disciplinary approach is used to understand the complexities inherent in the rapidly changing social-ecological systems (SES) of rural Indigenous fishing populations. This section will document and examine relevant concepts with the aim of reviewing and integrating them to support the research objectives. First, I explain the concepts of 'SES' and 'resilience' to derive the 'SES resilience' approach. Second, I integrate the 'SES resilience' approach with relevant scholarship on 'vulnerability and adaptation' and 'adaptive capacity.' Third, I introduce 'Indigenous knowledge' as a critical component of building 'resilience' and 'adaptive capacity.'

The SES approach is a robust approach toward looking at complex problems to create better understanding of human-environment systems (Berkes et al., 1998, Berkes et al., 2003). Social and ecological systems have historically been studied in separate disciplines related to the social or natural sciences (Berkes et al., 2000). Conventionally, mainstream ecology implicitly excluded people from the study of ecology, just as many social science disciplines limited their scope to human societies only, to the exclusion of the environment. However, natural and social systems are interconnected and a two-way relationship exists such that human activities affect ecosystems and ecosystem changes affect humans' livelihoods (Adger, 2000, Ommer et al., 2012). The two subsystems of SES—social and ecological—are interconnected but partly distinct, integrating the study of people and nature (Berkes et al., 2000, Berkes et al., 2008). The SES approach (Berkes et al., 2000, Chapin et al., 2010) emphasizes neither purely ecosystems nor societies; rather, the SES is the unit of study (Berkes et al., 2000, Berkes et al., 2008). Economic systems (Jansson, 1994) and markets are not separate and are deeply nested in SES (Harvey, 2006). Social and ecological interdependence in SES is demonstrated in many ways, from community-based and multi-level resource management (Berkes et al., 2008, Boyd and Folke, 2012). The study of SES is a fast-growing interdisciplinary field that focuses on how human societies deal with change and how they can build the capacity to adapt to change (Davidson-Hunt and Berkes, 2003, Boyd and Folke, 2012).

'Resilience thinking' has emerged as one of the main streams of thought for understanding the dynamics of SES. Though resilience thinking originated in an ecology background (Holling, 1973), it has been increasingly used by a large number of disciplines including human geography (Brown, 2016). Resilience thinking, in particular, provides a window for the study of change phenomena (Berkes et al., 2008) as both a challenge and an opportunity (Pelling, 2010). Key contextual attributes of the study of change phenomena are a high level of uncertainty and complexity (Berkes et al., 2008). The dynamic, unpredictable, and non-linear nature of SES makes it necessary to deal with its 'surprises' and to live within a constantly changing system (Walker et al., 2002). The assumption that uncertainty in socio-ecological systems can be alleviated by human control is being replaced by a belief in the necessity of people adapting to changes (Berkes et al., 2000). Further, resilience thinking challenges widely held notions about stability and resistance to change (Davidson-Hunt and Berkes, 2003).

The study of adaptive systems, such as complex small-scale fisheries, requires attention to scale, uncertainty, non-linearity, self-organization, and emergent properties like resilience (Berkes and Seixas, 2005, Berkes et al., 2008, Boyd and Folke, 2012, Berkes and Ross, 2013). Resilience concepts may be of great value in studies that seek to address the ways in which resource-dependent people respond to, cope with, and adapt to stresses and shocks, as well as take advantage of new opportunities (Berkes et al., 2008, Ford, 2012, Ford et al., 2012, Nakashima et al., 2012b). Stresses are long-term and constant strains or pressures, while a shock can be defined as an abrupt (often unexpected) and strong impact on the system (McLaughlin et al., 2009).

Stresses are within the range of the normal variability in which the system operates, while a shock goes beyond the normal range (Turner et al., 2003). How Vedda (Sri Lanka) and Inuit (Canadian Arctic), with their intimate relationships to natural systems, deal with the impacts of climate change is an apparent and timely example of complex SES (Berkes and Jolly, 2001, Ford et al., 2006, Ford et al., 2008, Pearce et al., 2010).

Resilience in SES refers to the ability to cope, adapt and transform. It is an interplay between disturbance and re-organization, sustaining and developing (Brown, 2016). The defining characteristics of resilient systems are: the potential to absorb stresses and shocks; the ability to self-organize; and the ability to build a capacity for learning and adaptation (Berkes, 2003, Berkes and Seixas, 2005, Armitage et al., 2008b, Berkes et al., 2008, Chapin et al., 2010, Berkes and Ross, 2013). Resilient systems require building capacity for self-organization, learning, and adaptation (Folke et al., 2003). Coping and adapting are both prerequisites for resilience (Marschke and Berkes, 2006). Coping strategies are short-term responses or temporary adjustments which can be related to survival strategy (Scoones, 1998). It allows people to make decisions that favor security and short-term gains, yet but may limit potential future options (Marschke and Berkes, 2006).

Adaptive strategies, in turn, are long-term responses or shifts in livelihood strategies (Scoones, 1998) that may (or may not) lead to the enhancement of livelihoods (Marschke and Berkes, 2006). The capacity to adapt to and shape change is called adaptive capacity (Berkes et al., 2000). Resilience can be defined as the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain still essentially the same function, structure, identity and feedbacks" (Walker et al., 2004:2). As defined by the Resilience Alliance, resilience is the capacity of a SES to absorb and/or withstand perturbations and other stressors such that the system retains the same regime, essentially maintaining its structure and functions; this describes the system's capacity for self-organization, learning, and adaptation—SES resilience (Holling, 1973, Gunderson and Holling, 2002, Walker et al., 2004).

The building of resilience and the reduction of vulnerability to the impacts of climate change in the context of small-scale fisheries is important (Smit and Wandel, 2006). Pelling (2010) defines resilience in the context of climate change adaptation as a “refinement of actions to improve performance without changing guiding assumptions or the questioning of established routines” (Brown, 2016:140). Resilience thinking and adaptation are overlapping concepts. ‘Adaptation’ can be defined as “adjustments in a system’s behaviour and characteristics that enhance its ability to cope with external stress” (Brooks, 2003:8). ‘Vulnerability’ is susceptibility to harm (Schroeder and Gefenas, 2009). Eriksen et al. (2011) suggest four principles for sustainable adaptation: 1). recognise the context for vulnerability, including multiple stresses; 2). acknowledge that different values and interests affect adaptation outcomes; 3). integrate local knowledge into adaptation responses; and 4). consider potential feedback between local and global processers.

The literature highlights five research areas (needs) that are underrepresented in contemporary adaptation approaches (Brown, 2016). These areas are: 1). climate change cannot be separated from other changes taking place in the SES; 2). the importance of cross-scale, cross-sectoral, and cross-jurisdictional boundaries and threshold effects; 3). a focus on feedback and inter-temporal dynamics; 4). the emergent properties of SES and great uncertainty in predicting trajectory change; and 5). social values, norms, rules, and preferences that have a significant influence on the system. There are diverse understandings about SES resilience within the climate change adaptation literature. Janssen (2007) identifies adaptation, vulnerability, and resilience as separate sub-fields, or domains, in global environmental change literature, but clear linkages exist (Brown, 2016). Apart from seeing resilience as the opposite of vulnerability, resilience is understood as a system property that provides an analytical lens for evaluating and assessing outcomes (Brown, 2016). Pelling (2010) defines resilience as the refinement of actions to improve performance without changing guiding assumptions or questioning established routines (Brown, 2016). In Pelling’s framework, adaptation is identified as resilience, as transition, and as transformation.

SES resilience is partly reflected by the livelihood security of a group or an individual (Berkes et al., 2003). Thus, SES resilience is a key aspect of the building of adaptive capacity (Berkes et al., 2003, Boyd and Folke, 2012, Brown, 2016). Scholars have identified four ways in which to build SES resilience so as to adapt to environmental change: living with change and uncertainty, nurturing diversity, fostering learning, and combining different kinds of knowledge (including Indigenous knowledge (IK)) (Berkes and Jolly, 2001, Folke et al., 2003, Berkes, 2007, Kofinas et al., 2013). Gomez-Baggethun et al. (Gómez-Baggethun et al., 2013) illustrate three important links between Indigenous knowledge and resilience (Brown, 2016). First, they suggest that IK itself is resilience. Second, IK is a source of resilience. Third, IK often provides insights into environmental change and diverse perspectives on the stresses that affect local SES (Pearce et al., 2015).

Because IK is an evolving accumulated knowledge—and the connected knowledge—of Indigenous peoples (Berrang-Ford et al., 2012, Ford et al., 2012, Nakashima et al., 2012b), it has the potential to complement scientific knowledge and can contribute to an overall usable knowledge that leads to knowledge co-production as a source of resilience (Berkes et al., 2008). Multi-level institutions can play a significant role in knowledge integration and adaptation (Boyd and Folke, 2012), especially in the climate-change-related global curtailing of policy-level decision making (e.g., IPCC) (Ford et al., 2016b). The role of Indigenous knowledge in climate change adaptation and resilience building is one of the key emphases of this research. Building on this conceptual foundation, this study integrates the theoretical elements of SES residence, vulnerability, and adaptation to make sense of the ways in which rural Indigenous fisher communities experience and adapt to climate change.

1.4 Adaptation to climate change

The Intergovernmental Panel on Climate Change (IPCC), in its fifth assessment report, defines adaptation as “the process of adjustment to actual or expected climate and its effects, in order to either lessen or avoid harm or exploit beneficial opportunities” (IPCC, 2014c: 76). Accordingly, adaptation includes a variety of strategies, actions, and behaviors that make populations (individuals, households, communities, society) more resilient to climate change (Ford et al., 2018b). Herein, adaptation may reduce exposure and sensitivity to climate impacts and/or build adaptive capacity to manage and take advantage of change (Smit and Wandel, 2006, Füssel, 2007). Adaptation can be characterized in multiple ways, including by a) purposefulness (autonomous and planned), b) timing (anticipatory and responsive), c) temporal scope (short and long term), d) spatial scale (individual to global), e) form (physical, social, and institutional), and

f) phase (groundwork to action) (Smit et al., 1999, Smit et al., 2000, Ford et al., 2018b). Importantly, adaptation may involve responses that specifically respond to climate impacts or address the underlying determinants of vulnerability; Dupuis and Biesbreok (2013), along with Ford et al in an Arctic context (2018b), refer to the former as climate centered adaptation and the latter as vulnerability centered adaptation (figure 1.1).

The vulnerability-centered adaptation perspective may be aimed at the essential social-economic-political-cultural dynamics that lead to climate vulnerability by weakening adaptive capacity or increasing exposure and sensitivity to impacts (Dupuis and Biesbroek, 2013, Agrawal and Lemos, 2015). This adaptation may not be aimed specifically at addressing climate change impacts; rather, if focusses on addressing non-climatic determinants of climate vulnerability and on building resilience at the household, community, and regional levels (Kelman et al., 2016, Ford et al., 2018b, Leite et al., 2019). More attention is being paid to vulnerability-centered adaptation because non-climatic conditions are important in determining vulnerability to climate change by changing sensitivity and exposure, and climate change, in many instances, is not the main driver of change but, rather, one among many multiple interacting factors (Janssen and Ostrom, 2006, Lei et al., 2014, Maru et al., 2014a, Maru et al., 2014b, Bunce and Ford, 2015, Ford et al., 2018b). These two perspectives capture a continuum of how adaptation can be conceptualized and place different weights on the origin of the problem for which adaptation is needed (Dupuis and Biesbroek, 2013, Ford et al., 2018b).

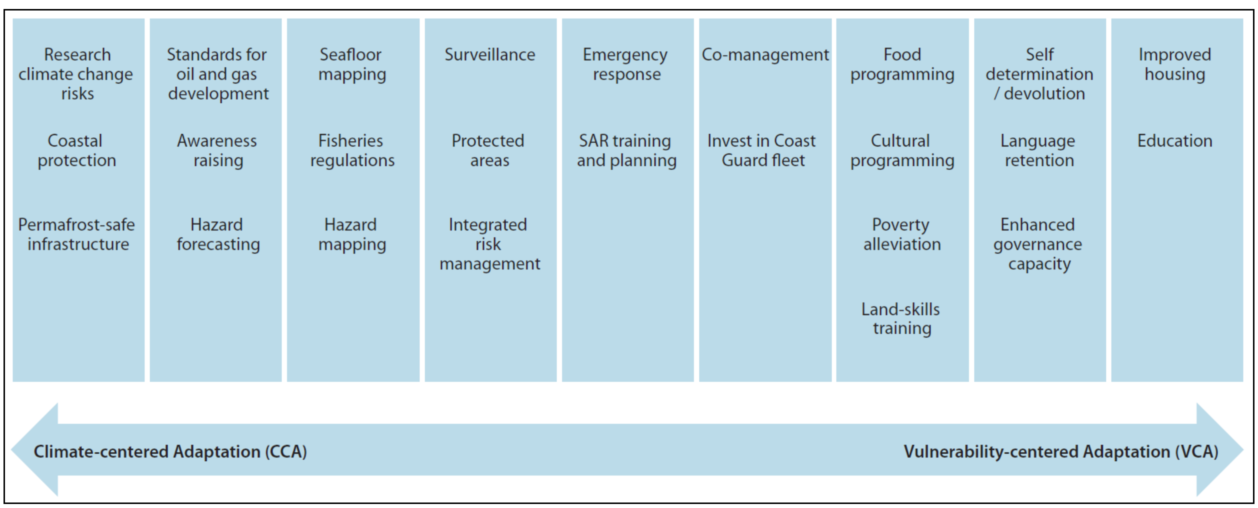

Figure 1.1: An adaptation continuum with Arctic-focused examples (climate-centered to vulnerability centered). The categories of climate-centered and vulnerability-centered adaptations are not distinct and mutually exclusive. Adaptation options can fall anywhere along the continuum. SAR = search and rescue.

Source: Ford et al. (Ford et al., 2018b: 308)

1.5 Scale of the study

According to Cash et al. (2006), scale is a dynamic entity that refers to the spatial and temporal frequency of a process or structure. Spatially, this research aims to understand how different Indigenous fisheries systems respond to change similarly (or differently) in different rural populations. The work thus takes place in two communities, and also focuses on the processes and conditions at larger spatial scales that influence communities (Turner et al. 2003). Temporally, this research examines the ways in which fishers experience change and how they have responded to change over the last 30 years. Resilience can be studied across the scale at different levels (Leite et al., 2019), such as individual (Hegney et al., 2007), household (Nguyen and James, 2013), community (Berkes and Jolly, 2001), and regional (Arctic Council, 2016). Thus, the term 'resilience' can be used for multiple levels, from individual to regional fisheries systems.

In this study, I focus specifically on resilience at the community level. Community refers to "some definable aggregation of households, interconnected in some way, and with a limited spatial extent" (Smit and Wandel, 2006: 283), and was selected as the focus of the research for a number of reasons. Firstly, assessing resilience requires in-depth understanding of how people interact with the environment and the integration of Indigenous knowledge, both of which require working closely with local people (Berkes, 2012). Secondly, small-scale fisheries are heterogenous entities with resilience varying significantly among and within communities, and thus necessitating in-depth investigation in specific places (Giuliani, 2003, Kasperson and Archer, 2005, Berkes and Davidson-Hunt, 2007, Cutter et al., 2008, Amundsen, 2015). Finally, the social-ecological system approach that I am using in this research focuses not merely on ecosystems *per se* or societies *per se* but, rather, on the social-ecological system (i.e., the community) as the unit of analysis (Berkes et al., 1998, Berkes et al., 2003). The study of social-ecological systems is not possible if its aim is limited to the individual, household, or regional level.

1.6 Methodological approach

I have developed an integrated comparative ethnographic research approach to study climate change adaptation in Indigenous fisher communities. The methodological scope maintains the following three characteristics, for a three-tier approach: theory development, empirical case studies, and comparative analysis. This study involves extensive field data collection using multiple-methods (participant observations, semi-structured interviews, focus group discussions, and key informant interviews) in the rural fishing communities of the Canadian Arctic and Eastern Sri Lanka. A community-based participatory research approach was used throughout the project. This section starts by elaborating on and justifying the application of a participatory community-based approach, the choice of inquiry, and the three-tier approach. This thesis uses a manuscript format. Details specific to each objective can be found in the respective chapters. I have included a specific chapter (2) to describe the overarching methods, definitions, logic, and essential methodological aspects pertaining to the thesis that reflects on the knowledge co-production process. This section aims to offer introductory insights into the study methodology.

1.6.1 Participatory Research approach

To obtain a deep understanding of how fishers experience climate change impacts and means of responding in an Indigenous context, I used a community-based participatory research (CBPR) approach (Hacker, 2013). As Freire (2000) points out, knowledge does not come only from academia, as ‘people’ and ‘community’ also create and possess knowledge. Studying climate adaptation is an ongoing process, particularly with the focus being on highly vulnerable rural Indigenous communities. CBPR holds promise as a strategy that could support the research process through community engagement in shaping knowledge production (Hacker, 2013). This research emphasizes learning from the community. CBPR has the potential to operationalise a ‘win-win structure’ for both the researcher and the community, helping to mitigate ethical considerations related to traditional research practices (Christoplos, 2010, McPherson et al., 2016).

My preliminary field visits helped identify “the community” in both the Arctic and Sri Lanka, as CBPR acknowledges community as a unit of identity (appendix D). In the summer of 2016, I visited each community for a period of two weeks to conduct preliminary data collection. My initial contact with the communities helped me understand their strengths and resources, as well as to obtain community consent regarding the research project. Data collection took place from the summer of 2017 to the winter of 2019. I made three visits to the Canadian Arctic community (eight weeks in the summer of 2017, two weeks in the spring of 2018, and two weeks in the winter of 2019). I made two trips to the Sri Lanka community (12 weeks in the fall of 2017 and another 12 weeks in the summer of 2018). The field data collection process facilitated the formation of a collaborative and equitable partnership while empowering power-sharing; this was characterised by: a) the involvement of local Indigenous people in the data collection process (research assistants, translators), b) being intimately involved in the daily local activities/lifestyle to build trust and foster co-learning (fishing and hunting trips, cultural activities, local meetings), and c) the exchange of continuous feedback for data collection, analysis, theme-building, and results dissemination processers to minimise the misinterpretation of results.

1.6.2 Case study based research

A case study approach working closely with the partner communities was used as the primary strategy of inquiry in conducting the research. Yin (2013: 23) defines the case study research approach as an "empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." Case studies enable the exploration and obtaining of a rich understanding of the processes being performed within a given context; it has the ability to generate answers to the questions "why?", "what?", and "how?" (Yin, 2013). As Creswell (2013) outlines, a case study enables in-depth examination of the process. This project focuses on how Indigenous fishers build SES resilience and adapt to climate change. Furthermore, the research is concerned with the ways in which people make sense of their experiences and lives. A significant amount of data comes from the individual perspectives and SES memory of locals (Rodríguez et al., 2019), as they are asked to interpret their views and observations.

1.6.3 Three-tier methodological approach: Conceptual; empirical; and comparative

A three-tier methodological approach was developed to guide the research objectives (i.e., conceptual; empirical; and comparative). Chapter 3 is built on a conceptual tier and has already been published in *Environmental Science and Policy* (Galappaththi et al., 2019c). Chapters 4 and 5 are built on an empirical tier. Chapter 4 has been published in *Journal of Environmental Management* (Galappaththi et al., 2019b) and chapter 5 has been published in *Climatic Change* (Galappaththi et al., 2020). Chapter 6 is on the comparative tier and is being prepared for submission to *Global Environmental Change*.

First, a literature review was conducted to develop the conceptual framework for assessing community adaptation to climate change in an Indigenous fisheries context (objective one, Chapter 3). Two bodies of literature on complex human-environment systems and climate change adaptation in rural Indigenous fisheries were drawn upon to this end. Textual content analysis was carried out on selected journal articles with the aim of examining the main themes and trends, major research gaps, and possible ways forward in climate change adaptation research. Data were coded manually and specific recordings were maintained in Excel and PowerPoint files. The key characteristics of the framework and indicators for assessing community adaptations were partly developed using both latent and manifest content analysis (Vaismoradi et al., 2016) of both cognate and thesis literature domains. Multiple conceptual diagrams of social-ecological systems, adaptation, and change processes were developed based on the extracted data and emerged themes. An initial conceptual framework was synthesized building on the cognate research paper that I produced as a partial requirement of my PhD comprehensive exam. The characteristics and indicators of the conceptual framework were further developed as an iterative creation with feedback obtained from the study communities of Inuit (Canada) and Coastal-Vedda (Sri Lanka) during the initial phase of field data collection.

Second, empirical field data were collected over three years (since 2016) in two study locations in the Canadian Arctic and Eastern Sri Lanka (figure 1.2) to apply the proposed conceptual framework to the assessment of community adaptations to climate change impacts in the context of Indigenous fisher populations. These two populations and regions were selected because they reflect the diverse cultures, livelihoods, and environmental characteristics of remote Indigenous fisher populations globally in high- and low-income nations and the diversity of the biophysical environments in which they live, thereby facilitating the development of broad insights into Indigenous resilience, vulnerability, and adaptation.

The selected regions share other similarities, including socio-economic inequality, and sensitivity to climate change, remoteness, dependence on the biophysical environment for diet and well-being, concerns over the erosion of Indigenous knowledge, and a particularly high attachment to fisheries. Additionally, they have experienced rapid economic development over the past decade. In this sense, they are in a state of transition that has implications for climate adaptation. The contrast between and similarity of these study sites underpins one of the aims of this thesis to assess both the generalizability and the context dependence of resilience and climate adaptation in a small-scale fisheries context.

Qualitative field data were collected through participant observations, semi-structured interviews, focus group discussions, and key informant interviews in Inuit and Coastal-Vedda SSFs communities. Field data collection focused on the term ‘change’ to minimise the biases of respondents because of the intertwined nature of climate change and the associated implications on human-environment systems. Both empirical studies were assessed using the characteristics of the same conceptual framework that was developed to address the first research objective. Information about the detailed study area and the methods of each case study can be found in Chapters 4 and 5, which are related to research objectives two and three, respectively.

Figure 1.2: Two case study regions: Pangnirtung Inuit community (Canadian Arctic) and Kunjankalkulam Coastal-Vedda community (Eastern Sri Lanka).
Source: Google maps (https://www.google.com/maps).

Third, a comparative analysis was conducted to compare and contrast the empirical assessments of the two SSFs case studies. Comparative studies are important in social science research but have had limited use in climate change adaptation and SSFs, partly due to the diverse nature of SSFs communities (Maru et al., 2014a, Salas et al., 2018, Conway et al., 2019). Comparative analysis is the key reason for the use of two case studies in this research, as noting individual case studies is essential to developing a deeper understanding of particular areas unique to the case (Mills et al., 2017). Comparative studies are used to test theoretical frameworks, refine novel concepts, and discover new relationships while contributing additional insights to individual case studies (Lesnikowski, 2019).

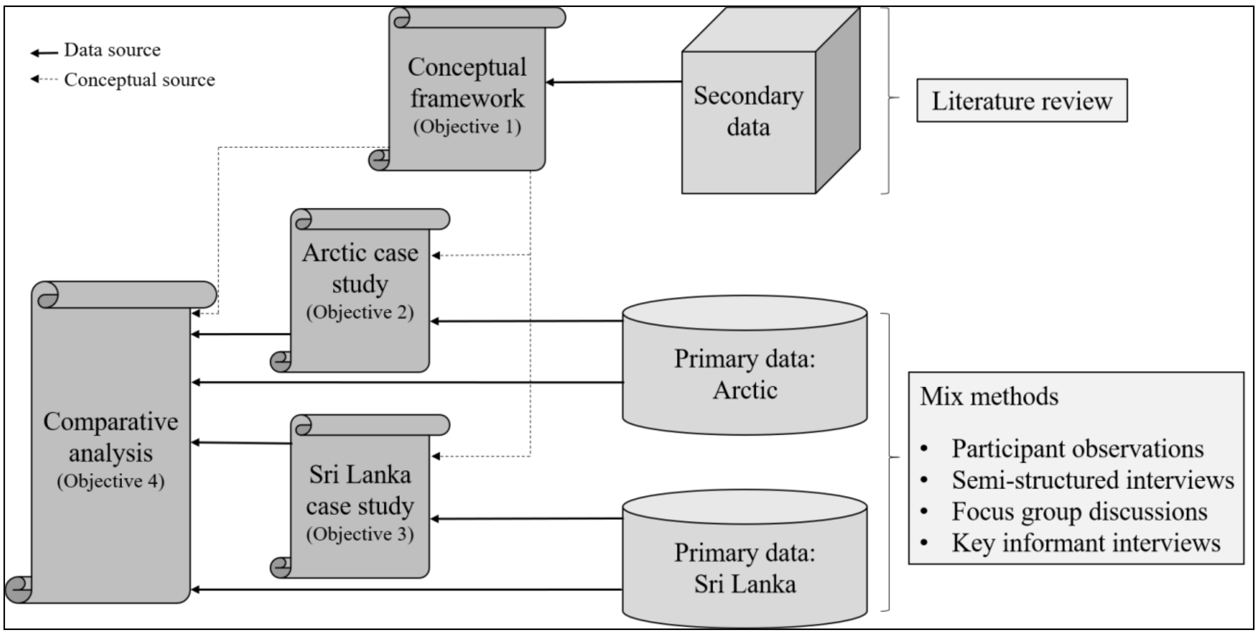

Figure 1.3: Overview of thesis methodology.

The cylinder-like box shape refers to the primary data collected using mixed methods. The cube-like box shape refers to secondary data collected through an extensive literature review. The parchment shapes refer to developed articles (results chapters) of the thesis methodology.

Comparative analysis provides a broader perspective for subject case studies about the relative nature of adaptation to climate change (Watson et al., 1998). This allows individual SSFs systems, scientists, and policymakers to uncover the bigger picture of climate change adaptation in a fisheries context. Comparative studies help answer specific questions such as: i) what are the characteristics of climate change impacts experienced by the Indigenous fishers, ii) what are the common adaptive strategies, iii) what are the possible means of building resilience, and iv) what are the definitive characteristics of successful adaptation in SSFs. However, most existing studies in the community adaptation literature are aimed at communities within the same country, which limits the broader application of the findings in terms of establishing links to the regional adaptation policy (Maru et al., 2014a, Conway et al., 2019). The detailed methodology of the comparative studies can be found in Chapter 6.

Table 1.1: Overview of data collection procedures.

Objectives	Methods (n)	Types of respondents
To develop a conceptual framework to assess community adaptation to climate change in fisheries.	Literature review (>128) Focus group discussions (3) Key informant interviews (18)	Inuit and Coastal-Vedda fishers, elders, Coastal-Vedda leaders, Inuit leaders, officers of local fisheries institutions, relevant government representatives.
To assess community adaptation to climate change in the Inuit community of the Canadian Arctic.	Participant observations (4 months) Semi-structured interviews (62) Focus group discussions (6) Key informant interviews (25)	Turbot and Arctic char fishers including elders, Hunters and Trappers Association, the fish plant, Department of Fisheries and Oceans, Nunavut Wildlife Management Board, the hamlet office, Nunavut territorial government agencies, the soup kitchen, the community weather station, Baffin fisheries.
To assess community adaptation to climate change in the Coastal-Vedda community of Eastern Sri Lanka.	Participant observations (6 months) Semi-structured interviews (74) Focus group discussions (17) Key informant interviews (38)	Coastal-Vedda fishers including elders, fisheries, and aquaculture line authorities, government ministries, local universities, non-governmental organizations, as well as individuals with specific knowledge (e.g., National Vedda chief-Sri Lanka).
To carry out a comparative analysis of two case studies (i.e., Inuit of Canadian Arctic and Coastal-Vedda of Sri Lanka).	Comparative analysis using above case studies	N/A

1.7 Thesis outline

This thesis consists of seven chapters. This chapter explains the research background and context, the key theoretical contributions, and the methodological approach used to address my PhD research objectives. The next chapter (2) describes the overarching methods pertaining to the thesis, aimed at conceptual, empirical, and comparative research objectives. This chapter describes the development of the conceptual framework in detail, including the key steps and the ways it was operationalized. Further, this chapter elaborates on the details about field data collection methods, data analysis, and ethical and positionality considerations related to the empirical case studies (i.e., chapters 4 and 5). Finally, this chapter depicts the specific data analysis used for the comparative analysis (chapter 6).

Chapters 3-6 are written as individual papers. That is, I have adopted a manuscript format aimed at peer-reviewed disciplinary journals. Chapter 3 has already been published in *Environmental Science and Policy* and Chapter 4 has been published in *Journal of Environmental Management*. Chapter 5 has also been published in *Climatic Change* and Chapter 6 is being prepared for submission to *Global Environmental Change*. The overview of the upcoming chapters of the thesis is as follows.

Chapter 3 proposes a conceptual framework for assessing community adaptation to climate change impacts in a fisheries context (objective one). This chapter provides specific knowledge about the domains of 'social-ecological systems resilience' and 'development resilience' used to develop the conceptual framework. The chapter defines resilience as a combined result of coping, adapting, and transforming capacities and as a process. This understanding of resilience is integrated with the three development resilience concepts of resistance, rootedness, and resourcefulness to develop 'place-specific elements' identified as human agency, collective action, institutions, and knowledge systems. Further, this chapter elaborates on how this proposed conceptual framework addresses many of the prevailing critiques of the notion of resilience.

Chapter 4 is an empirical case study of the coastal fisheries community of Pangnirtung in the Canadian Arctic. This chapter examines the ways in which Inuit fishers experience and respond to climate change. This chapter uses the characteristics of the proposed conceptual framework in Chapter 3 to assess the community adaptation of the Inuit population. The chapter provides details related to the study area and methods including mixed methods used for field data collection. Furthermore, this chapter identifies three community-level adaptive strategies and four place-specific attributes that can shape community adaptations in the Inuit fisheries context.

Chapter 5 is an empirical case study of the reservoir aquaculture community of Kunjankalkulam in Eastern Sri Lanka. This chapter examines the ways in which Indigenous Coastal-Vedda fishers experience and respond to systems change, including climate change. This study also adopts the conceptual framework proposed in Chapter 3 to assess the community adaptations of the

Coastal-Vedda population. The chapter provides details related to the field area and the Indigenous Vedda people of Sri Lanka following the methods. Also, this study identified three community-level adaptive strategies and four place-specific attributes that can shape community adaptations in Coastal-Vedda reservoir aquaculture systems.

Chapter 6 compares two uniquely different climate-sensitive rural populations (i.e., Inuit of Canadian Arctic and Coastal-Vedda of Sri Lanka) to broaden our understanding of how fisheries- and aquaculture-dependent Indigenous communities respond and adapt to climate change impacts. This chapter is also guided by the conceptual framework proposed in Chapter 3 and used as main data sources in Chapters 4 and 5. This chapter identifies sources of resilience and adaptive capacities related to the rural Indigenous and SSF settings in terms of adapting to climate change impacts. Further, it identifies the definitive characteristics of a successful community adaptation process to inform adaptation policy development.

Finally, Chapter 7 concludes the thesis with a discussion of how each chapter's findings help deepen our understanding of adaptation to climate change in rural Indigenous communities in diverse geographical regions by addressing the research questions/objectives. It also explains the significance of this research with regard to the study's comparative nature and identifies opportunities for adaptation to climate change policy focusing on SSFs. Additionally, it reflects on future research opportunities in the area of community adaptation to climate change.

1.8 References

ADGER, W. N. 2000. Social and ecological resilience: are they related? *Progress in human geography,* 24**,** 347-364.

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

ADGER, W. N., BUTLER, C. & WALKER-SPRINGETT, K. 2017. Moral reasoning in adaptation to climate change. *Environmental Politics***,** 1-20.

ADHIKARI, S., KESHAV, C. A., BARLAYA, G., RATHOD, R., MANDAL, R., IKMAIL, S., SAHA, G., DE, H., SIVARAMAN, I. & MAHAPATRA, A. 2018. Adaptation and Mitigation Strategies of Climate Change Impact in Freshwater Aquaculture in some states of India. *Journal of FisheriesSciences. com,* 12**,** 16-21.

AGRAWAL, A. & LEMOS, M. C. 2015. Adaptive development. *Nature Climate Change,* 5**,** 185.

ALLISON, E. H. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish Fish.,* 10**,** 173-196.

AMUNDSEN, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment,* 20**,** 257-276.

ARAOS, M., FORD, J., BERRANG-FORD, L., BIESBROEK, R. & MOSER, S. 2017. Climate change adaptation planning for Global South megacities: the case of Dhaka. *Journal of Environmental Policy & Planning,* 19**,** 682-696.

ARCTIC COUNCIL 2016. Arctic Resilience Report, Arctic Council. *In:* CARSON, M. & PETERSON, G. (eds.). Stockholm: Stockholm Environment Institute and Stockholm Resilience Centre.

ARKEMA, K. K., GUANNEL, G., VERUTES, G., WOOD, S. A., GUERRY, A., RUCKELSHAUS, M., KAREIVA, P., LACAYO, M. & SILVER, J. M. 2013. Coastal habitats shield people and property from sea-level rise and storms. *Nature Climate Change,* 3**,** 913-918.

ARMITAGE, D. R., PLUMMER, R., BERKES, F., ARTHUR, R. I., CHARLES, A. T., DAVIDSON-HUNT, I. J., DIDUCK, A. P., DOUBLEDAY, N. C., JOHNSON, D. S. &

MARSCHKE, M. 2008. nagement for social-ecological complexity. *Frontiers in Ecology and the Environment,* 7**,** 95-102.

ASSEMBLY, G. 2014. Sustainable Development goals, Improving human and planetary wellbeing. *Global change biology,* 82**,** 20-23.

BARANGE, M., BAHRI, T., BEVERIDGE, M. C., COCHRANE, K. L., FUNGE-SMITH, S. & POULAIN, F. 2018. Impacts of climate change on fisheries and aquaculture, Synthesis of current knowledge, adaptation and mitigation options. Rome: Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Technical Paper No. 627, Rome. 628pp. Rome: FAO.

BERKES, F. 2003. Alternatives to conventional management: Lessons from small-scale fisheries. *Environments,* 31**,** 5.

BERKES, F. 2007. Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural hazards,* 41**,** 283-295.

BERKES, F. 2012. *Sacred ecology,* New York, Routledge.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F., COLDING, J. & FOLKE, C. 2008. *Navigating social-ecological systems: building resilience for complexity and change*, Cambridge University Press.

BERKES, F. & DAVIDSON-HUNT, I. J. 2007. Communities and social enterprises in the age of globalization. *Journal of Enterprising Communities: People and Places in the Global Economy,* 1**,** 209-221.

BERKES, F., FOLKE, C. & COLDING, J. (eds.) 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience,* Cambridge, UK: Cambridge University Press.

BERKES, F., FOLKE, C. & COLDING, J. 2000. *Linking social and ecological systems: management practices and social mechanisms for building resilience*, Cambridge University Press.

BERKES, F. & JOLLY, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology,* 5**,** 18.

BERKES, F. & ROSS, H. 2013. Community resilience: toward an integrated approach. *Society & Natural Resources,* 26**,** 5-20.

BERKES, F. & SEIXAS, C. S. 2005. Building resilience in lagoon social–ecological systems: a local-level perspective. *Ecosystems,* 8**,** 967-974.

BERRANG-FORD, L., DINGLE, K., FORD, J. D., LEE, C., LWASA, S., NAMANYA, D. B., HENDERSON, J., LLANOS, A., CARCAMO, C. & EDGE, V. 2012. Vulnerability of indigenous health to climate change: A case study of Uganda's Batwa Pygmies. *Social science & medicine,* 75**,** 1067-1077.

BOILLAT, S. & BERKES, F. 2013. Perception and interpretation of climate change among Quechua farmers of Bolivia: indigenous knowledge as a resource for adaptive capacity. *Ecology and Society,* 18.

BOYD, E. & FOLKE, C. (eds.) 2012. *Adapting institutions: Governance, complexity and social-ecological resilience,* New York: Cambridge University Press.

BROOKS, N. 2003. Vulnerability, risk and adaptation: A conceptual framework. *Tyndall Centre for Climate Change Research Working Paper,* 38**,** 1-16.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

BRZOSKA, M. & FRÖHLICH, C. 2016. Climate change, migration and violent conflict: vulnerabilities, pathways and adaptation strategies. *Migration and Development,* 5**,** 190-210.

BUNCE, A. & FORD, J. 2015. How is adaptation, resilience, and vulnerability research engaging with gender? *Environmental Research Letters,* 10**,** 123003.

CASH, D., ADGER, W. N., BERKES, F., GARDEN, P., LEBEL, L., OLSSON, P., PRITCHARD, L. & YOUNG, O. 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. *Ecology and society,* 11.

CHAPIN, F. S., CARPENTER, S. R., KOFINAS, G. P., FOLKE, C., ABEL, N., CLARK, W. C., OLSSON, P., SMITH, D. M. S., WALKER, B. & YOUNG, O. R. 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology & Evolution,* 25**,** 241-249.

CHRISTOPLOS, I. 2010. Understanding climate change adaptation: lessons from community-based approaches. *imate and Development,* 2**,** 73-74.

CINNER, J. E. 2012. Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Glob. Environ. Change,* 22**,** 12-20.

CISNEROS-MONTEMAYOR, A. M., PAULY, D., WEATHERDON, L. V. & OTA, Y. 2016. A global estimate of seafood consumption by coastal indigenous peoples. *PLoS One,* 11**,** e0166681.

CONWAY, D., NICHOLLS, R. J., BROWN, S., TEBBOTH, M. G., ADGER, W. N., AHMAD, B., BIEMANS, H., CRICK, F., LUTZ, A. F. & DE CAMPOS, R. S. 2019. The need for bottom-up assessments of climate risks and adaptation in climate-sensitive regions. *Nature Climate Change,* 9**,** 503-511.

CRESWELL, J. W. 2013. *Qualitative inquiry and research design: Choosing among five approaches,* Thousand Oaks, Sage.

CUTTER, S. L., BARNES, L., BERRY, M., BURTON, C., EVANS, E., TATE, E. & WEBB, J. 2008. A place-based model for understanding community resilience to natural disasters. *Global environmental change,* 18**,** 598-606.

DAVIDSON-HUNT, I. J. & BERKES, F. 2003. Nature and society through the lens of resilience: toward a human-in-ecosystem perspective. *Navigating social-ecological systems: Building resilience for complexity and change***,** 53-82.

DENIS, M. & MOSER, S. C. 2015. IPCC: calling social scientists of all kinds. *Nature,* 521**,** 161-161.

DONEY, S. C., FABRY, V. J., FEELY, R. A. & KLEYPAS, J. A. 2016. Ocean Acidification: The Other CO2 Problem. *Annual Review of Marine Science* 1**,** 169-192.

DUPUIS, J. & BIESBROEK, R. 2013. Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. *Global Environmental Change,* 23**,** 1476-1487.

ERIKSEN, S., ALDUNCE, P., BAHINIPATI, C. S., MARTINS, R. D. A., MOLEFE, J. I., NHEMACHENA, C., O'BRIEN, K., OLORUNFEMI, F., PARK, J. & SYGNA, L. 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate and Development,* 3**,** 7-20.

FAO 2015. Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector, by Cecile Brugère and Cassandra De Young. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, Italy.

FAO 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome: Food and Agriculture Organization of the United Nations.

FERNÁNDEZ-LLAMAZARES, Á., GARCIA, R. A., DÍAZ-REVIRIEGO, I., CABEZA, M., PYHÄLÄ, A. & REYES-GARCÍA, V. 2017. An empirically tested overlap between indigenous and scientific knowledge of a changing climate in Bolivian Amazonia. *Regional Environmental Change*, 1-13.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FORD, J., BERRANG-FORD, L., BIESBROEK, R., ARAOS, M., AUSTIN, S. & LESNIKOWSKI, A. 2015. Adaptation tracking for a post-2015 climate agreement. *Nature Climate Change,* 5**,** 967.

FORD, J., FALK, K. & TESAR, C. 2018a. Adaptation and resilince (Chapter 11). *In:* AMAP (ed.) *Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region.* Oslo, Norway: Arctic Monitoring and Assessment Programme (AMAP).

FORD, J., MAILLET, M., POULIOT, V., MEREDITH, T., CAVANAUGH, A. & TEAM, I. R. 2016a. Adaptation and Indigenous peoples in the United Nations Framework Convention on Climate Change. *Climatic Change,* 139**,** 429-443.

FORD, J. D. 2012. Indigenous Health and Climate Change. *American Journal of Public Health,* 102**,** 1260-1266.

FORD, J. D., CAMERON, L., RUBIS, J., MAILLET, M., NAKASHIMA, D., WILLOX, A. C. & PEARCE, T. 2016b. Including indigenous knowledge and experience in IPCC assessment reports. *Nature Climate Change,* 6**,** 349-353.

FORD, J. D., CAMERON, L., RUBIS, J., MAILLET, M., NAKASHIMA, D., WILLOX, A. C. & PEARCE, T. 2016c. Including indigenous knowledge and experience in IPCC assessment reports. *Nature Clim. Change,* 6**,** 349-353.

FORD, J. D., CLARK, D., PEARCE, T., BERRANG-FORD, L., COPLAND, L., DAWSON, J., NEW, M. & HARPER, S. L. 2019. Changing access to ice, land and water in Arctic communities. *Nature Climate Change,* 9**,** 335-339.

FORD, J. D., SHERMAN, M., BERRANG-FORD, L., LLANOS, A., CARCAMO, C., HARPER, S., LWASA, S., NAMANYA, D., MARCELLO, T. & MAILLET, M. 2018b.

Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. *Global environmental change,* 49**,** 129-139.

FORD, J. D., SMIT, B. & WANDEL, J. 2006. Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. *Global Environmental Change,* 16**,** 145-160.

FORD, J. D., SMIT, B., WANDEL, J., ALLURUT, M., SHAPPA, K., ITTUSARJUAT, H. & QRUNNUT, K. 2008. Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *The Geographical Journal,* 174**,** 45-62.

FORD, J. D., VANDERBILT, W. & BERRANG-FORD, L. 2012. Authorship in IPCC AR5 and its implications for content: climate change and Indigenous populations in WGII. *Climatic change,* 113**,** 201-213.

FORSYTH, T. 2017. Community based adaptation. *In:* VON STORCH, H. (ed.) *Oxford Research Encyclopedia of Climate Science.* Oxford, UK: Oxford University Press.

FREIRE, P. 2000. *Pedagogy of the oppressed,* London, Bloomsbury Publishing.

FRISCH, L., MATHIS, J., KETTLE, N. & TRAINOR, S. 2015. Gauging perceptions of ocean acidification in Alaska. *Marine Policy,* 53**,** 101-110.

FÜSSEL, H.-M. 2007. Vulnerability: a generally applicable conceptual framework for climate change research. *Global Environmental Change,* 17**,** 155-167.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2019a. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C. (eds.) *Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, Bangkok, 8–10 August, 2016. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO. 240 pp. Licence: CC BY-NC-SA 3.0 IGO.*

GALAPPATHTHI, E. K., FORD, J., BENNETT, E. & BERKES, F. 2019b. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada *Journal of Environmental management,* 250**,** 11.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019c. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2020. Climate change and adaptation to social-ecological change: the case of indigenous people and culture-based fisheries in Sri Lanka. *Climatic Change*.

GIULIANI, M. V. 2003. Theory of attachment and place attachment. *In:* M. BONNES & T. LEE, M. B. (eds.) *Psychological theories for environmental issues* Aldershot: Ashgate.

GÓMEZ-BAGGETHUN, E., CORBERA, E. & REYES-GARCÍA, V. 2013. Traditional ecological knowledge and global environmental change: research findings and policy implications. *Ecology and society,* 18**,** 8.

GRIGGS, D., STAFFORD-SMITH, M., GAFFNEY, O., ROCKSTRÖM, J., ÖHMAN, M. C., SHYAMSUNDAR, P., STEFFEN, W., GLASER, G., KANIE, N. & NOBLE, I. 2013. Policy: Sustainable development goals for people and planet. *Nature,* 495**,** 305.

GUNDERSON, L. H. & HOLLING, C. S. (eds.) 2002. *Panarchy: understanding transformations in human and natural systems,* Washington: Island press.

HACKER, K. 2013. *Community-based participatory research,* London, Sage.

HARVEY, D. 2006. *Spaces of global capitalism,* London, Verso.

HEGNEY, D. G., BUIKSTRA, E., BAKER, P., ROGERS-CLARK, C., PEARCE, S., ROSS, H., KING, C. & WATSON-LUKE, A. 2007. Individual resilience in rural people: a Queensland study, Australia. *Rural and remote health,* 7**,** 1-13.

HENDRIX, C. S. & SALEHYAN, I. 2012. Climate change, rainfall, and social conflict in Africa. *Journal of peace research,* 49**,** 35-50.

HICKS, C. C., LEVINE, A., AGRAWAL, A., BASURTO, X., BRESLOW, S. J., CAROTHERS, C., CHARNLEY, S., COULTHARD, S., DOLSAK, N. & DONATUTO, J. 2016. Engage key social concepts for sustainability. *Science,* 352**,** 38-40.

HOLLING, C. S. 1973. Resilience and stability of ecological systems. *Annual review of ecology and systematics***,** 1-23.

IPCC 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. In C.B., Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgley, eds. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014a. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014b. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014c. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.). Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland.

IPCC 2018a. de Coninck, H., A. Revi, M. Babiker, P. Bertoldi, M. Buckeridge, A. Cartwright, W. Dong, J. Ford, S. Fuss, J.-C. Hourcade, D. Ley, R. Mechler, P. Newman, A. Revokatova, S. Schultz, L. Steg, and T. Sugiyama, 2018: Strengthening and Implementing the Global Response. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [MassonDelmotte,V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

IPCC 2018b. Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/.

IPCC 2019a. Barioni, L.G., T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu, 2019: Food Security (Chapter 5). In: Climate change and land. An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [Contreras, E.M., and A.A. Diouf (eds.)]. In Press.

IPCC 2019b. Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.

JANSSEN, M. A. 2007. An update on the scholarly networks on resilience, vulnerability, and adaptation within the human dimensions of global environmental change. *Ecology and Society,* 12**,** 9.

JANSSEN, M. A. & OSTROM, E. 2006. Resilience, vulnerability, and adaptation: A cross-cutting theme of the International Human Dimensions Programme on Global Environmental Change. *Global Environmental Change,* 16**,** 237-239.

JANSSON, A. 1994. *Investing in natural capital: the ecological economics approach to sustainability*, Island Press.

JAYANTHI, M., THIRUMURTHY, S., SAMYNATHAN, M., DURAISAMY, M., MURALIDHAR, M., ASHOKKUMAR, J. & VIJAYAN, K. K. 2018. Shoreline change and potential sea level rise impacts in a climate hazardous location in southeast coast of India. *Environmental Monitoring and Assesment,* 190**,** 50-64.

JENNINGS, S., PASCOE, S., HALL-ASPLAND, S., LE BOUHELLEC, B., NORMAN-LOPEZ, A., SULLIVAN, A. & PECL, G. 2016. Setting objectives for evaluating management adaptation actions to address climate change impacts in south-eastern Australian fisheries. *Fisheries Oceanography,* 25**,** 29-44.

JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C. 2019. Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, Bangkok, 8–10 August, 2016. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO. 240 pp. Licence: CC BY-NC-SA 3.0 IGO.

KASPERSON, R. E. & ARCHER, E. R. 2005. Vulnerable Peoples and Places. *Ecosystems and Human Well-Being: Current State and Trends: Findings of the Condition and Trends Working Group,* 1**,** 143.

KELMAN, I., GAILLARD, J., LEWIS, J. & MERCER, J. 2016. Learning from the history of disaster vulnerability and resilience research and practice for climate change. *Natural Hazards,* 82**,** 129-143.

KENCH, P., THOMPSON, D., FORD, M., OGAWA, H. & MCLEAN, R. 2015. Coral islands defy sea-level rise over the past century: Records from a central Pacific atoll. *Geology,* 43**,** 515-518.

KEYS, P. W., GALAZ, V., DYER, M., MATTHEWS, N., FOLKE, C., NYSTRÖM, M. & CORNELL, S. E. 2019. Anthropocene risk. *Nature Sustainability*.

KOFINAS, G., CLARK, D., HOVELSRUD, G., ALESSA, L., AMUNDSEN, H., BERMAN, M., BERKES, F., CHAPIN III, F., FORBES, B. & FORD, J. 2013. Adaptive and transformative capacity. *Arctic Council. Arctic Resilience Interim Report. Stockholm Environment Institute and Stockholm Resilience Centre. Stockholm***,** 71-91.

KUHNLEIN, H. V., ERASMUS, B., SPIGELSKI, D. & BURLINGAME, B. E. 2013. *Indigenous peoples' food systems and well-being: Interventions & policies for healthy communities,* Rome, FAO/CINE.

LAM, V. W., CHEUNG, W. W. & SUMAILA, U. R. 2016. Marine capture fisheries in the Arctic: winners or losers under climate change and ocean acidification? *Fish and Fisheries,* 17**,** 335-357.

LEI, Y., YUE, Y., ZHOU, H. & YIN, W. 2014. Rethinking the relationships of vulnerability, resilience, and adaptation from a disaster risk perspective. *Natural hazards,* 70**,** 609-627.

LEITE, M., ROSS, H. & BERKES, F. 2019. Interactions between individual, household, and fishing community resilience in southeast Brazil. *Ecology and Society,* 24.

LESNIKOWSKI, A. 2019. *Climate change adaptation policy formulation among local governments: A policy instruments approach.* PhD, McGill University.

LESNIKOWSKI, A., FORD, J., BIESBROEK, R., BERRANG-FORD, L., MAILLET, M., ARAOS, M. & AUSTIN, S. E. 2017. What does the Paris Agreement mean for adaptation? *Climate Policy,* 17**,** 825-831.

LEU, T. C. 2019. Tourism as a livelihood diversification strategy among Sámi indigenous people in northern Sweden. *Acta Borealia,* 36**,** 75-92.

LORENZEN, K., AINSWORTH, C. H., BAKER, S. M., BARBIERI, L. R., CAMP, E. V., DOTSON, J. R. & LESTER, S. E. 2017. Climate Change Impacts on Florida's Fisheries and Aquaculture Sectors and Options for Adaptation. *Florida's Climate: Changes, Variations, & Impacts*.

MARSCHKE, M. J. & BERKES, F. 2006. Exploring strategies that build livelihood resilience: a case from Cambodia. *Ecology and Society,* 11**,** 42.

MARU, Y. T., SMITH, M. S., SPARROW, A., PINHO, P. F. & DUBE, O. P. 2014a. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Global Environmental Change,* 28**,** 337-350.

MARU, Y. T., STAFFORD-SMITH, M., SPARROW, A. & PINHO, P. F. 2014b. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Glob. Environ. Change,* 28**,** 337-350.

MCLAUGHLIN, A. A., DOANE, L. S., COSTIUC, A. L. & FEENY, N. C. 2009. Stress and resilience. *Determinants of minority mental health and wellness.* Springer.

MCPHERSON, J. M., SAMMY, J., SHEPPARD, D. J., MASON, J. J., BRICHIERI-COLOMBI, T. A. & MOEHRENSCHLAGER, A. 2016. Integrating traditional knowledge when it appears to conflict with conservation: lessons from the discovery and protection of sitatunga in Ghana. *Ecology and Society,* 21.

MEES, H. 2017. Local governments in the driving seat? A comparative analysis of public and private responsibilities for adaptation to climate change in European and North-American cities. *Journal of Environmental Policy & Planning,* 19**,** 374-390.

MILLS, J., HARRISON, H., FRANKLIN, R. & BIRKS, M. Case study research: Foundations and methodological orientations. Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 2017. DEU, 17.

MIRZA, M. M. Q. 2003. Climate change and extreme weather events: can developing countries adapt? *Climate policy,* 3**,** 233-248.

MISTRY, J. & BERARDI, A. 2016. Bridging indigenous and scientific knowledge. *Science,* 352**,** 1274-1275.

NAKASHIMA, D., GALLOWAY MCLEAN, K. G., THULSTRUP, H., RAMOS CASTILLO, A. & RUBIS, J. T. 2012a. Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation.

NAKASHIMA, D. J., MCLEAN, K. G., THULSTRUP, H., CASTILLO, A. R. & RUBIS, J. 2012b. Weathering uncertainty: traditional knowledge for climate change assessment and adaptation. UNESCO Paris.

NEW, M., LIVERMAN, D., SCHRODER, H. & ANDERSON, K. 2011. Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences,* 369**,** 6-19.

NGUYEN, K. V. & JAMES, H. 2013. Measuring household resilience to floods: a case study in the Vietnamese Mekong River Delta. *Ecology and Society,* 18.

NILSSON, M., GRIGGS, D. & VISBECK, M. 2016. Policy: map the interactions between Sustainable Development Goals. *Nature News,* 534**,** 320.

O'REILLY, C. M., ALIN, S. R., PLISNIER, P.-D., COHEN, A. S. & MCKEE, B. A. 2003. Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa. *Nature,* 424**,** 766.

OMMER, R. E., PERRY, R. I., MURRAY, G. & NEIS, B. 2012. Social–ecological dynamism, knowledge, and sustainable coastal marine fisheries. *Current Opinion in Environmental Sustainability,* 4**,** 316-322.

PEARCE, T., FORD, J., WILLOX, A. C. & SMIT, B. 2015. Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic,* 68**,** 233.

PEARCE, T., SMIT, B., DUERDEN, F., FORD, J. D., GOOSE, A. & KATAOYAK, F. 2010. Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. *Polar Record,* 46**,** 157-177.

PELLING, M. 2010. *Adaptation to climate change: from resilience to transformation*, Routledge.

PIGGOTT-MCKELLAR, A. E., MCNAMARA, K. E., NUNN, P. D. & WATSON, J. E. 2019. What are the barriers to successful community-based climate change adaptation? A review of grey literature. *Local Environment,* 24**,** 374-390.

RODRÍGUEZ, M. V., DAVIDSON-HUNT, I. & BERKES, F. 2019. Social-ecological memory and responses to biodiversity change in a Bribri Community of Costa Rica. *Ambio-Biodiversity Change and Human Adaptation***,** 1-12.

SALAS, S., BARRAGÁN-PALADINES, M. J. & CHUENPAGDEE, R. 2018. *Viability and Sustainability of Small-Scale Fisheries in Latin America and The Caribbean,* London, Springer.

SAVO, V., MORTON, C. & LEPOFSKY, D. 2017. Impacts of climate change for coastal fishers and implications for fisheries. *Fish and Fisheries,* 18**,** 877-889.

SCHIPPER, E. L. F., AYERS, J., REID, H., HUQ, S. & RAHMAN, A. (eds.) 2014. *Community-based adaptation to climate change: scaling it up,* London: Routledge.

SCHROEDER, D. & GEFENAS, E. 2009. Vulnerability: Too vague and too broad? *Cambridge Quarterly of Healthcare Ethics,* 18**,** 113-121.

SCOONES, I. 1998. Sustainable rural livelihoods: a framework for analysis. *IDS working paper* 72.

SEGGEL, A. & DE YOUNG, C. 2016. Climate change implications for fisheries and aquaculture: summery of the findings of the Intergovernmental Panal on Climate Change fifth assessment report. *FAO Fisheries and aquaculture technical paper.* Rome: Food and Agriculture Organization of the United Nations.

SIMONOVIC, S. P. 2017. Adaptation to climate change: risk management. *In:* KOLOKYTHA, E., OISHI, S. & TEEGAVARAPU, R. S. V. (eds.) *Sustainable Water Resources Planning and Management Under Climate Change.* Singapore: Springer.

SMIT, B., BURTON, I., KLEIN, R. J. & STREET, R. 1999. The science of adaptation: a framework for assessment. *Mitigation and adaptation strategies for global change,* 4**,** 199-213.

SMIT, B., BURTON, I., KLEIN, R. J. & WANDEL, J. 2000. An anatomy of adaptation to climate change and variability. *Climatic change,* 45**,** 223-251.

SMIT, B. & WANDEL, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global environmental change,* 16**,** 282-292.

SMITH, H. & BASURTO, X. 2019. Defining small-scale fisheries and examining the role of science in shaping perceptions of who and what counts: A systematic review. *Frontiers in Marine Science,* 6**,** 236.

SPEERS, A. E., BESEDIN, E. Y., PALARDY, J. E. & MOORE, C. 2016. Impacts of climate change and ocean acidification on coral reef fisheries: an integrated ecological–economic model. *Ecological economics,* 128**,** 33-43.

SUMAILA, U. R., CHEUNG, W. W., LAM, V. W., PAULY, D. & HERRICK, S. 2011. Climate change impacts on the biophysics and economics of world fisheries. *Nature climate change,* 1**,** 449.

TURNER, B. L., KASPERSON, R. E., MATSON, P. A., MCCARTHY, J. J., CORELL, R. W., CHRISTENSEN, L., ECKLEY, N., KASPERSON, J. X., LUERS, A. & MARTELLO, M. L. 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the national academy of sciences,* 100**,** 8074-8079.

VAISMORADI, M., JONES, J., TURUNEN, H. & SNELGROVE, S. 2016. Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice,* 6**,** 100-110.

VOSS, R., QUAAS, M. F., SCHMIDT, J. O. & KAPAUN, U. 2015. Ocean acidification may aggravate social-ecological trade-offs in coastal fisheries. *PloS one,* 10**,** 1-8.

WALKER, B., CARPENTER, S., ANDERIES, J., ABEL, N., CUMMING, G., JANSSEN, M., LEBEL, L., NORBERG, J., PETERSON, G. D. & PRITCHARD, R. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation ecology,* 6**,** 14.

WALKER, B., HOLLING, C. S., CARPENTER, S. R. & KINZIG, A. 2004. Resilience, adaptability and transformability in social--ecological systems. *Ecology and society,* 9**,** 5.

WATSON, R. T., ZINYOWERA, M. C., MOSS, R. H. & DOKKEN, D. J. 1998. The regional impacts of climate change: an assesment of vulnerability, A Special Report of IPCC Working Group II. Cambridge: IPCC.

WHEELER, T. & VON BRAUN, J. 2013. Climate change impacts on global food security. *Science,* 341**,** 508-513.

YIN, R. K. 2013. *Case study research: Design and methods,* New York, Sage publications.

ZAVALETA, C., BERRANG-FORD, L., FORD, J., LLANOS-CUENTAS, A., CÁRCAMO, C., ROSS, N. A., LANCHA, G., SHERMAN, M. & HARPER, S. L. 2018. Multiple non-climatic drivers of food insecurity reinforce climate change maladaptation trajectories among Peruvian Indigenous Shawi in the Amazon. *PloS one,* 13**,** e0205714.

Chapter 2. Methodology

It is useful to provide the overall logic behind my methods, as well as definitions of terms used throughout the thesis here to allow the manuscript chapters to remain concise and focused. The goal of this chapter is to describe the overarching methodological approaches used to address the study objectives. The study/thesis objectives are: 1) to develop a conceptual framework to assess community adaptation in a fisheries context, 2) to assess the community adaptation of Inuit populations in Arctic Canada, 3) to assess the community adaptation of Coastal-Vedda communities of Eastern Sri Lanka, and 4) to carry out a comparative analysis of Inuit and Coastal-Vedda fishing communities to understand opportunities for climate adaptation.

This chapter is structured around three sections aimed at the overarching objectives of the thesis, i.e., the conceptual framework, two empirical case studies, and the comparative analysis. Section 2.1 illustrates the four key steps adopted to develop the conceptual framework (chapter 3) and how it is operationalized throughout the study. Further, this section describes the development of the conceptual framework throughout the study. Section 2.2 describes the methods pertaining to the two empirical chapters, 4 and 5 (i.e., Inuit and Coastal Vedda). This section will describe the selection of case study locations, the community-based participatory research approach, the field data collection methods, the data analysis, and ethical and positionality considerations. Section 2.3 contains the comparative analysis of the two case studies and describes how it derived specific results, such as eight sources of resilience and the definitive characteristics of successful adaptation. Documentation of this methodological information is essential for the thesis, enhancing credibility by improving the validity and reliability of the study (Golafshani, 2003).

2.1.1 Development of the conceptual framework

The first thesis objective is to develop a conceptual framework for assessing community adaptation in a fisheries context. Chapter 3 presents knowledge about the proposed conceptual framework. In this section, I will depict the logical process of the conceptual framework development in four steps (figure 2.1). Further, this section describes how the proposed conceptual framework is operationalized to assess community adaptations to climate change.

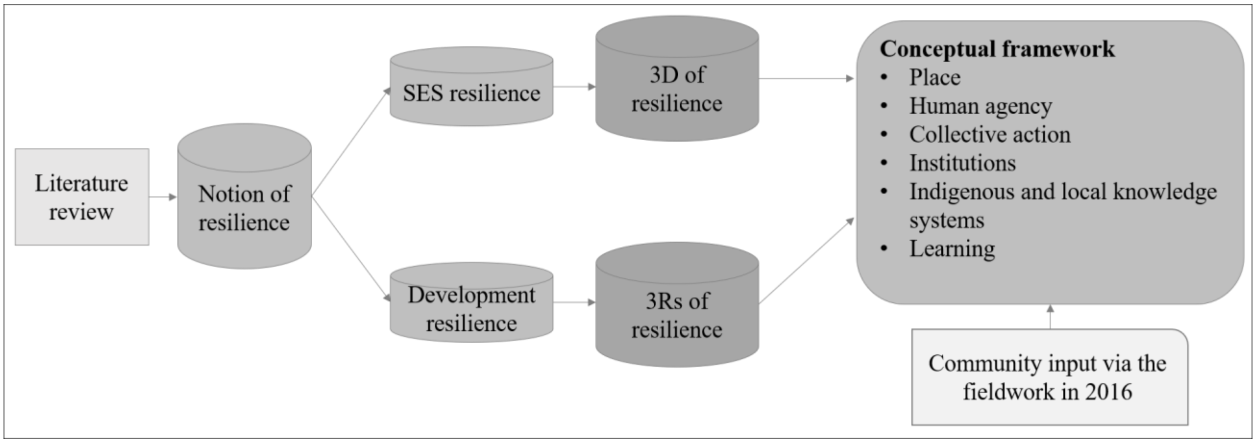

Figure 2.1: Development of the conceptual framework.
Note: The first step conducted a literature review to understand the key conceptual areas, including the notion of resilience. The second step identified two schools of resilience (i.e., social-ecological system resilience and development resilience). The next step selected conceptual tools from each theoretical area for the conceptual integration (i.e., 3D of resilience and 3Rs of resilience). The fourth step developed a conceptual framework as a result of theoretical integration. This conceptual framework received community input during fieldwork in 2016.

A literature review was conducted to develop the conceptual framework. Two main bodies of literature were identified for the textual content analysis. They are: 1) complex human-environment systems (60 publications) and 2) climate change adaptation in rural Indigenous populations (68 publications). Following Krippendorff (2018), I used content analysis as a method tool for textual analysis. The content analysis was guided by three key questions, which are: i) what are the main themes and trends on climate change adaptation research in complex human-environment system research? ii) what are the major research gaps highlighted and missing? and iii) what are the possible ways forward in climate change adaptation research aimed at rural Indigenous fisher populations? Based on the literature review, resilience and social-ecological systems approaches were identified as key conceptual areas for beginning the framework development process.

2.1.2 Step 1: Resilience and social-ecological systems

This thesis primarily builds on the conceptual elements of the notion of resilience. I define resilience as a combined result of coping, adapting, and transforming (using coping capacity, adaptive capacity, and transformative capacity) in response to a disturbance/change (Béné et al., 2012, 2014, 2016b). Resilience uses disturbances (or changes) as opportunities for doing "new things, for innovation, and for development" (Folke, 2006: 253). The notion of resilience is central to much thinking on the assessment of human-environment systems because it recognizes a wide range of characteristics inherent in complex systems (Berkes et al., 2003, Stokols et al., 2013, Brown, 2016) and it has the proven potential to capture dynamic interactions and processes (Berkes et al., 2003, Folke, 2016). The notion of resilience was initially developed in ecological studies and has been an important part of adaptive environmental management. More recently, resilience thinking has been increasingly adopted by development studies to cope with such problems as climate change, food security, political instability, and economic volatility (Béné et al., 2014, Bahadur et al., 2015, 2016, Bousquet et al., 2016, Brown, 2016, Jeans et al., 2017).

Folke (2016) describes two kinds of resilience: general resilience and specific resilience. Accordingly, specific resilience concerns what to what (Carpenter et al., 2001) and for whom (Brown, 2014). General resilience concerns the unknown to the unknowable to having the capacity to deal with complexity, uncertainty, and surprise (Folke, 2016). Thus, general resilience enables going beyond the study of cause and effect (i.e., linear relationships) and examines the complex nonlinear relationships (e.g., linkages) of human-environment systems (Berkes et al., 2003, Liu et al., 2007, Folke, 2016). Development of the conceptual framework for this study centered on 'general resilience' because examining the adaptation to climate change in Indigenous fisheries communities required that attention be paid to complexity, uncertainties, and nonlinearity.

Yet, there are multiple criticisms of the notion of resilience: a) Resilience rarely addresses the question of the resilience of what to whom? (Carpenter et al., 2001), b) Understanding resilience as maintaining the status quo (Brown, 2014) reinforces existing power relationships and structures without aiming to address root causes, c) The systems approach underplays the internal or endogenous drivers, so it focuses on a system which is disturbed by external or exogenous drivers (Brown, 2016), d) It fails to account for power and politics, and e) Resilience thinking aims for short-term stability rather than long-term sustainability (Smith and Stirling, 2010, Brown, 2016). Regardless of these critiques, the notion of resilience widely overlaps with other theoretical areas including adaptation (Nelson, 2011), vulnerability (Turner Ii, 2010), and sustainable livelihoods (Tanner et al., 2015).

I used the social-ecological systems approach as an analytical lens to develop the conceptual framework. A social-ecological system focuses not merely on ecosystems *per se* or societies *per se* but, rather, on the social-ecological system as a unit of analysis. Berkes and Folke (1998) initiated the use of the term 'social-ecological systems' as an integrated approach of human-in-nature and then related it to the notion of resilience (Folke, 2016). In the literature, the terms 'socio-ecological' and 'social-ecological' are used interchangeably. In this thesis, the term 'social-ecological systems' is used, and has a deeper meaning in the resilience context (Berkes, 2011, Folke, 2016). Linguistically, 'social-ecological systems' gives equal attention to social and ecological subsystems (Berkes et al., 1998). It provides an analytical lens through which to examine complex human-environment problems such as climate change impacts (Berkes et al., 2003).

2.1.3 Step 2: Identification of two domains for integration

The scholarship areas of social-ecological system resilience and development resilience are identified as two schools of resilience scholarship suitable for conceptual integration to develop the framework. The first domain, i.e., social-ecological system resilience, originated from resilience thinking, while the second domain, i.e., development resilience, originated from development studies. I have selected these two domains after thoroughly examining the key mismatches and complementarities between resilience and development studies, and their implications for understanding social-ecological system change and policy development. Section A1 of appendix A illustrates the examination of the key mismatches and complementarities between resilience and development studies.

There are multiple reasons to support the idea of the integration of resilience thinking and development studies. As Bousquet et al. (2016) state, the adoption of a resilience-centered approach such as the "theory of development resilience" (Barrett and Constas, 2014), which focuses on the capacity of the system, is one of the conditions for the funding of certain nongovernmental agencies' work on climate-change-related development concerns internationally. Increasingly, the concept of resilience is used as a unit of analysis to examine social-ecological systems equipped with high poverty avoidance capacities.

Further, Folke (2016) argues that sustainable development actions address humanity's need to be guided by development approaches based on epistemologies and ontologies that appreciate human-biosphere interactions. In resilience thinking and social-ecological systems research, humans are considered to be part of social-ecological systems, such as the planet or biosphere (Folke, 2016). Humans are central to various development concerns, such as poverty alleviation, inequality reduction, and the solving of power-related issues embedded in a biosphere context (Folke et al., 2016). Though social-ecological systems may seem to be the sustainable biosphere pathway to human well-being, efforts to increase resilience in one group can undermine the resilience of another group, thereby increasing the latter's vulnerability (Lebel et al., 2006, Leach et al., 2010). Thus, importantly, efforts to improve resilience may lead to unsustainable pathways (Westley et al., 2011).

The notion of resilience and development studies is, to some extent, already integrated (Barrett and Constas, 2014, Béné et al., 2014, Bahadur et al., 2016, Bousquet et al., 2016, Brown, 2016). This integration provides useful tools for understanding key mismatches and complementarities between the two domains for better collaboration, possibly with promising outcomes. Human-development-related aspects such as inequality, issues of resource distribution, power, and politics were not at the core of the original idea of resilience; rather, they were combined to form part of the complex adaptive social-ecological system analysis (Folke, 2016). These aspects have been featured in the human development domain (Brown, 2016). Collaboration across different knowledge domains allows scientists to explicitly address the lacking aspects of emerging and evolving resilience thinking while co-producing knowledge (Berkes et al., 2003, Brown, 2016, Folke, 2016). Bousquet et al. (2016) recognize 'social-ecological system resilience' and 'development resilience' as two schools of resilience.

As illustrated in section A1 of appendix A, I identified key complementarities between resilience and development studies. First, both domains have multiple common interests: a) diversity as a means of improving resilience (Ostrom, 2005); b) a dynamic perspective that aims at trajectories and tipping points (Walker and Salt, 2006, van Nes et al., 2016); and c) the importance of social capital and learning (Aldrich and Meyer, 2015, Bousquet et al., 2016). Second, the overlapping challenges of both areas, such as poverty and inequality, and unsustainable social-ecological system pathways, can threaten human welfare and global sustainability (Bousquet et al., 2016). Finally, both domains look at trajectories of change (for example, development resilience theory and the adaptive cycle) (Gunderson and Holling, 2002, Barrett and Constas, 2014).

As illustrated under section A1 of appendix A, I discussed mismatches between resilience and development studies. First, development studies seek to reconcile development and humanitarian orientations with the aims of political and institutional challenges (Bousquet et al., 2016). Resilience uses a systemic approach focusing on complexities and the dynamic nature of interlinked social-ecological systems, including the role of specific actors and institutions (Berkes et al., 2003). Second, development research is aimed at the most vulnerable human populations and their interactions with natural resources (Barrett and Constas, 2014). Social-ecological system resilience is aimed at the social-ecological system as a unit of analysis (Berkes et al., 1998). Third, social-ecological system resilience focuses on promoting 'safe and just' viable trajectories within social-ecological system boundaries; in contrast, development research is committed to promoting positive trajectories for the wellbeing of the most vulnerable (Leach et al., 2013). Finally, multiple critiques of resilience are available in various disciplines, including development studies (Brown and Westaway, 2011, Brown, 2014, Redman, 2014, Brown, 2016). The integration of these two domains allows for the addressing of most resilience critiques while bridging the disciplinary gap (Table 3.4 in chapter 3).

2.1.4 Step 3: Conceptualization of 3D and 3Rs

The conceptual framework builds on the recent work of two key international development scholars who use the notion of resilience for human development research. First, I used Christopher Bene's 3D understanding of resilience (i.e., resilience being a combined result of coping, adapting, and transformative capacities) from the social-ecological system resilience domain (Béné et al., 2012, 2014, Bahadur et al., 2016). Second, I used Katrina Brown's 3Rs of resilience (i.e., resistance, rootedness, and resourcefulness) from the development resilience domain (Brown, 2016). Both the 3D understanding and the 3Rs of resilience provide intellectual tools for effective integration, helping to address the place-based approach to assessing climate adaptation and key critiques of resilience thinking.

2.1.3.1 3D of resilience

Bene et al. (2014) identified (absorptive) coping capacity, adaptive capacity, and transformative capacity as the three critical features of resilience—3D, or the three dimensions. Resilience emerges as a combined result of 3D capacities, leading to incremental adjustments, persistence, and transformational responses, respectively (Béné et al., 2012, 2014, Bahadur et al., 2016). Adaptive capacity and transformative capacities are vital emphases in the social-ecological resilience literature (Folke, 2006, Folke et al., 2010, Béné et al., 2014). Bene et al. (2014), Bahadur et al. (2016), and Brown (2016) are explicit about coping capacity being a key part of resilience. Brown (2016) and Bahadur et al. (2016) also recognize three dimensions of resilience; this conceptualization has already been applied to a human development context (Jeans et al., 2017). Table 2.1 offers a comparison of 3D capacities.

Table 2.1: Comparison of the three capacities of resilience

Capacities	Coping capacity	Adaptive capacity	Transformative capacity
Aim	Stability	Flexibility	Change (for example, structure)
Process	Coping	Adapting	Transforming
Characteristics	Anticipating, planning, preparing, coping, buffering, recovering swiftly	Learning from disturbance, adjusting incrementally to changes, enhancing human development and well-being, making proactive and informed choices, taking advantage of opportunities	Substantial change, altering the structural factors that put people at risk, tackling the drivers of vulnerability, systems-level
Disturbances	Shock/stress-specific	Can be specific shocks or flexible	Multiple risks
Origin of capacity	Proactive and reactive	Proactive	Beyond proactive; reshapes ‘rules of the game/governance’
Action and interventions that help build capacity	Early warning systems, emergency preparedness, climate-proofing, microcredit, insurance, social protection, social capital, psychosocial well-being, disaster relief	Productive assets, health education, nutrition, information, strong community institutions, sustainability, livelihoods, increased participation in micro-enterprise activities	Innovation, experimentation, empowerment, changing values/beliefs, transparency, inclusion, deep participation, policy shifts, changing the rules of the game, changing power relations at the household level
Time horizon	Short to medium term	Medium to long term	Long term

Modified from: Bahadur et al. (2016: 15)

Figure 2.2 visualizes the 3D of resilience using the mechanism of a seesaw. This figure will provide an understanding of the 'process' of how three capacities are situated in social-ecological systems change and how it functions in a human development context. As Bene et al. (2012) acknowledge, this linear 3D framing is conceptually useful but pragmatically simplistic, as it does not recognize the multi-stressor nature of the vulnerability; many stressors and shocks combine and occur together, each affecting the system with different relative intensities at different scales, and each requiring separate or integrated levels of resilience (O'Brien et al., 2004). For a better explanation, figure 2.2 applies to a small-scale fisheries social-ecological system whose livelihood relies on coastal fishery resources. The possible shocks could be extreme weather events, while stressors could be the implications of ocean acidification, such as a decrease in the number of fish caught in a coastal sea. The fishers of the present social-ecological systems can use the mechanism of a seesaw to deploy their 3D capacities to survive or move to the desired place (next potential social-ecological systems).

In the coping (or absorption) stage, fishers face various forms of change, such as disturbances including stressors or shocks. The initial reaction to this change is resistance. Fishers will start to use coping strategies after they inevitably begin to understand the change. For example, household fishers affected by food insecurity can adopt new fishing gear techniques, make adjustments (including certain diversification) in activities related to their livelihoods, and decide to obtain loans or connect to new social networks (Béné et al., 2016b). Furthermore, some short-term absorptive coping strategies can lead to unfavorable outcomes in the long run. For instance, selling off one's assets, withdrawing one's children from school, and cutting down on daily meals are common practices among fishers (Béné et al., 2016a). In this stage (figure 2.2-A), the seesaw is either not moving or the fishers do not rely on a seesaw at all because they use their existing capacities to maintain their essential activities. Continuation of the same stressors or new shocks within an increase in intensity will bring fishers to a stage at which they are no longer able to absorb and cope with the demands of extra capacities to survive within the same system. When coping capacity is exceeded, an individual or system will use its adaptive resilience (Cutter et al., 2008).

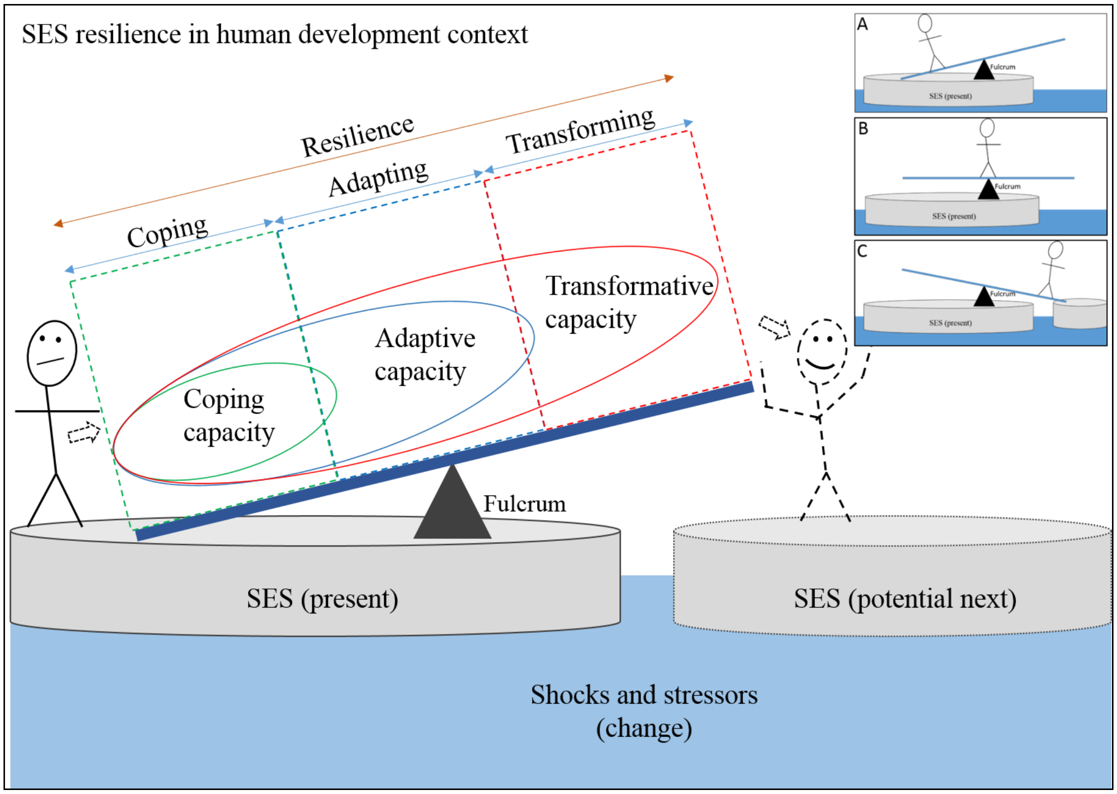

Figure 2.2: Visualization of the function of 3D resilience, using a seesaw mechanism.
Note: The aim of this visualization is to highlight the resilience being studied as a 'process' in this study, and communities moving through the stages (coping, adapting, and transforming) in the context of SES change. SES refers to social-ecological systems.

In the adapting stage, adaptive resilience reflects various adjustments or incremental changes in the system without major changes in function or structural identity (Béné et al., 2014). Some examples include adopting new (technologically advanced) fishing gear, diversifying income-generating activities, and engaging in collective action directed towards common concerns, such as shrimp disease in small-scale coastal aquaculture (Galappaththi and Berkes, 2015). Such adaptations can occur in the individual or collectively at multiple levels such as households, groups, and communities. This multi-level adaptation is an important feature of social-ecological system resilience in general (Boyd and Folke, 2012). Bene et al. (2014) describe some characteristics of such adaptations. First, adaptation at one level can influence adaptation at another level—adaptation is not a zero-sum game. Second, adaptation is a continuous and incremental process that is difficult to track or measure (Levine et al., 2011). Third, people typically do not adapt to one specific stressor, but to a combination of changes—it is rarely possible to untangle compound changes to which people are responding (Hertel and Rosch, 2010). Finally, 'adaptation' for one household could, in a different context, be perceived as a coping strategy for another. Fishers will illustrate their adaptive capacities through a change in the slope of the seesaw moving from figure 2.2-A to -B.

In the transforming stage, if the changes are significant and overwhelm the adaptive capacity, the system will transform with the fundamental alterations of the system's functions, structure, and identity. These alterations are no longer incremental and the process is transformative (deliberative or imposed) (Pelling, 2011, O'Brien, 2012). This new condition can change the nature of the system. In this stage, individuals or systems challenge and change the status quo (Folke et al., 2009). The challenges associated with transformation can include a combination of technological innovations, institutional restructuring, behavioral changes, and individual and system capacities (Béné et al., 2014). In this visualization in figure 2.2-C, the seesaw moves until it lands and settles in a different environment (a new social-ecological system). Compared to the previous adaptive slope of the seesaw, the transformative slope is moving in the opposite direction. The point of the process that slope direction change can identify is the 'tipping point'—an unstable equilibrium state (Folke et al., 2004, Reyer et al., 2015, van Nes et al., 2016). This state can result from a change in external conditions as well as a change in the state of the system.

2.1.3.2 3Rs of resilience

By combining individual agency with adaptive capacity and a systems perspective, Brown re-conceptualises a vision of resilience with the notion of 'everyday forms of resilience' to contribute a new development agenda with three core components: resistance, rootedness, and resourcefulness (Brown, 2016).

Resistance: Brown (2016: 194) defines resistance as the "ability and capacity of people to withstand external forces and to shape their own strategies." Resistance here indicates self-determination, strength, agency, and power. This concern for power and politics at the heart of resilience involves the ways in which new opportunities can be discovered so as to study change and the shaping and mobilization of positive transformation. Brown establishes the direct linkages among resilience, agency, power, and resistance based on empirical evidence—resistance as power or capacity to resist (Brown, 2016). In ecology, resistance refers to a system's ability to remain essentially unchanged in the face of disturbances—closely related to 'resilience' but mostly associated with stability rather than adaptability (Hoover et al., 2014). In the social sciences, 'resistance' refers to an undermining of power relations or a creation or expansion of space for decision-making. This resistance is often understood as oppositional—for instance, the dominated against the dominator, the oppressed against the oppressor (Brown, 2016).

Resistance can also include the reforming of cultural norms or the challenging of conventional values. In society, resistance can be associated with political or social movements. Matyas and Pelling (2015) recognize the role of resistance in positioning future resilience to shape disaster risk management policy. Brown (2016) argues that "resistance informs both the capacity and strategies of actors to influence slow and fast variables at different points in the adaptive cycle." Through a consideration of 'resistance' as one of the essential elements of resilience conceptualization, power-related aspects can be explicitly examined.

Rootedness: This recognizes the situated nature of resilience and the importance of culture and place, including the focus on identity and attachment. Rootedness is firmly associated with people, place or space, cultural practices, social networks, and a wide range of affective ties to 'home' (Lyon, 2014, Brown, 2016). Empirical evidence shows that attachment to place, and place-rooted identity, is a determinant of resilience, adaptation, and transformation (Devine-Wright, 2013). The natural and built environment, infrastructure, and services are also important for adaptive capacities and resilience in the community (Berkes and Ross, 2013). Moreover, cultural dimensions and moral reasoning are recognized as important in adaptation literature (Adger et al., 2012, Adger, 2016, Adger et al., 2017). Amin (2013: 141) mentions 'situated resilience', asserting that the "turbulent future will be addressed through the specifics of location" (Brown, 2016). Rootedness reflects the power of place and its identity, as well as strengths associated with belonging (Brown, 2016).

According to Broad and Cavanagh (2011), rootedness is more than place and power; it is about a much broader set of features at multiple scales and it introduces rootedness as a new paradigm for development. Broad and Cavanagh suggest that rootedness is an alternative to vulnerability as a strength-based approach for understanding how people, communities, and economies can thrive. Furthermore, they acknowledge rootedness's emphasis on contemporary development concerns such as human rights, ecological sustainability, participatory democracy, and equity (Brown, 2016). To Brown (2016), rootedness refers to intertwined people, place, and a sense of belonging. In psychology, rootedness is the strongest bond between people and their communities. Rootedness can create both positive and negative outcomes, either cohesive or divisive. Rootedness is also about a connection with the ecology of a place and sensitivity to social-ecological systems change (Berkes et al., 2003, Krupnik and Jolly, 2010, Berkes, 2012). Rootedness creates dynamic foci resilience strategies and locates them as working at and across multiple scales.

Resourcefulness: Resourcefulness is about the resources people can draw upon and their capacity to use them at the right time and in the right way to harness those resources and human capacity together (Brown, 2016). This understanding emphasizes the ability to collectively deal with difficult situations that reflect human agency and capabilities, opportunities, and innovation—for instance, community-based institutions' role in resourcefulness in networking and making a platform for collective action and the use of local knowledge associated with the place (Galappaththi et al., 2016, 2019a). This framing links resourcefulness to a "sense of place being transformed into a resource in times of need" (Chamlee-Wright and Storr, 2009), and "is about bouncing back, adapting and transforming" (Brown, 2016: 198).

Resourcefulness has links to innovation, social learning, and social capital—key components of adaptive capacity and resilience; it "implies assets, capacity, and elements of timeliness and initiative" (Brown, 2016: 198). Based on the empirical evidence, Brown identifies resourcefulness as a combination of entrepreneurial spirit, local knowledge, and business acumen that relies on social ties. Furthermore, she relates resourcefulness to 'Indigenous intelligence'—learning how to learn in living environments (Rival, 2009)—and "puts the ingenuity and practices associated with local knowledge and lay[s] knowledge into the context" (Homer-Dixon, 2002, Berkes, 2012, Brown, 2016: 199). Resourcefulness is an element of resilience that links the social and ecological sub-systems of social-ecological systems. Petrescu et al. (2016: 717), in their article ‘co-producing commons-based resilience’, describe ‘resourcefulness’ as a “relatively new concept that addresses the necessity to identify, make available and redistribute resources of space, knowledge, and power across local actors and communities to improve resilience.” Accordingly, resourcefulness is situated within resilience as a more positive element that creates an agency of empowerment in communities.

2.1.5 Step 4: Conceptual framework

As a result of the integration of 3D and the 3Rs of resilience, I developed the conceptual framework (as in figure 2.3) to improve the understanding of social-ecological systems change supporting policy development in a human development context. This framework (figure 2.3) was further developed over the course of my PhD research. Figure 3.1 in chapter 3 shows an evolved version of figure 2.3.

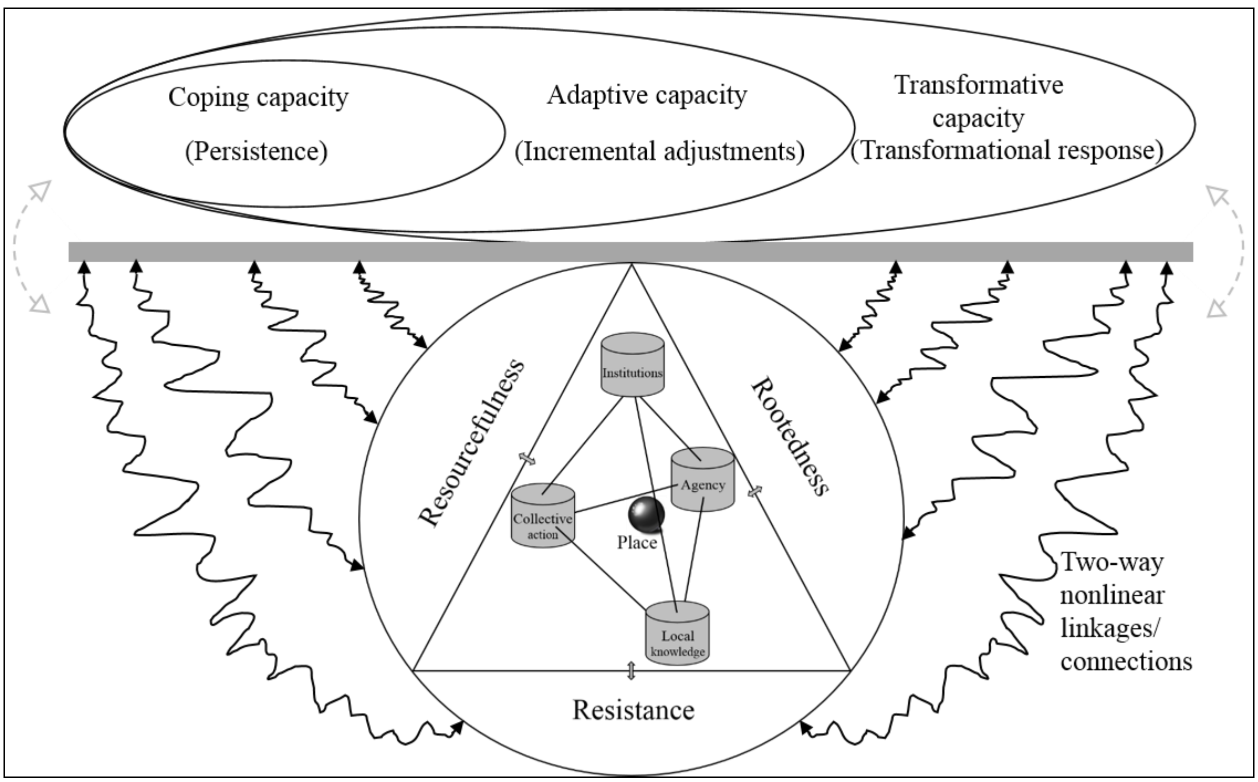

Figure 2.3: Integrated framework (3D-Rs).

This integrated framework includes the 3D capacities of resilience (coping, adaptive, and transformative capacities) as well as the 3Rs (resistance, rootedness, and resourcefulness). This place-specific framework allows for the capturing of unique attributes of a local setting that relates to the well-being of individuals, households, and communities. The center of the fulcrum represents a network of four elements (collective action, institutions, agency, and local knowledge) that is extracted from the 3Rs and that is intimately related to the notion of resilience. I termed this a network of ‘place-based elements’ to emphsise the overlapping nature of these elements in the community setting. Here, ‘collective’ action refers to action taken together by a group of two or more people to meet a common desired objective (Ostrom, 1990, 2014). ‘Institutions’ refers to adapting local organizations formed by the society that facilitates collective action to meet a common local goal (for example, community cooperatives and associations) (Ostrom, 1990, Boyd and Folke, 2012, Galappaththi and Berkes, 2014). ‘Local knowledge’ refers to the co-evolving cumulative body of knowledge that belongs to a specific place and that is handed down through generations by cultural transmission (Berkes, 2012). ‘Agency’ refers to the individual's capacity to act independently in making his or her own choices (Brown and Westaway, 2011).

Place-based elements and the 3Rs constantly determine and balance the 3D capacities of resilience through multiple nonlinear linkages (connections) to face the social-ecological systems change (figure 2.3). This two-way connection between fulcrum and seesaw reflects the ways in which resilience capacities and the 3Rs’ elements influence, and are interdependent of, each other. These two-way linkages represent three key aspects crucial to the system. First, continuous learning from past events and minor errors returns to the place-based elements to improve their capacity—social-ecological learning (Berkes and Turner, 2006, Taleb, 2012). This learning can occur within the network of place-based elements. Second, interconnectedness among such elements creates feedback across different levels and scales that changes the dynamics and complexities of social-ecological systems (Fischer et al., 2015, Homer-Dixon et al., 2015). This aspect includes an understanding of ecosystem processes and dynamics, and ecological knowledge helps in tuning human development with biosphere capacities (Folke, 2016). Third, continuous learning and interconnectedness together, allows a self- or re-organization to adapt to changing conditions (Berkes and Ross, 2016).

Figure 3.1 (chapter 3) contains the conceptual framework that I further developed from the initial conceptual framework (figure 2.3) during the first phase of field data collection in spring/summer 2017. Key changes from figures 2.3 to 3.1 are: a) use of a cross-section of a tube-shaped system (instead of a fulcrum-and-seesaw mechanism) to bring a clear time dimension to the framework (as illustrated using a visual mechanism of a seesaw), b) use of the term 'learning' to represent the two-way non-linear linkages to better comply with an Indigenous context, c) identification and definition of the framework's characteristics (i.e., place, human agency, collective action, institutions, knowledge systems, and learning and feedback), and d) development of indicators under each framework characteristic based on the literature and feedback received from the communities. These changes were made as a result of an iterative process with both Canadian Arctic and Eastern Sri Lanka community representatives (including local research assistants and key informants) to better align the conceptual framework for field data collection.

After completion of my fieldwork in 2019, I further modified the conceptual framework, as in figure 6.1 in chapter 6. Key changes from figure 3.1 (chapter 3) to figure 6.1 (chapter 6) are: a) 3Rs removed from the framework, as it is represented by the place-based elements (initially, place-based elements were extracted from the 3Rs), b) replacement of the term 'two-way nonlinear linkages' with the term 'learning' and inclusion of the former in the network of place-based elements (considered as the framework characteristics), c) addition of arrows to indicate shocks and stressors (or change), and d) appearance change to simplify the key elements of the framework (i.e., change, the process of community adaptation, resilience capacities, and place-based elements or framework characteristics).

2.1.6 Operationalisation of the conceptual framework

The conceptual framework was operationalised in three different ways. First, the framework characteristics were used to maintain conceptual consistency, providing guidance throughout the study. The field data collection process was guided by the characteristics of the framework. For example, the topic guide for the semi-structured interviews was structured around these framework characteristics (Appendix: tables B1 and C1). Framework characteristics provide the structure for data analysis and conceptual guidance for two empirical chapters (i.e., chapters 4 and 5), helping to maintain conceptual consistency across case studies, which is essential for comparative analysis. Further, the same framework characteristics were used in guiding the comparative analysis (chapter 6). Second, the conceptual framework was used to maintain a place-specific focus throughout the knowledge production process. Place-based work is essential for assessing resilience, as different Indigenous fisher populations, as noted previously in the thesis. Third, the conceptual framework is used to maintain the focus on the community adaptation process rather than stability-oriented assumptions. The conceptual framework can capture adaptation ‘processes’, as it builds on resilience-oriented approaches and has the ability to capture characteristics of dynamic complex adaptive systems.

The development of the conceptual framework was an iterative process; the final version of the framework is depicted in figure 6.1. However, all the versions of conceptual frameworks consist of the same characteristics: place, human agency, collective action, institutions, knowledge systems, and learning.

2.2 Methods for empirical studies

The previous section discussed how I developed the conceptual framework and its application throughout the thesis (i.e., thesis objective one). This section will illustrate how I addressed the second and third thesis objectives, and the overarching methods pertaining to the thesis aimed at empirical case studies. The second thesis objective is to assess the community adaptation to climate change in the context of the Pangnirtung Inuit community of Arctic Canada. The third thesis objective is to assess the community adaptation to the social-ecological change of the Kunjankalkulam Coastal-Vedda community of Eastern Sri Lanka. These objectives are addressed in the upcoming manuscript chapters, 4 and 5, respectively. All published findings here are derived from an iterative process with the research participants (communities). Further, these findings underwent multiple member checking processes and a rigorous peer-review process before being published in research journals. This section will answer specific questions such as a) How were the case study locations selected? b) How and why did I use a community-based participatory approach? c) Which data collection methods were used and why and how were such methods employed? d) How did I analyse the field data and what does the iterative process look like? and e) What are the ethical and positionality considerations related to this study?

2.2.1 The selection of case study locations

The two study locations are the Pangnirtung Inuit community in Arctic Canada and the Kunjankalkulam Coastal-Vedda community of Eastern Sri Lanka (figure 1.2). I chose these communities for multiple reasons: a) they have a high level of fisheries activities, b) they have a high level of remoteness and susceptibility to changes including climate change, c) they hold an Indigenous identity as a community, d) they have recently undergone key social, economic, and political changes, and e) they have a high level of feasibility regarding the ability to collect data.

The Inuit of Pangnirtung inhabit an Eastern Arctic region that has experienced one of the most substantial signs of climate change, with highly sensitive lifestyles (Ford, 2012). Future warming is anticipated to be double the global average temperature, with climate and associated sea ice conditions changing more rapidly than predicted by climate models (IPCC, 2018). Inuit communities are among the most remote on earth, are highly dependent on fishing, are experiencing rapid socio-cultural change with respect to modernization and resource development, and have human development indicators similar to those of many middle-income and some low-income nations (Ford et al., 2006, Ford, 2012, Ford et al., 2012). The research works with the Pangnirtung Inuit community located on Baffin Island, Nunavut Territory, because of the community's high attachment to, and dependence on, the fishing lifestyle as compared to other Canadian Arctic communities, while limited research has examined the adaptation of Inuit small-scale fisheries to climate change (Ford et al., 2006, Ford et al., 2008, Ford et al., 2010, Ford, 2012, Ford et al., 2012).

The Indigenous Coastal-Vedda in Eastern Sri Lanka live in traditional remote communities that receive minimal attention from the Sri Lankan government (Manogaran and Pfaffenberger, 1996). Geographic and cultural isolation, political inequity, and economic development combine to create significant vulnerability to climate change (Yamane, 2003). Importantly, multiple transformations rooted in decades of war, the tsunami devastation (2004), and recent political changes in the new government (2015) influence the coastal Vedda in Eastern Sri Lanka. Four Coastal-Vedda communities are located in the Mutur, Vakarai, and Valaichchenai areas, including the Kunjankalkulam Coastal-Vedda community. The Coastal-Vedda people in Sri

Lanka speak the Tamil and/or Vedda languages. The Kunjankalkulam Coastal-Vedda population in this region is highly dependent on culture-based fisheries and the associated natural habitats, including forests, estuaries, lagoons, and mangroves. Culture-based fishery is the key livelihood activity. It is common to observe women walking into shallow waterbodies to fish using traditional methods.

These Indigenous communities were selected to facilitate the development of broad insights into Indigenous resilience, vulnerability, and adaptation. The selected regions reflect the diverse culture, livelihoods, and environmental characteristics of remote Indigenous fisher populations globally in high- and low-income nations and the diversity of the biophysical environments in which they live. The selected regions share other similarities, including experiences with marginalisation and injustice in the face of government development/political activities, major government changes in 2015, socio-economic inequality, sensitivity to climate change, remoteness, dependence on the biophysical environment for diet and well-being, concerns about the erosion of Indigenous knowledge, and a particularly high attachment to fisheries. Additionally, they have experienced rapid economic development over the past decade. In this sense, they are in a state of transition that has implications for climate adaptation.

The contrast in, and similarity of, these study sites underpin the aim of this project: to assess both the generalizability and the context-dependence of resilience and climate adaptation in the small-scale fisheries context that leads to the central question—what are the opportunities for adapting to the impacts of climate change? Equally, my co-supervisor, Dr. James Ford, has long-established contacts and ongoing projects working with Inuit communities in the region. Sri Lankan Vedda communities were selected partly because of the limited (or lack of) studies on climate change adaptation with respect to small-scale Indigenous fisher groups using an integrated scholarship approach (SES resilience, vulnerability, and adaptation) as well as my ethnic connection and previous research experience, and the uniqueness these factors bring to this study.

2.2.2 Community-based participatory research (CBPR)

A community-based participatory research (CBPR) approach was used to produce the knowledge stemming from the assessment of climate adaptations in both Pangnirtung (Inuit) and Kunjankalkulam (Coastal-Vedda) communities (Israel et al., 2003, Minkler et al., 2003, Yahya Salimi et al., 2012, Hacker, 2013). CBPR can be defined as a "collaborative research approach designed to ensure and establish a structure for participation by communities affected by the issue under study, representatives of organizations, and researchers in all aspects of the research process" so as to improve well-being by taking action, including social change (Viswanathan et al., 2004, Hacker, 2013: 1). The principles of CBPR overlap with those of the community-based adaptation (CBA) research approach and are widely used for climate change adaptation research, with both terms sometimes used interchangeably (Ayers and Forsyth, 2009, Christoplos, 2010, Harvey et al., 2012, Ford et al., 2016, Ensor et al., 2018, Ford et al., 2018).

I used a CBPR approach for multiple reasons. First, studying climate adaptation is an ongoing process, particularly with the focus being on highly vulnerable rural Indigenous communities (Ayers and Forsyth, 2009). CBPR holds promise as a strategy that can support the research process through community engagement in shaping knowledge co-production (Hacker, 2013). Second, this research emphasizes learning from the community (objectives 2-3) (Christoplos, 2010). CBPR can have a win-win structure for both the researcher and the community, as it helps reduce ethical considerations related to traditional research practicies (Christoplos, 2010, McPherson et al., 2016). Finally, pressure exists from community partners who want to be involved in the process so as to solve and learn about their own community concerns. CBPR provides a friendly atmosphere for locals' active participation in the research (Archer et al., 2014). Thus, CBPR is particularly useful when the research focuses on emergent problems, such as climate change, for which the community is seeking solutions or more evidence and data (Hacker, 2013).

The strength of CBPR is well-recognised. The study's relevancy and authenticity with respect to the local community, as well as community ownership, are key strengths of CBPR (Ayers and Forsyth, 2009). This approach builds local capacity and community skills together with those of the researchers. The process builds trust and bridges community/academic barriers (Ford et al., 2016). The outcomes of CBPR deepen knowledge of the community context and needs. The co-learning process provides a basis for a comprehensive interpretation of results, bringing the community perspective to an academic understanding. The results of the CBPR can support community-level social action and sustainable change (Israel et al., 2003, O'toole et al., 2003, Viswanathan et al., 2004, Wallerstein and Duran, 2006, Hacker, 2013).

CBPR also has challenges. The time required to build community and partnership relationships is greater than that required by other research approaches. Funding and administrative limitations can pressure the researcher to compromise the research process (Piggott-McKellar et al., 2019). Regardless of compromises, the researcher risks the potential loss of control with respect to managing the research, due to the sharing of power and flexibility (Ensor et al., 2018). Moreover, conflicts between partners over strategies, dissemination, interpretations, and other decisions are possible. Some outputs of CBPR may not be generalizable in specific academic environments (Israel et al., 2003, Minkler et al., 2003, O'toole et al., 2003). An awareness of the challenges related to CBPR is important to mitigating its associated risks.

Throughout the development of my research, I have partnered and co-planned with both the Inuit (n=4 elders) and Coastal-Vedda (n=3 elders) communities. First, during the initial stage of my fieldwork, we (the community representatives and myself) co-planned for the field data collection. In addition to research participants, the community representation consisted of locally hired research assistants and translators. In both communities, I initially spent a considerable amount of time discussing the project (2-3weeks). Research assistants mostly helped through their ideas about a) the best possible ways to reach respondents for interviews, b) culturally appropriate ways of doing research, and c) developing my cultural competence in the context of the communities. Most Inuit research assistants and translators had previous experience working with other researchers, and they were chosen as recommended by the communities. However, this was not the case in the Coastal-Vedda community. Further, during the initial stage, I obtained community consent for the indicators I developed as part of the conceptual framework (chapter 3). This was a formal process (via paperwork) involving the Inuit of Pangnirtung with the intervention of the Nunavut Research Institute. However, with Coastal-Vedda of Kunjankalkulam, this was an informal process via oral consent.

During the data analysis stage, research assistants supported and contributed to the theme-building activities and results verification, e.g., to understand the most prominent social-ecological system changes for Coastal-Vedda and the key adaptive strategies for facing changes in fisheries systems in both communities. Further, we organized numerous focus group discussions to verify and validate specific data and emerging themes. During the results interpretation stage, I relied on community members to assist with the interpretation of the results, e.g., what specific quotes meant in a local context and what were the best quotes for conveying particular information such as the weakening of Indigenous and local knowledge systems. During the results dissemination stage, community members (including research assistants) and I worked together to ensure that a) we did not produce any results that could result in misinterpretation and b) we avoided specific information that communities did not want to share in the results. The results dissemination began as an ongoing process using various methods aimed at diverse audiences (Appendix A-section A4). I contacted specific community representatives for the post-dissemination work, e.g., addressing research journal reviews (chapters 4-5) and writing future project proposals.

Based on my CBPR experience, the approach acknowledges community as a unit of identity and identifying “the community” is an essential initial step in CBPR. I found that this principle aligns well with the social-ecological system approach, which also uses combined social and ecological sub-systems (i.e., community) as a unit of analysis (Berkes et al., 1998). Because community representatives do not fully represent the community perspective, the use of mixed qualitative data collection methods was important and played a critical role in this research (e.g., combining participant observation with interviews). Further, the CBPR approach builds on the strengths and resources within the community and the active participation of community members who bring their skills and input to the study. This can have the potential to facilitate collaborative and equitable partnerships in all phases of research while empowering power-sharing (Schipper et al., 2014, Ensor et al., 2018). This principle fosters co-learning and capacity-building among all research partners (Christoplos, 2010).

I also experienced various challenges in using a CBPR approach. Active community participation throughout the research project was challenging to attain. Active involvement of

Indigenous community members requires additional effort, as most fishers have limited time for other activities (e.g., participation in research). During the early stage of my fieldwork, I had to partner with other community members (e.g., recruiting the community radio person as a research assistant) to reach fishers and make contact with specific knowledge-holders (e.g., elders). During the later stages of my fieldwork, I was able to elicit more active community participation (e.g., fishing trips and community events). Furthermore, managing two distant communities over the research timeline in compliance with CBPR principles is challenging due mainly to resource limitations, including time, money, and energy. For example, I observed a low retention rate of research assistants throughout the project, as community members are affected by seasonality and other opportunities/distractions, especially in Inuit communities. Spending data collection time in both Arctic and Sri Lanka communities, back-and-forth episodically, distracts the focus on the CBPR process for each case study.

2.2.3 Data collection methods

Data collection seeks to understand resilience and its drivers in the Indigenous fisheries setting. Further, data collection seeks to understand, identify, examine, and evaluate opportunities for social-ecological resilience-building and vulnerability reduction (i.e., adaptation) with respect to the impacts of climate change on remote Indigenous fisher populations. To achieve this, participant observation, semi-structured interviews, focus group discussions, and key informant interviews were used as data collection methods.

2.2.3.1 Participant observation

The goal of participant observation is to advance one's understanding of a natural setting (i.e., the people, environment, and interactions within and among the system) by becoming a part of everyday interactions (Berkes et al., 2003, Kearns, 2003). According to Zikumund (2003:244), participant observation is a "situation in which an observer gains firsthand knowledge by being in or around the social setting being investigated." Laurier (2016) defines participant observation as a method that gathers local and contextualized knowledge of groups, events, or practices. The "true power of participant observation relies on researchers' actual participation and intimacy with the people, place, and culture" studied (Laurier, 2016:170). This method can move researcher perspectives from outsider to insider (local). For example, spending a couple of months in a waste collection vehicle will change researchers' lenses in terms of how they look at rubbish in the streets (Laurier, 2016). Every participant observation setting is unique (Kearns, 2003, DeWalt and DeWalt, 2010) and there is no one best way to conduct participant observation in qualitative research (Kawulich, 2005).

DeWalt and DeWalt (2010) describe three advantages of participant observation and recognize it as both a data collection tool and an analytical tool. First, participant observation enhances the quality of qualitative data collected in the field. Second, participant observation improves the quality of the interpretation of field data (including field data collected using other methods), allowing results from other methods to be observed and checked. Third, participant observation facilitates the formulation of new research questions. On the other hand, literature also describes the weaknesses of participant observation. First, Hay (2016) recognizes that, in a more structured setting, the presence of a researcher (overt approach) could alter locals' natural behavior. Second, according to Laurier (2016:179), this method is "not designed for generalizing beyond the event, group, or practice you are studying." Third, Laurier mentions that the exploratory nature of this method makes it unsuitable for hypothesis testing and that participant observation data are tied to the researcher and are difficult to represent and share (Laurier, 2016). However, participant observation has been increasingly adopted and adapted in qualitative research in human geography (Flowerdew and Martin, 2005).

I conducted participant observation in both Pangnirtung and Kunjankalkulam totaling 10 months over three years. During my fieldwork, I spent an extensive amount of time with community members (mostly fishers and their families) involved in their day-to-day activities. With Inuit, I spent time on the tundra drinking tea and chatting with people, while I spent some nights watching stars and the northern lights (Castleden et al., 2012). With Coastal-Vedda, I harvested honey and medicinal plants in the forest. In both communities, I had the opportunity to participate in fishing activities (i.e., Arctic char and turbot fishing in the Arctic and village tank fishing in Sri Lanka). Moreover, I participated community events in both communities (e.g., Pangnirtung musical festival, Sri Lanka new year festival). In Pangnirtung, I was invited to play traditional games and taste country food (e.g., raw meat of beluga, char, seal, caribou, muskox). Throughout my fieldwork, I was open about my intention of participating in community members' daily activities to help them understand that I was interested in learning about the experience. To keep records of my experience, I used a field diary that I updated every night (more details about this can be found on page 80).

Participant observation data allowed me to develop a sense of how Indigenous fishers spend their days and also learn about aspects of their fishing way of life that came up in casual discussions. This enabled me to observe the actual conditions associated with climate impacts (e.g., how melting sea ice limits access to food in the Arctic), the mechanisms of local collaborations (e.g., how community-based organizations empower fishers for better fishery management), and how selected fisher communities face climate change in reality. Further, participant observation helped me understand and contextualise people's responses in interviews, build cultural competence, and cross-reference (where possible) what people said with what they did (Collings, 2009). Thus, I was able to better understand opportunities for building resilience and vulnerability reduction.

2.2.3.2 Semi-structured interviews

Interviews are categorized on a continuum of unstructured, semi-structured, and highly structured (Hancock et al., 1998). Semi-structured interviews aim to compare participants' in-depth responses with individual diversity and flexibility (Dunn, 2003). Interviews are more than 'a chat'; they are verbal exchanges of information in which one person (the interviewer) asks questions of another person (the interviewee), with the interviewee answering the questions (Dunn, 2003, Longhurst, 2016). Traditionally, interviews were a 'face-to-face' verbal interchange, but now they also employ the use of telephones or the internet (Dunn, 2003, Longhurst, 2016). Longhurst (2016:153) recognizes both semi-structured interviews and focus group methods in geography as being "about talking with people both in-person and online but in ways that are self-conscious, orderly and partially structured." Semi-structured interviews rely on interactions between the interviewer and the interviewee. However, focus groups rely on interaction among interviewees (Longhurst, 2016). Semi-structured interviews are facilitated and guided by the interviewer without compromising interviewees' ability to explore the issues they feel are important (Longhurst, 2016). Having an 'interview guide' (or 'topic guide') is essential to effectively guiding the semi-structured interview (Dunn, 2003). According to Dunn (2003), an interview guide is a simple set of keywords that addresses primary areas of research to help the researcher (interviewer) remember discussion topics.

The strength of the semi-structured interview as a data collection method has been widely recognized (Dunn, 2003, Zikmund, 2003, Creswell, 2013, Yin, 2014, Longhurst, 2016). First, this method can fill in the knowledge gap created by other methods, such as participant observation or data from secondary sources, by allowing questioning to focus on specific topics related to the research (Dunn, 2003). Second, it is useful as a means of investigating complex behaviors and motivations by collecting a diversity of experiences (Longhurst, 2016). Third, interviews create an understanding of the plurality of people's opinions and meanings (Dunn, 2003, Zikmund, 2003). However, semi-structured interviews present challenges, as well. First, to be performed successfully, a semi-structured interview requires specific interviewing skills (Dunn, 2003). Second, obtaining a sufficient number of semi-structured interviews requires extensive preparation, thought, and practice (Longhurst, 2016). Finally, the researcher must have good analytical skills to analyse the data effectively (Hoggart et al., 2002). Still, the advantages of semi-structured interviews overcome their drawbacks, as they allow for the gathering of in-depth and richer data (Longhurst, 2016).

I used the snowball sampling technique for recruiting Indigenous fishers in Sri Lanka and the Canadian Arctic to participate in interviews. There is evidence of snowball sampling being commonly used in qualitative research, specifically when one is using 'interviews' as primary data collection methods (Atkinson and Flint, 2001). This technique is often used for hidden target populations – such as remote Inuit and Vedda communities – that are not easily accessible (Atkinson and Flint, 2001, Flowerdew and Martin, 2005). Further, I used my previous semi-structured interview skills and experience with Canadian sub-Arctic Indigenous people and Sri Lankan local fishers to complete semi-structured interviews in Inuit and Coastal-Vedda communities.

Before recruiting participants for semi-structured interviews, I informed the communities about the research project and the opportunity to participate in an interview. In Pangnirtung, I used a community Facebook page and radio for publicity, while in Kunjankalkulam, I provided information through community fisheries meetings and word of mouth. Aligning with the snowball sampling technique, in both communities, I started with multiple points (e.g., three snowballs beginning from the village chief, fish landing site, and women's day-time fishing site in Coastal-Vedda community). I began with the informed consent for every interview I planned. All the meetings were organized face to face with some tea and refreshments depending on the setting (e.g., some were on the water and ice while fishing). The interview questions were guided by the topic guide, which was customized to address specific contextual differences between Inuit and Coastal-Vedda fisheries (Appendix: table B1 and C1). Most interviews were voice-recorded with the permission of the respondent. Similarly, I took some photos to provide evidence in data collection. Translators were used in both communities as appropriate. Recorded SSIs ranged from 45 minutes to two hours. I compensated all the respondents as pre-agreed for their time and support. At the end of the interview, some respondents introduced new participants for upcoming interviews. However, some people showed up for interviews without being referred by anyone. I continued recruiting participants until saturation (i.e., when interviews provided no new relevant information).

The semi-structured interview data allow me to obtain the necessary understanding related to the research objectives, such as qualitative data associated with specific climate shocks and stressors, local innovations, collaborations for facing change, and relevant governance and policy. I conducted semi-structured interviews with local Indigenous people. The interview guide was structured by the conceptual framework, as in chapter 3. This method helped me better address the research question of how to examine opportunities for building climate resilience and vulnerability reduction in both Indigenous communities. Semi-structured interviews allowed me to get more directions for participant observation data (e.g., fishing trips and community events).

2.2.3.3 Focus groups

The purpose of a focus group is to gain knowledge about a specific topic or need by interviewing a group of individuals who are directly affected by the particular issue or area of interest (Creswell, 2013). Cameron (2010:152) defines a focus group as a "small group of people discussing a topic or issue defined by a researcher." A focus group is a researcher-guided group discussion about a specific topic, that provides group opinions and perspectives, arguments and agreements, in-depth understandings, and collective knowledge (Morgan, 1996, Kallbekken and Aasen, 2010). Thus, focus group data can be used to: explore the depth and gravity of opinions regarding the subject; document differences in perspectives; understand the factors that influence the community's opinions or behaviour; evaluate reactions to proposed services; and learn about participants by observing their interactions (Hancock et al., 1998). A wide range of sampling techniques is available for selecting participants for focus groups; these include purposive, initial screening questioners, snowball sampling, and on-site recruitment (Cameron, 2010). The choice of sampling technique depends on the research context and target group. The researcher can develop questions or topics before the focus group discussion and can inform the participants beforehand to be prepared (Cameron, 2010). A language that is clear and understandable (to the participant) is essential to a productive focus group discussion (Hancock et al., 1998). The participants' attendance of focus group discussions and grouping need special attention. A focus group typically lasts for one to two hours; the same group can be interviewed many times, and multiple groups may participate (Cameron, 2010). Usually, a focus group consists of six to ten people, but smaller discussions can also lead to fruitful discussions (Breen, 2006).

A focus group allowed me to collect data about a community adaptation to change in a relatively short period of time (Carey and Asbury, 2016). Discussion between group members can reveal hidden questions (Breen, 2006). Comparisons can be made spontaneously between different experiences to explore consensus and diversity with respect to a research topic (Cameron, 2010). There are also limitations to a focus group. A focus group is time-consuming to organize because group members' concerns may be involved in this process (Cameron, 2010). During the discussion, the researcher may need to exert effort to maintain the timing and topic focus. Focus group discussions require good facilitators. The power dynamics of the selected group can affect the group's opinion and focus group data (Carey and Asbury, 2016). Moreover, there may be irrelevant data that researchers must identify and remove during data analysis (Hancock et al., 1998).

I conducted 23 focus group discussions in both Inuit and Coastal-Vedda communities. These focus groups were organized as an ongoing process focusing on thesis objectives 2-3 (Appendix: table C3). I found that organizing focus groups in the Inuit setting was much more complicated than it was in the Coastal-Vedda setting, as it was difficult to find an overlapping time for Inuit fishers due to their other priorities. My research assistants and translators helped me organize focus groups. In the Arctic community, I conducted all focus groups in the hamlet building; the participants were determined based on the specific question that was to be addressed. There were few overlaps (participants) among the six focus groups in the Arctic, while in the Sri Lanka community, there were many overlaps among the focus group participants. I facilitated all the focus groups with the research assistants and translators. I compensated all the participants and offered refreshments for their time and support. Throughout the data collection stages, I used focus group discussions to explore key emerging findings. During the later stages, specific focus groups were organized as part of the result dissemination process to ensure the accessibility, flow, and exchange of information among community and research partners.

2.2.3.4 Key informant interviews

Key informants are individuals, or a group of people, who possess specific skills, knowledge, experience, and/or specialized backgrounds in the research project or project participants (Kumar, 1989, Taylor and Blake, 2015). They can also be people who adequately represent the target research sample (participants) and their activities to the researcher (Mack et al., 2005). According to Mack et al. (2005), key informant interviews can be carried out individually or as a focus group. According to Taylor and Blake (2015), a strength of the key informant interview method is its ability to provide insider information, which is difficult to obtain by using other qualitative methods like participant observations. Moreover, key informants can provide only selected required information and less unnecessary data (Kumar, 1989, Sofaer, 2002, Taylor and Blake, 2015). However, Sofaer (2002) identifies some drawbacks of this method. Considerable time and effort are required to identify and select the correct key informants. Further, the relationship between the researcher and the key informant can influence the type of information obtained. Moreover, the method can lead to disagreements among individuals, thereby producing frustration in the analysis.

I conducted 63 key informant interviews related to Inuit and Coastal-Vedda communities. The aim of my key informant interviews was to obtain more specific information that was not accessible through semi-structured interviews. For example, I interviewed fisheries extension officers from both the Department of Fisheries and Oceans (Canada) and the National Aquaculture Development Authority (Sri Lanka) to obtain details about the co-management process. Further, I used key informants for data validation and clarification purposes. For instance, key informant interviews helped me understand what people said with respect to what they did (e.g., allowable fisheries quotas) and to cross-reference this (where possible) with key informants (e.g., fisheries extension officers) for further contextualization. The manner in which I conducted key informant interviews was similar to that of semi-structured interviews, though they mostly took place outside the community (e.g., government ministries, local universities, research institutions, other communities). Further, I prepared specific questions for each key informant (i.e., I did not rely on the topic guide) depending on the knowledge holders' specialized area and data gaps in my research.

2.2.4 Data analysis

I began data analysis during the first field season in 2017. This process stretched to the end of the thesis writing stage. My data analysis was a complex iterative process that developed over the research project. Data were gathered through participant observations, semi-structured interviews, focus group discussions, and key informant interviews. This section describes the main ways in which analyzed data were gathered from participant observations and interviews (semi-structured, focus groups, and key informants). Further, this section describes the three-phase coding process used to analyse data (figure 2.4).

Participant observation data were qualitatively analyzed in multiple ways. First, I carried out data reduction using indexing, coding (for themes and characteristics), managing coding and indexing, and word searching (DeWalt and DeWalt, 2010). Second, I used display and effective data representation methods such as quotes, vignettes, cases, tables, matrices, and charts to efficiently review a large amount of data (DeWalt and DeWalt, 2010). Third, I developed ideas about emerging themes and patterns and how they fit into the overriding themes or came together to create meaning to interpret participant observation data (DeWalt and DeWalt, 2010). I used member checking to manage researcher biases (DeWalt and DeWalt, 2010, Creswell, 2013, Yin, 2014).

During my fieldwork, I recorded the participant observation data in a field diary that I updated daily (Heller et al., 2011). I maintained two field diaries—one each for the Inuit and Coastal-Vedda fieldwork—and filled them with stories, diagrams, drawings, and maps that related to my daily experience. Further, I used photos, videos, and field artifacts (e.g., gifts, drawings and paintings, carvings) to capture participant observation data, which allowed me to reconnect with actual experiences. After my first phase of field data collection in 2017, I started reading my field diaries and trying to reconnect with my field experience. First, I started with the Arctic field diary.

Semi-structured interview data analysis started with the transcribing of recorded data (Creswell, 2013). Content analysis was then used to develop themes, patterns, and variables, and I used 'manifest' and 'latent' content analysis (Dunn, 2003, Babbie, 2015). Manifest content analysis is aimed at the objective, surface, or concrete content. Manifest content analysis is the analysis of what the text says corresponding to the content aspect and describes the visible, obvious components (Graneheim and Lundman, 2004). I used the Microsoft Word Navigation tool to manifest content analysis. Latent content analysis is the analysis of what the text says about the relationship aspect and involves an interpretation of the text's underlying meaning (Graneheim and Lundman, 2004). The latent content analysis seeks the underlying or implicit meanings, e.g., whether 'climate change' is mentioned in the text in an approving or disapproving manner. Primarily, I performed the latent content analysis by carefully reading the transcribed material and talking with community members to obtain clarifications. After the content analysis, I created a new understanding by relating and combining the outcomes (key words and meanings) of both the manifest and latent content analysis (Cope, 2010, Longhurst, 2016). Categorization of key words allows for the building of themes and the location of connections among categories, thereby imbuing qualitative data with meaning (Dunn, 2003, Cope, 2010). Focus group and key informant interview data analysis is similar to semi-structured interview data analysis. However, for focus groups, the process is much more time-consuming because of the emphasis on the interaction between the participants (Cameron, 2010, Carey and Asbury, 2016).

During fieldwork, I organised data collection records such as semi-structured interviews, focus groups, and key informant interviews. I transcribed most of my interviews (my research assistants transcribed some of them) and organized some of the data into a Microsoft Excel datasheet. For example, the first datasheet consisted of the columns for a) data category (refers to the characteristics of the conceptual framework), b) specific questions (e.g., age, gender, number of households, primary source of income/food, fishing gear use), and c) relevant primary data under each case study number (e.g., case 1, case 2). I completed this datasheet during my fieldwork, which allowed me to generate descriptive statistics to obtain a general understanding of the communities before I started my data analysis.

Before starting my second phase of data collection, I reread the interview and focus group transcripts and field diary entries to begin coding phase one (figure 2.4). During this phase, I reformatted and reorganized all the transcripts by breaking down, examining, conceptualizing, comparing, and categorizing data, in which I conducted 'open coding' (Strauss, 1987, Strauss and Corbin, 1990). I used two questions to guide the coding process: a) How do fishers experience change? and b) How do fishers respond to change? As a result of coding phase one, I developed multiple themes and categories related to the guiding questions. In addition to the general themes, I noticed emerging themes and specific areas in which the representation was weak. For example, I found, based on the first round of data collection, the fisher women's voice in Coastal-Vedda is underrepresented, and I altered my focus in the following field season accordingly.

During the second phase of data collection in 2018, I received feedback about, and consent from, the community representatives regarding the categories and themes that I had developed as a result of coding phase one. The process of returning research findings to research participants in order to test the credibility of the research findings is often referred to as "member checking" (Baxter and Eyles, 1997). Member checking is one of the strategies used to establish rigor in qualitative research; it can ensure qualitative validity by providing credibility and minimizing misinterpretations that can arise in interview conversations (Baxter and Eyles, 1997, Turner and Coen, 2008, Birt et al., 2016). The first member checking experience took place in Inuit and Coastal-Vedda communities during the second data collection season. For example, I organized a focus group discussion and focus-group-like meetings to obtain community feedback. I invited research participants to participate in such meetings and presented my results (with translators).

First, we obtained feedback from the greater audience in the community. Second, I got feedback from the research team, including local research assistants. Third, I contacted key informants to address specific concerns. I made corrections based on the feedback.

After my second field season in 2018, I moved to coding phase two. I re-read the transcription material and developed secondary themes under each primary theme. For example, under the primary theme of knowledge systems, I developed secondary themes such as the use of different kinds of knowledge, the weakening of knowledge systems, and ways to co-produce knowledge. I organized captured evidence (textual, quotes, and photos) under each sub-category. Some primary themes were further categorized beyond sub-categories. The characteristics of the conceptual framework were used to guide the categorization process (Galappaththi et al., 2019c). At the end of coding phase two, I contacted each community for member checking (Baxter and Eyles, 1997). To do this, I visited the Arctic community in person, while I contacted the Sri Lankan community via cell phones and some electronic methods (WhatsApp and Viber). As a result of member checking, appropriate changes were incorporated into the coding process as appropriate. This included combining different sub-categories (e.g., feedback and learning), using specific terminologies (i.e., corrections of translated terms), including more institutions as co-management partners, and making corrections and additions to harvest data.

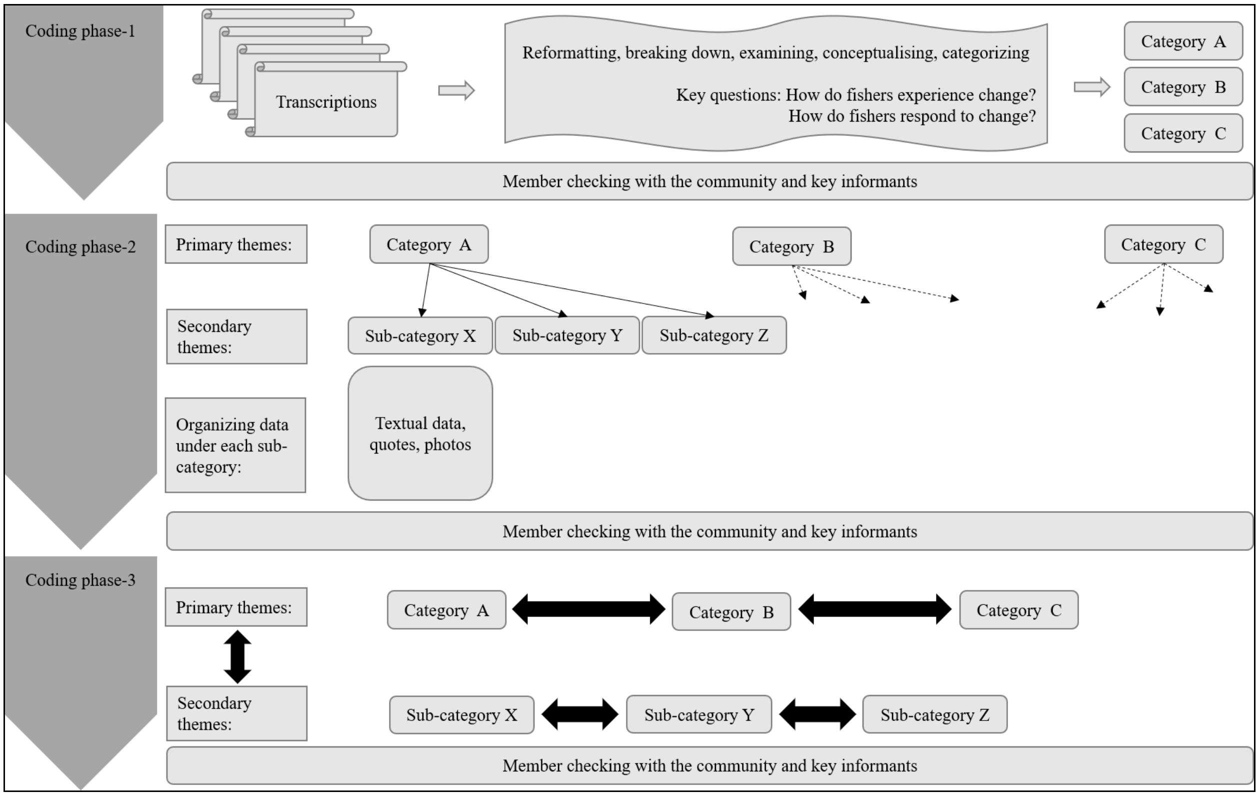

Figure 2.4: Coding process for data analysis.
Note: The figure illustrates the key phases of the overall coding process, vertically from top to bottom (i.e., coding phases one to three). Under each coding phase is an illustration of the major steps and components of the process. The content under phase one starts from the transcripts and moves to the development of key categories and the member checking process. The content under phase two represents the development of secondary themes and the organization of data following member checking. The content under phase three indicates how to relate both primary and secondary themes to better understand the data and its interpretations, following member checking.

In coding phase three, I moved all categorized data (i.e., themes and their evidence) into multiple Microsoft Excel spreadsheets. This allowed me to examine a large amount of data and see the relationships among the primary themes and secondary themes and beyond. I revisited my conceptual framework and related each emerging theme, trying to understand relationships. I used Excel color coding as a mechanism to further re-organize different levels of categories. As I went through this analytical process, I recorded ideas about the data, its interpretation, and theoretical understanding (Strauss, 1987, Christensen, 2011). The conceptual framework proposed in chapter 3 shows multiple drivers of resilience (i.e., framework characteristics); my analysis focused on multiple trends, stressors, and processes related to community-level climate adaptation.

I started reading the Excel spreadsheet materials and then reorganized specific themes (data) in the Microsoft PowerPoint and Word programs to develop thematic maps, tables, figures, and descriptive statistics (Jackson, 2001). This allowed me to better understand how the different categories related to one another, teasing out relationships among coding categories (Christensen, 2011). Throughout this analytical process, I revisited my research objectives and conceptual framework to ensure that I was moving in the right direction (Cope, 2010). I then started reorganizing relevant themes under the research objective (i.e., manuscript-based chapters) of my thesis. As Crang and Cook (2007: 133) point out, "writing and analysis are inseparable". Throughout my writing process, I was also able to better understand the complexities among different data, themes, evidence, and linkages between key concepts. After writing each empirical chapter, I sent my key results and discussion to the community representatives to member check and minimize any misinterpretation.

Some of the key themes that emerged from this coding process were diversification, technology, co-management, institutions, and aquaculture (i.e., community adaptive strategies). The development of adaptive strategies and place-based attributes in both Inuit and Coastal-Vedda chapters (4 and 5) was the result of an iterative process with the corresponding communities. Mixed methods were used to collect primary data. The same evidence (data) was gathered and validated through multiple means (participant observation, interviews, focus group). Throughout the data analysis process, multiple times I conducted member checking with community representatives and adjusted appropriately. Additionally, at the end of the analytical process, these empirical results were checked with the community representatives in two stages: first, before the first draft of each empirical chapter was finished and, second, to receive feedback to (re) submit the reviews to the research journals as part of the peer-review process.

Credibility in qualitative research is achieved when research findings resonate as authentic with research participants and are understood by people outside the community or experience (Lincoln and Guba, 1985, Cutcliffe and McKenna, 1999, Patton, 1999). In addition to member checking with research participants, I received the opportunity to present this empirical chapter and its components at relevant scientific conferences and to publish it in disciplinary peer-reviewed research journals. For example, I presented my Inuit case study during the Annual

ArcticNet Scientific meetings (2017 and 2018) in both research poster and paper presentation forms. Further, I presented my Sri Lankan case study as a paper presentation at the 3rd World Small-Scale Fisheries Congress held in Thailand (2018).

2.2.5 Ethical and positionality considerations

Hay (2003:39) identifies three key reasons why ethical research practice is important. First, ethical behavior helps protect the rights of research participants, communities, and the environment involved in the research. Second, "and perhaps a little more self-interestedly, ethical behavior helps assure a favorable climate for the continued conduct of scientific inquiry." Third, a growing demand exists among the public for accountability in scientific research (AAAS, 2016). Thus, the principal questions in research ethics are: Is this just (Justice)?, Am I doing harm/good (Beneficence)?, and Am I showing respect? (Hay, 2003).

2.2.5.1 Ethical considerations

The main aspects of ethical considerations are 'privacy,' 'confidentiality' and 'anonymity,' 'critical reflexivity,' researchers' difficulties in adapting to participants' worldviews, gender and power relations, and power and politics among research partners. Many people feel happier living their daily lives without being observed, and people tend to change their behavior when an outsider is watching them (Johnson, 1992). Privacy "involves the idea that people's everyday lives ought not to be invaded or studied without good reason" (Johnson, 1992: 216). In participant observation, watching a target group without its consent is a severe ethical consideration that applies to this method (Dabney et al., 2004). Participant observation can raise the issue of the subjects' right to 'privacy' (Zikmund, 2003). For example, misleading participants with respect to consent, deception, harm to participants, lack of confidentiality and anonymity, and undisclosed positionality could stem from any participant observation method (Dillman, 1977, Musante and DeWalt, 2010).

A high level of 'critical reflexivity' or 'reflexivity' can help the researcher stay on track and mitigate distractions throughout the period of participant observation (Freshwater and Rolfe, 2001, Pain, 2004, Dowling, 2016). 'Reflexivity' "is a process of constant, self-conscious scrutiny of the self as a researcher and of the research process" (England, 1994, Dowling, 2016: 34).

Being mindful and vigilant of this while staying engaged in participant observation can result in self-awareness about ‘what you are thinking’ and ‘how you are acting,' self-reflection about individual experiences, and self-reflexivity of collective referents (Andreotti, 2014). I used the research field diary as a tool to make this research more reflexive (Dowling, 2016). For example, there were many instances in which I was overwhelmed by the life stories of my respondents. Reading the field diary and engaging in the habit of daily mindful meditation helped me re-align my focus back on the research.

‘Confidentiality’ and ‘anonymity’ are among the top-listed ethical considerations (Longhurst, 2016). Confidentiality is an active attempt to keep research participants’ data/information private unless the informant provides consent to release the information (Montello and Sutton, 2006). Anonymity is when “subjects remain nameless” (Berg, 2007: 79). For example, protecting the confidentiality and anonymity of a patient’s semi-structured interview data is a common topic of discussion in the medical research literature (Kaiser, 2009). I have paid extra attention to these considerations in my research. I always found a suitable ‘place’ to comfortably hold a conversation with the participant (Longhurst, 2016). For example, I conducted interviews in private and isolated (from other people) places such as on the Arctic tundra, on the sea, in private office rooms, and at fish landing sites. Further, all the quotations I used in empirical chapters and publications remain anonymous. A secured approach guarantees both confidentiality and anonymity in (i.e., during and after) data collection and reporting; such efforts included data storage on a password-protected computer accessible only by me and other project researchers who had been screened for access (e.g., research assistants) (Longhurst, 2016).

Research participants who take part in semi-structured interviews and focus groups might express sexist, racist, or other offensive views during those interviews, particularly when one is working in different cultural contexts (Longhurst, 2016). For example, when a researcher from a Western society that maintains a certain worldview and attitude conducts an interview in a developing country (or vice versa), he or she might have trouble adapting to the participants’ worldview. In this research, I represented neither Western nor Indigenous worldviews. As Krueger and Casey (2014) highlight, I listened and paid attention to research participants without judgment. Understanding the relevant culture before traveling to conduct my research was helpful to some extent. Mostly, I obtained experience dealing with such situations, as there are no easy solutions (Longhurst, 2016). I found gender and power relations to be more deeply rooted ethical considerations related to semi-structured interviews, focus groups, and participant observations.

Power relations among the researcher, funding organizations, research institutions, and participants can create ethical concerns, such as power inequality and the misuse of power (Linda, 2007, Yow, 2014). Who controls the research process is important because the process should be ongoing and collaborative (Ritchie, 2014). Cultivation of trust, the development of collaborative relationships, and shared decision-making are ways in which a researcher can embed himself/herself in the ongoing research process (High, 2016); learning-by-doing is a way to do this. A community-based participatory research approach—see above discission—helped me maintain my focus on such ethical considerations (Hacker, 2013). Furthermore, the ethics surrounding the interpretive complexity of collected data can give different meanings to the story and create injustice for the narrator (Linda, 2007, Ritchie, 2014, Yow, 2014). As DeWalt and DeWalt (2010) discuss, I used five approaches towards managing ethical considerations in qualitative research methods: need for competency, meaning of informed consent, protection of confidentiality, maintenance of relationships, and ethical publications.

This research follows the guidelines established by McGill University's research ethics and compliance. First, I completed the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2). Second, I visited the communities to meet with the local people and partner organizations and to reaffirm the project's goals and objectives, confirm the timeline for community research and intervention, determine local ethical systems and perspectives on ethics, and identify the risks that communities face with respect to the research and possible ways in which those risks can be mitigated. Finally, an ethics protocol was developed and discussed with both communities (Eysenbach and Till, 2001). Key aspects of the protocol were: i). *Partnership agreements* between the researcher and the communities and/or partner organizations that outline how the research project should be directed and reported on, and that document the researcher's obligations (e.g., funding organizations such as IDRC, McGill North, NSTP); ii). *Guarantees of confidentiality*; iii). The use of *consent forms* (oral and written, translated) for all methods, specifying the project's aims and outlining the rights of the participants and the responsibilities of the researchers; and iv). *Formal ethics approvals* obtained from relevant bodies.

2.2.5.2 Positionality considerations

'Positionality' is widely discussed across the social sciences and humanities. Positionality is a "strategy that has been employed to contextualize research observations and interpretations"; this can involve the researcher identifying key political aspects of the self (Cloke *et al.* 2000, Moser 2008: 384). Positionalities can include aspects of identity, race, class, gender, age, sexuality, disability, and the researcher's previous (non)research experience with the field (Hopkins, 2007: 391). Positionality can change and develop throughout the research process. Thus, maintaining critical reflexivity is important, as it can affect knowledge production and be affected by potential ethical considerations (England, 1994, Rose, 1997, Hopkins, 2007). Moser (2008) argued about how a researcher's 'personality' can act (or perform) over the 'positionality' to shape the research process and knowledge production. In this research process, the researcher maintained two positionalities: in the context of Inuit people in the Canadian Arctic and Coastal-Vedda people in Sri Lanka.

What was my positionality in this research? I am a brown-colored male, able-bodied, born and raised in Sri Lanka, and presently based in Canada. Over the last four years, I have spent about four months with Inuit of Arctic Canada and about six months with Coastal-Vedda of Eastern Sri Lanka. I used mixed qualitative methods for data collection and worked closely with each community participant, including research assistants and translators.

Various traits affect my positionality within the Coastal-Vedda communities in Sri Lanka. First, I originated from a majority ethnic group (Sinhala) of Sri Lanka and presently am conducting research about Indigenous minority groups. Second, my Sri Lankan field area is directly affected by both the war and the 2004 tsunami. Some research participants know me as an activist based on my early social work with respect to the ethnic war and the tsunami. Third, I relied on translators because of the communities' unique language and dialect. Finally, my previous research experience with Sri Lankan shrimp farmers was very useful in helping me better understand the Coastal-Vedda context. My positionality with the Inuit people in Arctic Canada was much different from my positionality with the Sri Lankan Coastal-Vedda communities. My previous work experience with sub-Arctic Canadian Indigenous communities helped me better understand the Arctic context. I believe that my ethnic origin and personality (Moser, 2008) helped me build a friendly relationship with most of the Inuit people within a short time. During my third and fourth visits to the community, some people greeted me with 'welcome home!'—an indication of our friendship.

Throughout the course of the research, my positionality within each community also evolved. Notably, over the last four years, I have undergone a transformation in my way of thinking and worldview. Further, I know that some of the community members also went through various changes that could affect the research positionality. These changes in positionality should have affected my data collection and data analysis processes. Throughout the knowledge co-production process, I have tried to be mindful and vigilant about positionality at the individual and collective levels.

2.3 Methods for comparative study

The fourth research objective is to conduct a comparative analysis of the vulnerabilities and adaptive responses of two small-scale fisheries communities (i.e., Sri Lankan and Canadian Arctic case studies). I addressed this research objective through a four-step systematic approach. The first step is the development of a place-specific resilience-based conceptual framework to assess community adaptation in small-scale fisheries systems. The second step is to assess Inuit small-scale fisheries systems by using the proposed conceptual framework. The third step is to assess Coastal-Vedda's small-scale fisheries systems using the same framework as that used in the Inuit case study. I used the same field data collection methods to assess both case studies, as explained in section 2.2. The fourth step is to conduct a comparative analysis of two case studies. I have discussed the details of these four steps in chapter 6.

In climate change adaptation research, most comparative studies are used to make comparisons within the regions or countries, and most of the available studies build on secondary data. Comparative studies are very important in social studies, as they help generate broader insights that could inform climate change adaptation policy. In chapter 6, I offer more comprehensive insights into climate change adaptation across spatial and temporal dimensions by examining the broader applicability of findings through an examination of what is either different from or similar to other small-scale fisheries systems (Maru et al., 2014). The details about the comparative studies are also available in chapter 6; this section aims to describe how I developed specific adaptation insights.

I used content analysis to carry out a comparative analysis of the two case studies (Yow, 2014, Hancock and Algozzine, 2015, Berg, 2016). The key techniques I used were 'manifest' and 'latent' content analysis (Vaismoradi et al., 2016, Krippendorff, 2018) (see section 2.2.4 for operational details). After completion of the Inuit and Coastal-Vedda case studies, I started re-reading both manuscripts to obtain a broader understanding of the two case studies. Further, I started re-reading my research objectives and coding materials from the field data analysis, as described in section 2.2.4. This included revisiting my conceptual framework to fine-tune my conceptual understanding of the comparative analysis. Using framework characteristics as conceptual guidance, I began further examining, reorganizing, breaking down, and combining, summarizing, and condensing data of the coding material (Strauss, 1987, Strauss and Corbin, 1990). I used Microsoft Excel speedsters to create long tables for purposes of comparing data from both case studies, while I used PowerPoint and Word documents to develop figure comparisons (e.g., comparison of institutional structures for fisheries co-management in both Inuit and Coastal-Vedda systems). Based on the reorganized coding material, and the developed tables and figures, I started writing the results section of the manuscript (chapter 6). I critically compared and contrasted the coded data from both case studies and documented this analysis in the results section (chapter 6). As Crang and Cook (2007) point out, I have revisited coding materials for some analysis throughout my writing.

Through the above-explained content analysis process, I identified prominent common themes and their relationships. I described these themes and interpretations under the discussion section of chapter 6 (e.g., four characteristics of the nature of climate change, two contextual differences of two fisheries systems, and two common adaptive responses). I used the following specific methods to develop eight sources of resilience and five definitive characteristics of successful adaptation.

To develop the eight sources of resilience, I brought up three different forms of analysis, combining: theory, coded data, and field evidence (figure 2.5). The first form of analysis is the characteristics of the conceptual framework (i.e., place, human agency, collective action, institutions, knowledge systems, and learning) (Galappaththi et al., 2019c) and specific resilience literature that can guide the analysis (e.g., (Folke et al., 2003, Galappaththi et al., 2019a)). The second form of analysis is the coded materials of comparative analysis that represent both Inuit and Coastal-Vedda data. I started further examining, reorganizing, combining, breaking down, and summarising the coding material (Strauss, 1987, Strauss and Corbin, 1990). Two fundamental questions that guided this process were: 1) How do fishers minimize vulnerability, and 2) How do fishers build resilience? From this analysis, I developed various themes related to the conceptual framework and specific sources of resilience literature (i.e., the first form of analysis) and the third form of analysis. The third form of analysis was the field data from each case study (e.g., interview transcripts, quotes, photos, videos, voice recordings, and the field diary). Bringing together these three forms of analysis and their interpretations (Fowler, 1997, Fairclough, 2013), I came up with the eight sources of resilience. I achieved member checking with the community representatives of both the Canadian Arctic and Sri Lanka.

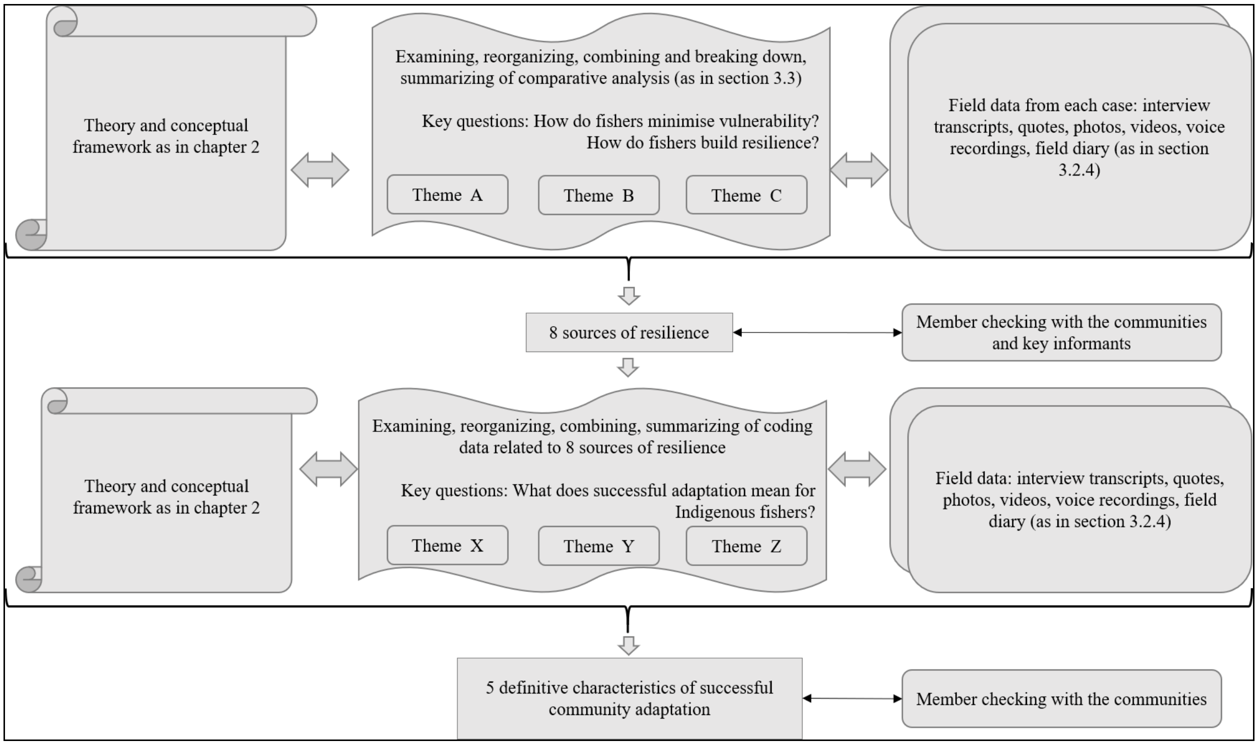

Figure 2.5: Coding process to produce eight sources of resilience and five characteristics of successful adaptation. Note: The figure illustrates the critical phases of analysis. At the top level, it shows the three components brought together, which are theory, coding material of comparative analysis, and field evidence. Eight sources of resilience are the combined result of relating and verifying these three components following the member checking with the communities and key informants. Similarly, the bottom level represents the three components used to develop five characteristics of successful adaptation.

To come up with the five definitive characteristics of the successful adaptation, I used an approach similar to that used to develop the sources of resilience. I combined three different forms of analysis, i.e., theory, coded data, and field evidence (figure 2.5). For the first form of analysis, I used a conceptual framework and specific literature about the successful community adaptation (e.g., (Adger et al., 2005, Osbahr et al., 2010, Piggott-McKellar et al., 2019)). Based on the literature, I argued that successful adaptation should: bring equitable benefits and opportunities to Indigenous fisher communities, and build resilience in the areas of food security, nutrition, and sustainable livelihoods. For the second form of analysis, I further examined, reorganized, combined, and summarized the coding material related to the eight sources of resilience (Strauss, 1987, Strauss and Corbin, 1990). The key question guiding this analysis is what successful adaptation means for Indigenous fishers. To examine this key question, I used three steps: 1) identification of the characteristics that make the community more resilient (when the features are present or practice), 2) identification of characteristics that weaken community resilience (or increase vulnerability) with the absence, and 3) identification of the overlapping features of steps a and b.

From this analysis, I developed themes related to the field evidence from both Indigenous communities. This third form of analysis included the field data, such as the interview transcripts, quotes, photos, videos, voice recordings, and field diary. Bringing together all three analyses and their interpretations, I developed various definitive characteristics of successful adaptation. These characteristics were member checked by both the Inuit and Coastal-Vedda communities (Turner and Coen, 2008, Birt et al., 2016). As a result of an iterative process, five characteristics were selected, as in chapter 6.

Compared to content analysis (section 2.2.4), the method I used in this section brings additional insights to the analysis. First, this method is ontologically constructionist rather than realist, as the meaning is constructed and fluid in ways that can be posited using interpretive methods. Here, the textual meaning is related to other text (theory and evidence). This is not the case with content analysis, which creates a fixed meaning based on the independent reality that exists in the field data. Second, this method creates more subjectivity through inductive reasoning as compared to content analysis. Finally, this method inserts a theoretical and practical discourse into the content analysis, thereby producing more relational meaning within the discursive context.

2.4 Conclusion

The goal of this chapter is to describe the overarching research methodology used to address the study objectives. Furthermore, this chapter explained the overall logic behind my methods, as well as defined terms used throughout the thesis here to allow the manuscript chapters to remain concise and focused. First, this chapter described the development of the conceptual framework (chapter 3) and how it was operationalized throughout the thesis. Second, the methods related to two empirical case studies in chapters 4 and 5 (i.e., Inuit and Coastal-Vedda) are described. This includes essential information about the selection of case study locations, the community-based participatory research approach, the field data collection methods, the data analysis, and ethical and positionality considerations. Finally, this chapter described the comparative analysis of the two case studies in chapter 5 and stated how this analysis produced specific results, such as eight sources of resilience and the definitive characteristics of successful adaptation.

2.5 References

AAAS. 2016. *American Association of the Advancement of Science* [Online]. Available: https://www.aaas.org/page/srhrl-ethics-law-activities [Accessed 30 Oct. 2016].

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

ADGER, W. N., ARNELL, N. W. & TOMPKINS, E. L. 2005. Successful adaptation to climate change across scales. *Global environmental change,* 15**,** 77-86.

ADGER, W. N., BARNETT, J., BROWN, K., MARSHALL, N. & O'BRIEN, K. 2012. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change,* 3**,** 112-117.

ADGER, W. N., BUTLER, C. & WALKER-SPRINGETT, K. 2017. Moral reasoning in adaptation to climate change. *Environmental Politics***,** 1-20.

ALDRICH, D. P. & MEYER, M. A. 2015. Social capital and community resilience. *American Behavioral Scientist,* 59**,** 254-269.

AMIN, A. 2013. Surviving the turbulent future. *Environment and Planning D: Society and Space,* 31**,** 140-156.

ANDREOTTI, V. 2014. Critical literacy: Theories and practices in development education. *Policy & Practice-A Development Education Review*.

ARCHER, D., ALMANSI, F., DIGREGORIO, M., ROBERTS, D., SHARMA, D. & SYAM, D. 2014. Moving towards inclusive urban adaptation: approaches to integrating community-based adaptation to climate change at city and national scale. *Climate and Development,* 6**,** 345-356.

ATKINSON, R. & FLINT, J. 2001. Accessing hidden and hard-to-reach populations: Snowball research strategies. *Social research update,* 33**,** 1-4.

AYERS, J. & FORSYTH, T. 2009. Community-based adaptation to climate change. *Environment: science and policy for sustainable development,* 51**,** 22-31.

BABBIE, E. R. 2015. *The practice of social research,* Bostern, Nelson Education.

BAGGIO, J., BROWN, K. & HELLEBRANDT, D. 2015. Boundary object or bridging concept? A citation network analysis of resilience. *Ecology and Society,* 20**,** 2.

BAHADUR, A., LOVELL, E. & PICHON, F. 2016. Effectiveness in Building Resilience: Synthesis report for Oxfam's Resilience Outcome Area. Oxfarm International.

BAHADUR, A. V., PETERS, K., WILKINSON, E., PICHON, F., GRAY, K. & TANNER, T. 2015. The 3As: Tracking resilience across BRACED. *Working and Discussion Papers. London: Overseas Development Institute* 57.

BARRETT, C. B. & CONSTAS, M. A. 2014. Toward a theory of resilience for international development applications. *Proceedings of the National Academy of Sciences,* 111**,** 14625-14630.

BAXTER, J. & EYLES, J. 1997. Evaluating qualitative research in social geography: establishing 'rigour'in interview analysis. *Transactions of the Institute of British Geographers,* 22**,** 505-525.

BÉNÉ, C., ARTHUR, R., NORBURY, H., ALLISON, E. H., BEVERIDGE, M., BUSH, S., CAMPLING, L., LESCHEN, W., LITTLE, D. & SQUIRES, D. 2016a. Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Development,* 79**,** 177-196.

BÉNÉ, C., HEADEY, D., HADDAD, L. & VON GREBMER, K. 2016b. Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. *Food Security,* 8**,** 123-138.

BÉNÉ, C., NEWSHAM, A., DAVIES, M., ULRICHS, M. & GODFREY-WOOD, R. 2014. Review article: resilience, poverty and development. *Journal of International Development,* 26**,** 598-623.

BÉNÉ, C., WOOD, R. G., NEWSHAM, A. & DAVIES, M. 2012. Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. *IDS Working Papers,* 2012**,** 1-61.

BERG, B. 2007. *Qualitative research methods for the social sciences,* Boston, California State University: Allyn and Bacon.

BERG, B. L. 2016. *Qualitative research methods for the social sciences,* Boston, Pearson Education.

BERKES, F. 2011. Restoring unity: The concept of marine social-ecological systems. *In:* OMMER, R., PERRY, R., COCHRANE, K. & CURY, P. (eds.) *World fisheries: A social-ecological analysis.* Sussex, UK: Wiley-Blackwell.

BERKES, F. 2012. *Sacred ecology,* New York, Routledge.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F., FOLKE, C. & COLDING, J. (eds.) 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience,* Cambridge, UK: Cambridge University Press.

BERKES, F. & ROSS, H. 2013. Community resilience: toward an integrated approach. *Society & Natural Resources,* 26**,** 5-20.

BERKES, F. & ROSS, H. 2016. Panarchy and community resilience: Sustainability science and policy implications. *Environmental Science & Policy,* 61**,** 185-193.

BERKES, F. & TURNER, N. J. 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology,* 34**,** 479.

BIRT, L., SCOTT, S., CAVERS, D., CAMPBELL, C. & WALTER, F. 2016. Member checking: a tool to enhance trustworthiness or merely a nod to validation? *Qualitative health research,* 26**,** 1802-1811.

BOUSQUET, F., BOTTA, A., ALINOVI, L., BARRETEAU, O., BOSSIO, D., BROWN, K., CARON, P., D'ERRICO, M., DECLERCK, F. & DESSARD, H. 2016. Resilience and development: mobilizing for transformation. *Ecology and Society,* 21.

BOYD, E. & FOLKE, C. (eds.) 2012. *Adapting institutions: Governance, complexity and social-ecological resilience,* New York: Cambridge University Press.

BRAND, F. S. & JAX, K. 2007. Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and society,* 12**,** 23.

BREEN, R. L. 2006. A practical guide to focus-group research. *Journal of Geography in Higher Education,* 30**,** 463-475.

BROAD, R. & CAVANAGH, J. 2011. Reframing Development in the Age of Vulnerability: from case studies of the Philippines and Trinidad to new measures of rootedness. *Third World Quarterly,* 32**,** 1127-1145.

BROWN, K. 2014. Global environmental change IA social turn for resilience? *Progress in Human Geography,* 38**,** 107-117.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

BROWN, K. & WESTAWAY, E. 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual review of environment and resources,* 36**,** 321-342.

CAMERON, J. 2010. Focusing on the Focus Group. *In:* HAY, I. (ed.) *Qualitative Research Methods in Human Geography.* New York: Oxford University Press.

CAREY, M. A. & ASBURY, J.-E. 2016. *Focus group research,* London, Routledge.

CARPENTER, S., WALKER, B., ANDERIES, J. M. & ABEL, N. 2001. From metaphor to measurement: resilience of what to what? *Ecosystems,* 4**,** 765-781.

CASTLEDEN, H., MORGAN, V. S. & LAMB, C. 2012. "I spent the first year drinking tea": Exploring Canadian university researchers' perspectives on community-based participatory research involving Indigenous peoples. *The Canadian Geographer/Le Géographe canadien,* 56**,** 160-179.

CHAMLEE-WRIGHT, E. & STORR, V. H. 2009. "There's no place like New Orleans": Sense of place and community recovery in the Ninth Ward after Hurricane Katrina. *Journal of Urban Affairs,* 31**,** 615-634.

CHRISTENSEN, J. 2011. *Homeless in a homeland: housing (in)security and homelessness in Inuvik and Yellowknife, Northwest Territories, Canada.* Doctor of Philosophy, McGill University.

CHRISTOPLOS, I. 2010. Understanding climate change adaptation: lessons from community-based approaches. *Climate and Development,* 2**,** 73-74.

CLOKE, P., COOKE, P., CURSONS, J., MILBOURNE. P., AND WIDDOWFIELD, R. 2000. Ethics, reflexivity and research: encounters with homeless people, *Ethics, Place & Environment,* 3, 133–54.

COLLINGS, P. 2009. Participant observation and phased assertion as research strategies in the Canadian Arctic. *Field Methods,* 21**,** 133-153.

COPE, M. 2010. Coding Transcripts and Diaries. *In:* CLIFFORD, N., FRENCH, S. & VALENTINE, G. (eds.) *Key Methods in Geography.* London: SAGE.

CRANG, M. & COOK, I. 2007. *Doing ethnographies,* Thousand Oaks, CA, Sage Publications.

CRESWELL, J. W. 2013. *Research design: Qualitative, quantitative, and mixed methods approaches,* New York, Sage publications.

CUTCLIFFE, J. R. & MCKENNA, H. P. 1999. Establishing the credibility of qualitative research findings: the plot thickens. *Journal of advanced nursing,* 30**,** 374-380.

CUTTER, S. L., BARNES, L., BERRY, M., BURTON, C., EVANS, E., TATE, E. & WEBB, J. 2008. A place-based model for understanding community resilience to natural disasters. *Global environmental change,* 18**,** 598-606.

DABNEY, D. A., HOLLINGER, R. C. & DUGAN, L. 2004. Who actually steals? A study of covertly observed shoplifters. *Justice Quarterly,* 21**,** 693-728.

DEVINE-WRIGHT, P. 2013. Think global, act local? The relevance of place attachments and place identities in a climate changed world. *Global Environmental Change,* 23**,** 61-69.

DEWALT, K. M. & DEWALT, B. R. 2010. *Participant observation: A guide for fieldworkers,* Lanham, Rowman Altamira Press.

DILLMAN, C. 1977. Ethical problems in social science research peculiar to participant observation. *Human organization,* 36**,** 405-407.

DOWLING, R. 2016. Power, Subjectivity, and Ethics in Qualitative Research. *In:* HAY, I. (ed.) *Qualitataive Research Methods in Human Geography.* 4th ed. New York: Oxford University Press.

DUNN, K. 2003. Interviewing. *In:* HAY, I. (ed.) *Qualitative research methods in human geography.* Melbourne: Oxford University Press.

ENGLAND, K. V. L. 1994. Getting personal: Reflexivity, positionality, and feminist research. *Professional Geographer,* 46**,** 80-89.

ENSOR, J. E., ABERNETHY, K. E., HODDY, E. T., ASWANI, S., ALBERT, S., VACCARO, I., BENEDICT, J. J. & BEARE, D. J. 2018. Variation in perception of environmental change in nine Solomon Islands communities: implications for securing fairness in community-based adaptation. *Regional Environmental Change,* 18**,** 1131-1143.

EYSENBACH, G. & TILL, J. E. 2001. Ethical issues in qualitative research on internet communities. *Bmj,* 323**,** 1103-1105.

FAIRCLOUGH, N. 2013. *Critical discourse analysis: The critical study of language,* NY, Routledge.

FISCHER, J., GARDNER, T. A., BENNETT, E. M., BALVANERA, P., BIGGS, R., CARPENTER, S., DAW, T., FOLKE, C., HILL, R. & HUGHES, T. P. 2015. Advancing sustainability through mainstreaming a social–ecological systems perspective. *Current Opinion in Environmental Sustainability,* 14**,** 144-149.

FLOWERDEW, R. & MARTIN, D. 2005. *Methods in Human Geography: A guide for students doing a research project,* London, Pearson Prentice Hall.

FOLKE, C. 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change,* 16**,** 253-267.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

FOLKE, C., BIGGS, R., NORSTRÖM, A., REYERS, B. & ROCKSTRÖM, J. 2016. Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society,* 21.

FOLKE, C., CARPENTER, S., WALKER, B., SCHEFFER, M., ELMQVIST, T., GUNDERSON, L. & HOLLING, C. S. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. *Annu. Rev. Ecol. Evol. Syst.,* 35**,** 557-581.

FOLKE, C., CARPENTER, S. R., WALKER, B., SCHEFFER, M., CHAPIN, T. & ROCKSTROM, J. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society,* 15**,** 20.

FOLKE, C., CHAPIN III, F. S. & OLSSON, P. 2009. Transformations in ecosystem stewardship. *In:* SF, C. I., GP, K. & C, F. (eds.) *Principles of Ecosystem Stewardship.* New York: Springer.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FORD, J. D. 2012. Indigenous Health and Climate Change. *American Journal of Public Health,* 102**,** 1260-1266.

FORD, J. D., BERRANG-FORD, L., KING, M. & FURGAL, C. 2010. Vulnerability of Aboriginal health systems in Canada to climate change. *Global Environmental Change,* 20**,** 668-680.

FORD, J. D., SHERMAN, M., BERRANG-FORD, L., LLANOS, A., CARCAMO, C., HARPER, S., LWASA, S., NAMANYA, D., MARCELLO, T. & MAILLET, M. 2018. Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. *Global environmental change,* 49**,** 129-139.

FORD, J. D., SMIT, B. & WANDEL, J. 2006. Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. *Global Environmental Change,* 16**,** 145-160.

FORD, J. D., SMIT, B., WANDEL, J., ALLURUT, M., SHAPPA, K., ITTUSARJUAT, H. & QRUNNUT, K. 2008. Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *The Geographical Journal,* 174**,** 45-62.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2016. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-195.

FORD, J. D., VANDERBILT, W. & BERRANG-FORD, L. 2012. Authorship in IPCC AR5 and its implications for content: climate change and Indigenous populations in WGII. *Climatic change,* 113**,** 201-213.

FOWLER, R. 1997. Norman Fairclough, Critical discourse analyisis The critical study of languageLondonLongman, 1995 Pp XIII, 265. *Language in Society,* 26**,** 421-423.

FRESHWATER, D. & ROLFE, G. 2001. Critical reflexivity: a politically and ethically engaged research method for nursing. *Nursing Times Research,* 6**,** 526-537.

GALAPPATHTHI, E. & BERKES, F. 2015. Drama of the commons in small-scale shrimp aquaculture in northwestern, Sri Lanka. *International Journal of the Commons,* 9**,** 347-368.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2019a. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C. (eds.) *Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, Bangkok, 8–10 August, 2016. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO. 240 pp. Licence: CC BY-NC-SA 3.0 IGO.*

GALAPPATHTHI, E. K. & BERKES, F. 2014. Institutions for managing common-pool resources: the case of community-based shrimp aquaculture in northwestern Sri Lanka. *Maritime Studies,* 13**,** 1-16.

GALAPPATHTHI, E. K., FORD, J., BENNETT, E. & BERKES, F. 2019b. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada. *Journal of Environmental management,* 250**,** 109534.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019c. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GALAPPATHTHI, E. K., KODITHUWAKKU, S. S. & GALAPPATHTHI, I. M. 2016. Can environment management integrate into supply chain management? Information sharing via shrimp aquaculture cooperatives in northwestern Sri Lanka. *Marine Policy,* 68**,** 187-194.

GOLAFSHANI, N. 2003. Understanding reliability and validity in qualitative research. *The qualitative report,* 8**,** 597-606.

GRANEHEIM, U.H. AND LUNDMAN, B. 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness, *Nurse Education Today* 24: 105-112

GUNDERSON, L. H. & HOLLING, C. S. (eds.) 2002. *Panarchy: understanding transformations in human and natural systems,* Washington: Island press.

HACKER, K. 2013. *Community-based participatory research,* London, Sage.

HANCOCK, B., OCKLEFORD, E. & WINDRIDGE, K. 1998. *An introduction to qualitative research*, Trent focus group Nottingham.

HANCOCK, D. R. & ALGOZZINE, B. 2015. *Doing case study research: A practical guide for beginning researchers,* London, Teachers College Press.

HARVEY, B., CARLILE, L., ENSOR, J., GARSIDE, B. & PATTERSON, Z. 2012. Understanding Context in Learning-centred Approaches to Climate Change Communication. *IDS Bulletin,* 43**,** 31-37.

HAY, I. 2003. Ethical Practice in Geographycal Research. *In:* CLIFFORD, N. & VALENTINE, G. (eds.) *Key Methods in Geography.* London: Sage.

HAY, I. 2016. *Qualitative research methods in human geography,* Melbourne, Oxford University Press.

HELLER, E., CHRISTENSEN, J., LONG, L., MACKENZIE, C. A., OSANO, P. M., RICKER, B., KAGAN, E. & TURNER, S. 2011. Dear diary: Early career geographers collectively reflect on their qualitative field research experiences. *Journal of Geography in Higher Education,* 35**,** 67-83.

HERTEL, T. W. & ROSCH, S. D. 2010. Climate change, agriculture, and poverty. *Applied Economic Perspectives and Policy,* 32**,** 355-385.

HIGH, S. 2016. *Centre for Oral History and Digital Storytelling* [Online]. Montreal, QC: Concordia University. Available: http://storytelling.concordia.ca/toolbox/ethics [Accessed 29 October 2016].

HOGGART, K., LEES, L., DAVIES, A. & MOULD, A. 2002. *Researching human geography,* London, Routledge.

HOMER-DIXON, T. 2002. *The ingenuity gap: can we solve the problems of the future?,* Toronto, Vintage Canada.

HOMER-DIXON, T., WALKER, B., BIGGS, R., CRÉPIN, A.-S., FOLKE, C., LAMBIN, E., PETERSON, G., ROCKSTRÖM, J., SCHEFFER, M. & STEFFEN, W. 2015. Synchronous failure: the emerging causal architecture of global crisis. *Ecology and Society,* 20.

HOOVER, D. L., KNAPP, A. K. & SMITH, M. D. 2014. Resistance and resilience of a grassland ecosystem to climate extremes. *Ecology,* 95**,** 2646-2656.

HOPKINS, P. E. 2007. Positionalities and knowledge: Negotiating ethics in practice. *ACME: An International E-Journal for Critical Geographies,* 6**,** 386-394.

IPCC 2018. Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/.

ISRAEL, B. A., SCHULZ, A. J., PARKER, E. A., BECKER, A. B., ALLEN, A. J. & GUZMAN, J. R. 2003. Critical issues in developing and following community based participatory research principles. *Community-based participatory research for health,* 1**,** 53-76.

JACKSON, P. 2001. Making sense of qualitative data. *In:* LIMB, M. & DWYER, C. (eds.) *Qualitative methodologies for geographers: Issues and debates.* London, UK: Arnold.

JEANS, H., CASTILLO, G. E. & THOMAS, S. 2017. Absorb, Adapt, Transform: Resilience capacities. Oxford, UK: Oxfam International.

JOHNSON, M. 1992. A silent conspiracy?: Some ethical issues of participant observation in nursing research. *International Journal of Nursing Studies,* 29**,** 213-223.

KAISER, K. 2009. Protecting respondent confidentiality in qualitative research. *Qualitative Health Research,* 19**,** 1632-1641.

KALLBEKKEN, S. & AASEN, M. 2010. The demand for earmarking: Results from a focus group study. *Ecological economics,* 69**,** 2183-2190.

KAWULICH, B. B. Participant observation as a data collection method. Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 2005.

KEARNS, R. A. 2003. Seeing with Clarity: Understanding Observational Research. *In:* HAY, I. (ed.) *Qualitative research methods in human geography.* Melbourne: Oxford University Press.

KRIPPENDORFF, K. 2018. *Content analysis: An introduction to its methodology,* London, Sage publications.

KRUEGER, R. A. & CASEY, M. A. 2014. *Focus groups: A practical guide for applied research,* Singapore, Sage publications.

KRUPNIK, I. & JOLLY, D. (eds.) 2010. *The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change,* Fairbanks, AK: Arctic Research Consortium of the United States.

KUMAR, K. 1989. Conducting key informant interviews in developing countries. Agency for International Development Washington DC.

LAURIER, E. 2016. Participant and Non-participant Observation. *In:* CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. (eds.) *Key methods in Geography.* London: Sage.

LEACH, M., RAWORTH, K. & ROCKSTRÖM, J. 2013. Between social and planetary boundaries: Navigating pathways in the safe and just space for humanity. *ISSC and UNESCO editors, World social science report 2013, changing global environments.* Paris, France: OECD Publishing and UNESCO Publishing.

LEACH, M., SCOONES, I. & STIRLING, A. 2010. *Dynamic sustainabilities: technology, environment, social justice,* London, UK, Routlsdge.

LEBEL, L., ANDERIES, J. M., CAMPBELL, B., FOLKE, C., HATFIELD-DODDS, S., HUGHES, T. P. & WILSON, J. 2006. Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society,* 11**,** 19.

LEVINE, S., LUDI, E. & JONES, L. 2011. Rethinking support for adaptive capacity to climate change. *Oxfam Policy and Practice: Climate Change and Resilience,* 7**,** 49-97.

LINCOLN, Y. S. & GUBA, E. G. 1985. *Naturalistic inquiry* Thousand Oaks, CA, Sage Publications.

LINDA, S. 2007. Legal and Ethical Issues in Oral History. *In:* CHARLTON, T. L., MYERS, L. E. & SHARPLESS, R. (eds.) *History of Oral History.* New York: Altamira Press.

LIU, J., et al. (2007). "Complexity of coupled human and natural systems." *Science* **317**(5844): 1513-1516.

LONGHURST, R. 2016. Semi-structured Interviews and Focus Group. *In:* CLIFFORD, N., COPE, M., GILLESPIE, T. & FRENCH, S. (eds.) *Key Methods in Geography.* 3 ed. London: Sage.

LYON, C. 2014. Place systems and social resilience: A framework for understanding place in social adaptation, resilience, and transformation. *Society & Natural Resources,* 27**,** 1009-1023.

MACK, N., WOODSONG, C., MACQUEEN, K. M., GUEST, G. & NAMEY, E. 2005. Qualitative research methods: A data collector's field guide. Family Health International.

MANOGARAN, C. & PFAFFENBERGER, B. 1996. The Sri Lankan Tamils: Ethnicity and Identity. *Geographical Review,* 86**,** 150-152.

MARU, Y. T., SMITH, M. S., SPARROW, A., PINHO, P. F. & DUBE, O. P. 2014. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Global Environmental Change,* 28**,** 337-350.

MATYAS, D. & PELLING, M. 2015. Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. *Disasters,* 39.

MCPHERSON, J. M., SAMMY, J., SHEPPARD, D. J., MASON, J. J., BRICHIERI-COLOMBI, T. A. & MOEHRENSCHLAGER, A. 2016. Integrating traditional knowledge when it appears to conflict with conservation: lessons from the discovery and protection of sitatunga in Ghana. *Ecology and Society,* 21.

MINKLER, M., BLACKWELL, A. G., THOMPSON, M. & TAMIR, H. 2003. Community-based participatory research: implications for public health funding. *American journal of public health,* 93**,** 1210-1213.

MONTELLO, D. & SUTTON, P. 2006. *An introduction to scientific research methods in geography,* London, Sage Publications.

MORGAN, D. L. 1996. Focus groups. *Annual review of sociology***,** 129-152.

MOSER, S. 2008. Personality: a new positionality? *Area,* 40**,** 383-392.

MUSANTE, K. & DEWALT, B. R. 2010. *Participant observation: A guide for fieldworkers*, Rowman Altamira.

NELSON, D. R. 2011. Adaptation and resilience: responding to a changing climate. *Wiley Interdisciplinary Reviews: Climate Change,* 2**,** 113-120.

O'TOOLE, T. P., AARON, K. F., CHIN, M. H., HOROWITZ, C. & TYSON, F. 2003. Community-based Participatory Research. *Journal of general internal medicine,* 18**,** 592-594.

O'BRIEN, K. 2012. Global environmental change II From adaptation to deliberate transformation. *Progress in Human Geography,* 36**,** 667-676.

O'BRIEN, K., LEICHENKO, R., KELKAR, U., VENEMA, H., AANDAHL, G., TOMPKINS, H., JAVED, A., BHADWAL, S., BARG, S. & NYGAARD, L. 2004. Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global environmental change,* 14**,** 303-313.

OSBAHR, H., TWYMAN, C., ADGER, W. & THOMAS, D. 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society,* 15.

OSTROM, E. 1990. *Governing the commons: The evolution of institutions for collective action,* New York, Cambridge University Press.

OSTROM, E. 2014. Collective action and the evolution of social norms. *Journal of Natural Resources Policy Research,* 6**,** 235-252.

OSTROM, O. 2005. Understanding institutional diversity. *Princeton: Princeton University Press,* 17**,** 8.

PAIN, R. 2004. Social geography: participatory research. *Progress in human geography,* 28**,** 652.

PATTON, M. Q. 1999. Enhancing the quality and credibility of qualitative analysis. *Health services research,* 34**,** 1189.

PELLING, M. 2011. *Adaptation to climate change: from resilience to transformation,* London and New York, Routledge.

PETRESCU, D., PETCOU, C. & BAIBARAC, C. 2016. Co-producing commons-based resilience: lessons from R-Urban. *Building Research & Information,* 44**,** 717-736.

PIGGOTT-MCKELLAR, A. E., MCNAMARA, K. E., NUNN, P. D. & WATSON, J. E. 2019. What are the barriers to successful community-based climate change adaptation? A review of grey literature. *Local Environment,* 24**,** 374-390.

REDMAN, C. 2014. Should sustainability and resilience be combined or remain distinct pursuits? *Ecology and Society,* 19.

REYER, C. P., BROUWERS, N., RAMMIG, A., BROOK, B. W., EPILA, J., GRANT, R. F., HOLMGREN, M., LANGERWISCH, F., LEUZINGER, S. & LUCHT, W. 2015. Forest resilience and tipping points at different spatio-temporal scales: approaches and challenges. *Journal of Ecology,* 103**,** 5-15.

RITCHIE, D. A. 2014. *Doing oral history,* New York, Oxford University Press.

RIVAL, L. 2009. The resilience of indigenous intelligence. *In:* HASTRUP, K. (ed.) *The question of resilience: social responser to climate change.* Copenhagen: The Royal Danish Academy of Sciences and Letters.

ROSE, G. 1997. Situating knowledges: positionality, reflexivities and other tactics. *Progress in human geography,* 21**,** 305-320.

SCHIPPER, E. L. F., AYERS, J., REID, H., HUQ, S. & RAHMAN, A. (eds.) 2014. *Community-based adaptation to climate change: scaling it up,* London: Routledge.

SMITH, A. & STIRLING, A. 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society,* 15.

SOFAER, S. 2002. Qualitative research methods. *International Journal for Quality in Health Care,Oxford Journals,* 14**,** 329–336.

STOJANOVIC, T., MCNAE, H. M., TETT, P., POTTS, T. W., REIS, J., SMITH, H. D. & DILLINGHAM, I. 2016. The "social" aspect of social-ecological systems: a critique of analytical frameworks and findings from a multisite study of coastal sustainability. *Ecology and Society,* 21.

STOKOLS, D., LEJANO, R. & HIPP, J. 2013. Enhancing the resilience of human–environment systems: A social ecological perspective. *Ecology and Society,* 18.

STRAUSS, A. & CORBIN, J. 1990. *Basic of Grounded Theory Methods,* Thousand Oaks, CA: Sage.

STRAUSS, A. L. 1987. *Qualitative analysis for social scientists,* Cambridge, NY, Cambridge University Press.

TALEB, N. N. 2012. *Antifragile: Things that gain from disorder,* New York, Random House Incorporated.

TANNER, T., LEWIS, D., WRATHALL, D., BRONEN, R., CRADOCK-HENRY, N., HUQ, S., LAWLESS, C., NAWROTZKI, R., PRASAD, V. & RAHMAN, M. A. 2015. Livelihood resilience in the face of climate change. *Nature Climate Change,* 5**,** 23-26.

TAYLOR, G. & BLAKE, B. J. 2015. Key informant interviews and focus groups. *In:* CHESNAY, M. D. (ed.) *Nursing research using data analysis: Qualitative designs and methods in nursing.* NY: Springer.

TURNER II, B. 2010. Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science? *Global Environmental Change,* 20**,** 570-576.

TURNER, S. & COEN, S. E. 2008. Member checking in human geography: interpreting divergent understandings of performativity in a student space. *Area,* 40**,** 184-193.

VAISMORADI, M., JONES, J., TURUNEN, H. & SNELGROVE, S. 2016. Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice,* 6**,** 100-110.

VAN NES, E. H., ARANI, B. M., STAAL, A., VAN DER BOLT, B., FLORES, B. M., BATHIANY, S. & SCHEFFER, M. 2016. What Do You Mean,'Tipping Point'? *Trends in Ecology & Evolution,* 31**,** 902-904.

VISWANATHAN, M., AMMERMAN, A., ENG, E., GARLEHNER, G., LOHR, K. N., GRIFFITH, D., RHODES, S., SAMUEL-HODGE, C., MATY, S. & LUX, L. 2004. Community-based participatory research: Assessing the evidence: Summary. Evidence-based practice center, north-Carolina.

WALKER, B. & SALT, D. 2006. *Resilience thinking: sustaining ecosystems and people in a changing world,* Washington, DC, Island Press.

WALLERSTEIN, N. B. & DURAN, B. 2006. Using community-based participatory research to address health disparities. *Health promotion practice,* 7**,** 312-323.

WESTLEY, F., OLSSON, P., FOLKE, C., HOMER-DIXON, T., VREDENBURG, H., LOORBACH, D., THOMPSON, J., NILSSON, M., LAMBIN, E. & SENDZIMIR, J. 2011. Tipping toward sustainability: emerging pathways of transformation. *AMBIO: A Journal of the Human Environment,* 40**,** 762-780.

YAHYA SALIMI, Y., SHAHANDEH, K., MALEKAFZALI, H., LOORI, N., KHEILTASH, A., JAMSHIDI, E., FROUZAN, A. S. & MAJDZADEH, R. 2012. Is Community-based Participatory Research (CBPR) Useful? A Systematic Review on Papers in a Decade. *International Journal of Preventive Medicine,* 3**,** 386–393.

YAMANE, A. Rethinking vulnerability to climate change in Sri Lanka. 9th International conference on Sri Lanka Studies, 28th–30th November, 2003.

YIN, R. K. 2014. *Case study research: Design and methods,* New York, Sage publications.

YOW, V. R. 2014. *Recording oral history: A guide for the humanities and social sciences,* New York, Rowman & Littlefield.

ZIKMUND, W. G. 2003. *Business research methods,* New Delhi, South-western cengage learning.

Preface to Chapter 3

The lack of robust conceptual tools for evaluating community adaptations to climate change limits the effective development of adaptation policy. This is an explicit research gap in climate adaptation research in general and it is even more important in the context of Indigenous fisheries due to their high dependence on fish for food security. Chapter 3 situates the thesis within the growing need for a conceptually robust and widely applicable (place-specific) approach to assessing the community adaptation process in the fisheries context. It also provides an essential theoretical foundation for the thesis and serves the purpose of a literature review. I developed this framework based on the integration of various conceptual elements related to the theoretical areas of social-ecological systems resilience and development resilience. I then use this framework throughout the thesis in the forthcoming empirical and comparative analysis chapter(s).

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Chapter 3. A framework for assessing community adaptation to climate change in a fisheries context

Abstract

There is a rapidly growing body of scholarship on climate change adaptation in diverse contexts globally. Despite this, climate adaptation at the community level has not received adequate conceptual attention, and a limited number of analytical frameworks are available for assessing place-specific adaptations, particularly in a fisheries context. We use conceptual material from social-ecological systems (SES) resilience *and* human development resilience to build an integrated framework for evaluating community adaptations to climate change in a fisheries setting. The framework defines resilience as the combined result of coping, adapting, and transforming—recognizing resilience as a system's capacity and as a process. This understanding of resilience integrates with the three development resilience concepts of resistance, rootedness, and resourcefulness to develop 'place-based elements' which refer to collective action, institutions, agency, and Indigenous and local knowledge systems. The proposed framework can capture a local setting's place-specific attributes relating to the well-being of individuals, households, and communities, and the through integration of SES and human development conceptualizations addresses some of the key critiques of the notion of resilience. We have proposed this framework for application in context-specific environments—including fisheries—as a means of assessing community adaptations.

3.1 Introduction

Fisheries and associated activities support millions of livelihoods and contribute to the creation of food security and to the wellbeing of coastal, freshwater systems and beyond. More than 400 million people globally, for example, critically depend on fish for their food security (Seggel and De Young, 2016), and fisheries alone supply three billion people with almost 20 percent of their average [per] capita intake of animal protein (IPCC, 2014a: 452). Globally, more than 850 million people live within 100 km of the coast and are being impacted by changing coastal systems (IPCC, 2014b). Fisheries-dependent communities are distinct environments that maintain unique activities, cultures, and governance structures to face environmental and climate change (Adger, 2016). People have always taken autonomous actions to adapt to change (Parry et al., 1998). The meaning of the term "adaptation" in the context of climate change has evolved over the past decade (Pielke et al., 2007), and adaptation research has grown rapidly with the idea that extensive preparedness is needed to manage climate-related risks, especially with respect to vulnerable fishing populations (Moss et al., 2013).

Combined with other factors that have already had profound consequences on socio-economically vulnerable populations (Béné et al., 2016b), climate change impacts affect communities in an integrated fashion, increase the complexity of efforts to identify and understand adaptation (Ford et al., 2006, Ford et al., 2016d). Research has recently focused attention on the study of vulnerable human societies (for example, small-scale fisheries) in a global environmental change setting, using advancements in resilience thinking, development studies, and vulnerability apporaches, and drawing upon interdisciplinary approaches (Ford et al., In Press). The concepts of climate change adaptation and resilience are becoming core concerns in international development with many donors advocating for the mainstreaming of climate change adaptation and resilience into development policy (Ayers et al., 2014, Brown, 2016, Sherman et al., 2016).

According to the IPCC fifth assessment report (2014a: 390), few frameworks are available for assessing the characteristics of community adaptation to climate change in terms of identifying which adaptations are needed and assessing the effectiveness of potential adaptation options. The lack of a conceptual framework for assessing community adaptation to climate change limits our ability to systematically analyse cases, build theory, upscale adaptations to the policy level, and answer practical questions including: How can local adaptation initiatives be designed such that they are effective and appropriate in different contexts? What enables or undermines the effectiveness of community adaptations? How can community adaptations effectively link with government policy to address national adaptation plans?

This paper seeks to fill this gap in the literature, developing a conceptual framework for examining community adaptations to social-ecological change with a focus on small-scale fisheries. Specifically, the paper examines how the integration of resilience thinking and development studies could create a better understanding of the implications of social-ecological change and policy development. The paper begins by examining what resilience is and states the two domains used to conceptualize this framework (SES and development studies), and then illustrated the conceptual framework, including definitions of the conceptual elements, characteristics of the framework, and indicators to evaluate community adaptation. Finally, the paper uses multiple case studies to illustrate applications of proposed framework.

3.2 Notion of resilience and two domains

This paper understands resilience as the combined result of coping, adapting, and transforming in response to a disturbance/change (Béné et al., 2012, 2014, 2016c). We conceptualise resilience as a function of coping capacity, adaptive capacity, and transformative capacity. The concept of resilience developed independently in diverse fields, such as psychology, engineering, disaster response, and systems ecology; these different applications provide various meanings for the term ‘resilience’ (Baggio et al., 2015, Brown, 2016) (table 3.1). According to Folke (2016: 2), “in resilience thinking, adaptation refers to human actions that sustain development on current pathways.” A resilience approach takes advantage of disturbances (or changes) and uses them as opportunities to do “new things, for innovation, and for development” (Folke, 2006: 253). For greater clarity, scientists have proposed the term “social-ecological resilience” (Folke, 2006, Brand and Jax, 2007). In the social-ecological systems (SES) domain (what we refer to as the first domain in this paper), resilience is a system’s capacity to continually change and adapt while remaining within the same critical thresholds (Berkes and Ross, 2013).

Table 3.1: Various definitions of the term ‘resilience’.

Definition	Key emphasis	Reference
“The capacity of people to learn, share and make use of their knowledge of social and ecological interactions and feedbacks, to deliberately and effectively engage in shaping adaptive or transformative social-ecological change.”	The capacity to face SES change.	(Arctic Council, 2016: 8)
“The capacity of individuals, communities, and systems to survive, adapt, and grow in the face of stress and shocks, and even transform when conditions require it.”	The capacity to face stress and shocks.	(Brown, 2016: 10)
“Resilience is about cultivating the capacity to sustain development in the face of expected and surprising change and diverse pathways of development and potential thresholds between them.”	Cultivating the capacity to sustain development.	(Folke, 2016: 1)
“The capacity of a SES to absorb disturbance and	The system’s property and ability	(Walker et al.,

reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks. In other words, stay in the same basin of attraction."	to withstand shocks and rebuild itself.	2004: 6)

As Berkes and Ross (2016: 186) note, "the original idea of ecological resilience (Holling, 1973) is derived from complex adaptive systems thinking." An understanding of "complex adaptive SES" helps one better appreciate resilience as a systems property or an emergent property of a system (Berkes and Ross, 2016). According to Brand and Jax (2007), however, tension exists between the initially defined concept of resilience in ecological literature (the system's ability to bounce back or return to equilibrium following disturbance) and the more recent notion of SES resilience. In contrast, Holling's (1973) view of resilience says little about returning to the original state, assuming a constant range of change (Folke et al., 2010, Berkes and Ross, 2013: 6). Holling's (1973) proposes that ecological systems' behavior stems from the interplay between two different system properties: stability and resilience. "[…] there is another property, termed resilience, that is a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973: 14).

Increasingly, many scholars have identified capacity and agency as important components related to resilience definitions (Bohle et al., 2009, Brown and Westaway, 2011, Robinson and Berkes, 2011, Coulthard, 2012, Béné et al., 2014, Brown, 2016). Agency is a central component of SES resilience (Brown and Westaway, 2011). According to Brown (2016: 6), "resilience is understood not only as a response to change but also as a strategy for building the capacity to deal with and shape the change" which is increasingly applied in both scientific and policy discourse. More recently, resilience thinking has been increasingly adopted by development studies (second domain) to address problems such as climate change, food security, natural disasters, political instability, and economic volatility (Béné et al., 2014, Bahadur et al., 2015, 2016, Bousquet et al., 2016, Brown, 2016, Jeans et al., 2017). Scientists provide reasons why such a collaboration between these two domains has been triggered and why this collaboration should persist (Bousquet et al., 2016). The proposed approach developed in this paper is a result of the integration of a wide range of conceptual elements from both domains of resilience, which are SES and development studies.

Baggio et al. (2015) identify resilience as not only a boundary object (Brand and Jax, 2007) but a bridging concept (Deppisch and Hasibovic, 2013), particularly in the SES field. Thus, the facilitation of discussions about the dynamics of complex systems could provide innovative theoretical and applied insights (Baggio et al., 2015). Brown (2012) though, questions the extent to which the relabeling of existing and conventional approaches such as resilience embraces true innovation. Nevertheless, Brand and Jax (2007) recognize that the redefinition of resilience (conceptual vagueness) could help foster communication across disciplines as well as between science and practice.

3.3 Conceptual framework for assessing community adaptations

The proposed framework integrates and advances the work primarily of two key international development scholars, who use the concept of resilience to study human development in the context of SES change. First, this framework uses Christophe Bene's three dimensions of resilience (3D), which considers resilience to be the combined result of coping, adapting, and transforming (Béné et al., 2014). Second, this framework uses Katrina Brown's 3Rs of resilience, which refers to resistance, rootedness, and resourcefulness (Brown, 2016). The framework's three key components are 3D, the 3Rs, and place-based elements (figure 3.1). (Please refer to table 3.2 for definitions of the conceptual framework.)

First, Bene et al. (2014) identified (absorptive) coping capacity, adaptive capacity, and transformative capacity as the three critical features of resilience—the three dimensions, or 3D. Resilience emerges as a combined result of 3D capacities, leading to persistence, incremental adjustments, or transformational responses, respectively (Béné et al., 2012, 2014, Bahadur et al., 2016). Adaptive capacity and transformative capacities are key emphases in social-ecological resilience literature (Folke, 2006, Folke et al., 2010, Béné et al., 2014). Bene et al. (2014), Bahadur et al. (2016), and Brown (2016) are explicit about coping capacity being a key aspect of resilience. Brown (2016) and Bahadur et al. (2016) also recognize three dimensions of resilience; this conceptualization has already been applied in a human development context (Jeans et al., 2017). Further, Bene explicitly discusses how resilience functions as a process in a human development setting (Béné et al., 2012). Second, Brown (2016) argues that a resilience-centered approach towards development studies might radically transform (bounce forward)—rather than "bounce back"—a version of resilience and responses to global problems (Folke, 2016). By combining individual agency with adaptive capacity and a systems perspective, she re-conceptualises a vision of resilience with the notion of "everyday forms of resilience" to contribute a new development agenda with three core components: resistance, rootedness, and resourcefulness (Brown, 2016) (Table 3.2). Third, this place-specific framework captures unique attributes of a local setting that relates to the well-being of individuals, households, and communities. The core of the adaptation process represents a network of four elements (collective action, institutions, agency, and Indigenous and local knowledge-ILK) derived from the 3Rs and related intimately to the notion of resilience. This paper calls such a network "place-based elements."

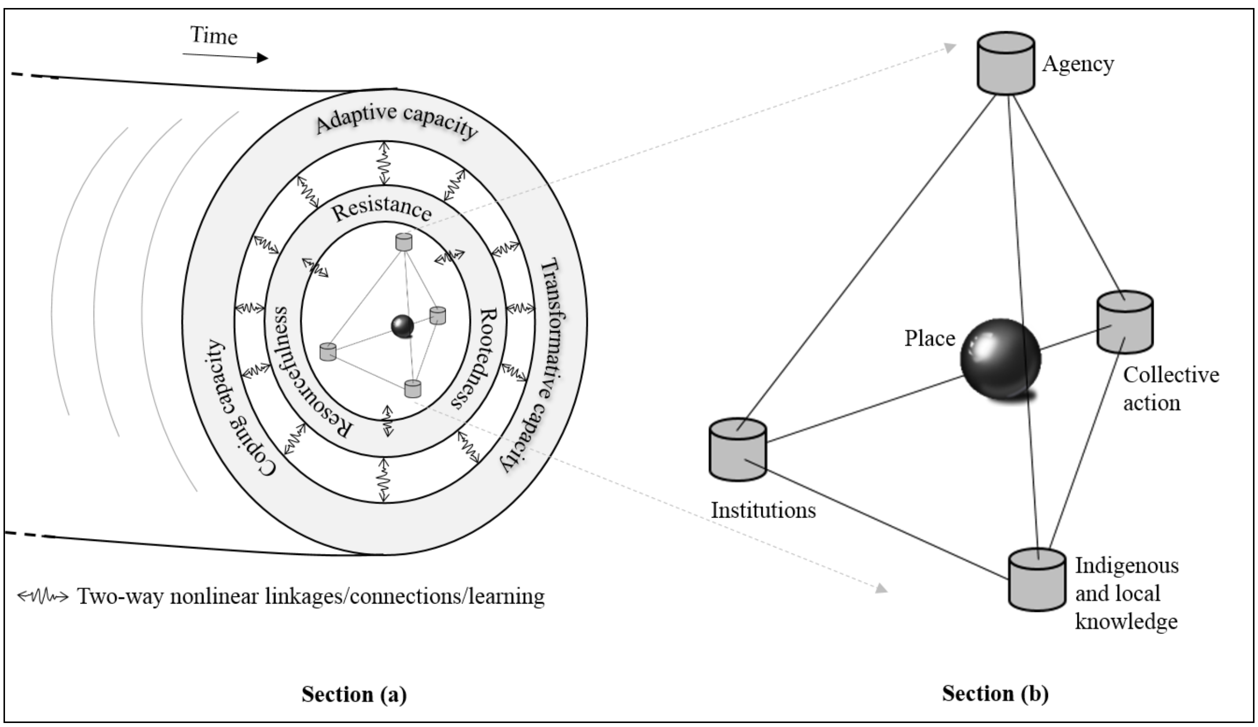

Figure 3.1: Conceptual framework (Building on Brown (2016) and Béné et al. (2014))

Section (a) shows a cross-section of the tube-shaped system that grows forward in the face of SES change (for example, climate change). The cross-section represents the framework's key components, which are place-based elements, 3Rs, and 3D capacities. All three components are connected through two-way nonlinear linkages. Section (b) illustrates the network of place-based elements located in the center of the framework. The zoomed-in version shows how such conceptual elements are positioned around the 'place.'

Place-based elements and the 3Rs constantly determine and cordinate the 3D capacities of resilience through multiple nonlinear linkages (connections) to face the social-ecological systems

(SES) change (Figure 3.1). This two-way link between 3Ds and 3Rs, as well as the network of place-based elements and the 3Rs, reflects their interdependence on each other. Such linkages represent three key aspects of the system. First, continuous learning from past events and slight failure (Taleb, 2012) returns to the place-based elements to improve their capacity—social-ecological learning (Berkes and Turner, 2006, Taleb, 2007, Taleb, 2012). Learning can take place within the network of place-based elements (for example, community institutions such as cooperatives). Also, such interactions can be negative and could disrupt learning (for example, the accumulation of vulnerability when community cooperatives are malfunctioning) (Galappaththi et al., 2016). Second, interconnectedness among such elements creates feedback across different levels and scales that change the dynamics and complexities of SES (Fischer et al., 2015, Homer-Dixon et al., 2015). This aspect includes an understanding of ecosystem processes and dynamics, and ecological knowledge helps tune human development with biosphere capacities (Folke, 2016). Third, together they trigger a self- or re-organization as a means of adapting to changing conditions (Berkes and Ross, 2016). For instance, a farmer-initiated zonal crop calendar system that manages small-scale shrimp aquaculture in Sri Lanka is an effective adaptation approach toward confronting the outbreak of shrimp diseases (Galappaththi and Berkes, 2015a, Galappaththi and Berkes, 2015b, Galappaththi et al., 2019a).

Table 3.2: Definitions of conceptual framework.

Components of the framework	Definition	Reference
Coping capacity	Coping capacity is actors' ability to draw on available skills, resources, and experiences as immediate responses for managing adverse stresses or shocks and maintaining persistence. Coping refers to a set of cognitive or behavioral strategies an individual or system uses to manage the demands of disturbances by using coping capacities.	(Lazarus, 1966, Martin-Breen and Anderies, 2011, Berman et al., 2012: 91, Béné et al., 2016b)
Adaptive capacity	Adaptive capacity is "the capacity to make adjustments and incremental changes in anticipation of or in response to change…" (Bahadur et al., 2016: 11). Adaptation can be planned, spontaneous, reactive, or anticipatory-driven; regardless, it is a manifestation of social adaptive capacity, as adaptive capacity consists of pre-conditions necessary for adaptation.	(Smit and Wandel, 2006, Bahadur et al., 2016, Brown, 2016, Simonovic, 2017)
Transformative capacity	Transformative capacity is a system's ability to create a new system with new fundamental characteristics when the existing system is untenable. Transformation, as Bahadur et al. (2016: 13) describe it, is the "radical action" of resilience that creates change in power structures and social and economic behaviors and that redefines drivers of risk and vulnerability regardless of specific shocks. Transformation goes beyond incremental	(Walker et al., 2004, Kofinas et al., 2013, Bahadur et al., 2016)

	adjustments that maintain the status quo; it brings more fundamental change to the social-ecological systems than does adaptation.	
Resistance	Brown (2016: 194) defines resistance as the "ability and capacity of people to withstand external forces and to shape their own strategies." Here, resistance indicates self-determination, strength, agency, and power. Brown establishes the direct linkages among resilience, agency, power, and resistance based on empirical evidence—resistance as power or the capacity to resist.	(Brown, 2016)
Rootedness	Rootedness recognizes the situated nature of resilience and the importance of culture and place, including the focus on identity and attachment. Rootedness is firmly associated with people, place, or space; cultural practices; social networks; and a wide range of affective ties to "home". Empirical evidence shows that attachment to place, and place-rooted identity, is a determinant of resilience, adaptation, and transformation.	(Devine-Wright, 2013, Lyon, 2014, Brown, 2016)
Resourcefulness	Resourcefulness is about the resources upon which people can draw and their capacity to use these resources at the right time and in the right way to harness the resources and human capacity together (Brown, 2016). This understanding emphasizes the ability to collectively deal with difficult situations that reflect human agency and capabilities, opportunities, and innovation. This framing links resourcefulness with a "sense of place being transformed into a resource in times of need" (Chamlee-Wright and Storr, 2009) and "is about bouncing back, adapting and transforming" (Brown, 2016: 198).	(Chamlee-Wright and Storr, 2009, Brown, 2016)
Collective action	Refers to action taken together by a group of two or more people to meet a common desired objective.	(Ostrom, 1990, 2014)
Institutions	Refers to local organizations formed by the society to facilitate collective action that meets a local goal (for example, community cooperatives and associations).	(Ostrom, 1990, Boyd and Folke, 2012, Galappaththi and Berkes, 2014)
Agency	A general understanding of agency is the individual's capacity to act independently in making his or her own decisions, while McLaughlin and Dietz (2008: 105) provide a more specific definition of agency as "capacity of individuals and corporate actors, with the diverse cultural meanings that they espouse, to play an independent casual role in history."	(McLaughlin and Dietz, 2008, Brown and Westaway, 2011)
Indigenous and local knowledge systems	Refers to the co-evolving cumulative body of knowledge (including observations, experience, lessons, and skills) belonging to a specific human-environment system (or place) and handed down through generations by cultural transmission; reflects Indigenous and/or local people's cultural identity.	(Berkes, 2012, Arctic Council, 2016)
Place	Refers to a social and physical space that has place attachments to individuals (or cultural groups) and processors. Attachment to the place is understood as the bonding that occurs between people and their meaningful environments [47]. The place is an essential consideration of the idea of rootedness.	(Giuliani, 2003, Scannell and Gifford, 2010, Brown, 2016)
Learning	Refers to the social learning, which itself refers to "collective action and reflection that occurs among different individuals and groups as they work to improve the management of human-environment interactions."	(Keen et al., 2005: 4)
Feedback	"The secondery effects of a direct effect of one variable on another, they cause a change in the magnitude of that effect. A positive feedback enhances the effect; a negative feedback diminishes it."	(Brown, 2016: 206)

We present the characteristics and indicators of the proposed conceptual framework to assess the ways in which communities adapt to change (table 3.3). Examination of such characteristics will allow for a better understanding of community adaptations as it broadly evaluates the effectiveness of the process of adaptation and its needs that are unique to a fisheries context using a range of place-based elements. Populations respond to change individually as well as collectively. In addition, the framework's characteristics work together as an interconnected SES. For instance, collective action, local institutions, and learning and knowledge systems are process integrated with respect to adaptation strategies, such as the implementation of community-based resource management systems in small-scale fisheries (Berkes, 2006). However, for evaluation purposes, we break down a system into analysable pieces. As shown in Table 3, the indicators and measures of each characteristic will allow for both quantitative and qualitative outcomes (for example, research findings, results, and recommendations) that feed adaptation policy to link community adaptations with government policies. Such outcomes will support the effective implementation of national adaptation plans and the development of community-sensitive adaptation programs.

Table 3.3: Characteristics of the framework for assessing adaptation to change

Characteristic	Measures and indicators	Key methods	References
Place	Measured by recognising related context-specific data, such as natural capital, vulnerability, and meaningful attachments to the place. Indicators: 1) number of species available for fishing, 2) level of fishery resource availability, 3) level of vulnerabilities for fishing operations such as climatic uncertainties, 4) changes in livelihood activities relative to place (for example, hunting to fishing), and 5) culture, including belief systems and perceptions that link to the place.	Participant observation, interviews	(Mayunga, 2007); (Adger et al., 2005b); (Folke et al., 2016); (Fernández-Llamazares et al., 2017); (De Silva et al., 2007, Knapp and Trainor, 2013); (Bennett, 2005)
Human agency	Measured using fishers' individual ownership/access to resources, application of diversity as a strategy, and use of technology. Indicators: 1) ownership of or access to fishing gear (for example, number of assets such as boats, canoes, nets, engines), 2) fishing gear diversity (number of different items of fishing gear used), 3) occupational mobility (number of different fishing operations practiced), 4) occupational multiplicity (total number of jobs in the household), 5) access to credit (loans) and insurance, 6) use of technological advancements, and 7) perceptions, equality, and gender roles.	Questionnaire/ survey, participant observation	(Cinner et al., 2015);(Bene, 2009, Selim et al., 2016); (FAO, 2015, McClanahan et al., 2015, Oviedo and Bursztyn, 2016, Koralagama et al., 2017, Shyam et al., 2017, Cinner et al., 2018b)
Collective action and collaboration	Measured by examining the level of sharing resources, information, and social networks. Indicators: 1) sharing of fish, 2) sharing of fishing gear, 3) spreading of weather information, 4) sharing of information related to fishing	Participant observation, interviews	(Ostrom, 1990); (Cox et al., 2010); (Galappaththi and Berkes, 2015a); (Galappaththi et al., 2016)

	operations (for example, fish market prices, production quotas, and fishing techniques/management practices), and 5) social networks. Application of Ostrom's design principles (Ostrom, 1990) allows for further assessment.		
Institutions	Measured by examining local institutions such as fishers' cooperatives, fish plants, and other local institutions support local fisheries. Indicators: 1) the aim of institutions (for example, contribution to local fishing activities), 2) ownership (for example, communal, local/Indigenous, private), 3) decision-making power, 4) existence of partnerships, and 5) leadership and influential individuals.	Key informant interviews, observations, secondary data	(Boyd and Folke, 2012); (Munoz et al., 2015); (Ostrom, 1990, Berkes and Armitage, 2010, Berman et al., 2012, Boyd and Folke, 2012, Galappaththi and Berkes, 2014, Cinner et al., 2018b)
Indigenous and local knowledge systems	Measured examining the use of Indigenous and/or local knowledge in fisheries SES. Indicators: 1) application of such knowledge, 2) the co-production of knowledge (combining Indigenous knowledge with other kinds of knowledge such as local knowledge and/or traditional knowledge), and 3) loss of local/Indigenous/traditional knowledge throughout the SES change.	Interviews, observations	(Berkes, 2012); (Lebel, 2013, Danielsen et al., 2014, McPherson et al., 2016, Fernández-Llamazares et al., 2017); (Manseau et al., 2005, Nakashima et al., 2012a, Reedy et al., 2014, Pearce et al., 2015)
Learning and feedback	Measured examining the aspects related to learning-by-doing, opportunities to learning, linkages, and philosophical worldviews. Indicators: 1) extent of the practice of learning-by-doing in fishing way of life, 2) the number of opportunities for learning, 3) the ways in which local philosophical worldviews are compatible with adaptive thinking, and 4) existence of two-way local and government linkages within the multi-level institutional structure.	Interviews, observations, secondary data	(Kelman et al., 2016, Cinner et al., 2018b); (Armitage et al., 2011)

The changing conditions in place-based elements can influence the 3D capacities, and vice versa, which may itself influence the SES options of persistent incremental adjustments or transformational responses. This interconnectedness implies that such elements have the ability to control or partly govern the trajectories (human development or SES) under complex and dynamic human-environment conditions. Both 3D capacities and the 3Rs—including place-based elements—together determine system trajectories (figure 3.2). For instance, with the impacts of climate change, it is important to examine the adaptations of remote Arctic communities, as each community has unique conditions such as natural environment, capacities (local institutions, knowledge systems, Inuit skills), resources (multiple species for food), vulnerabilities (changes in sea ice conditions), and government policies affecting those communities (Arctic Council, 2016). An integrated framework will provide useful inputs for adaptation policy for decision making, as it captures insights related to resilience thinking as well as development studies. The practices of coping, adapting, or transforming—depending on the selected SES—are adaptation policy options to consider at various levels, from household to global.

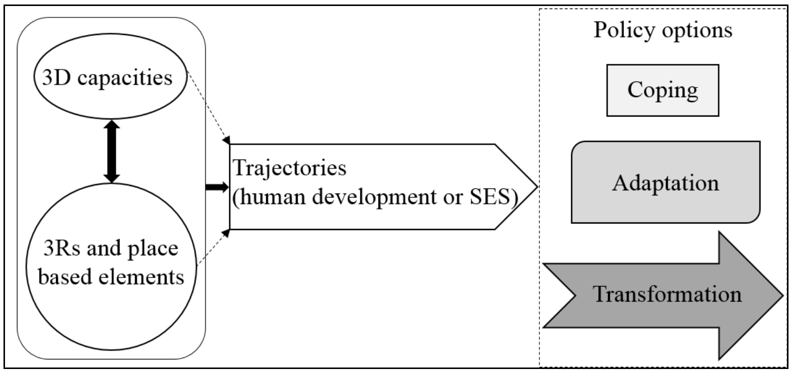

Figure 3.2: Trajectories and policy options

The suggested conceptual framework supports the assessment of climate adaptation and policy development for a few key reasons. First, the policy directly manages humans, not the climate, environment, or natural resources. Thus, human development aspects are key to assessing environment and climate adaptation policies. Second, some irreducible uncertainty always exists in any policy-level decision-making context. Thus, it is not advisable to assess policy goals using stability-oriented assumptions rather than resilience-oriented approaches (Brown, 2016). Third, the widespread availability of information and technological advancements makes people overconfident about their future adaptations and leads them to disregard vital aspects required in policies (Folke, 2016). Place-based considerations are among these missing aspects of the effective evaluation of adaptations, particularly in complex and highly uncertain SES such as fisheries.

The novelty of the approach lies in the use of resilience thinking and systemic perspectives to examine community adaptations aimed at a fisheries setting, and the integration of development and SES resilience domains, which collectviely addresses some of the prevailing key critiques in the notion of resilience. Multiple critiques of resilience are available in various disciplines, including development studies (Béné et al., 2014, Béné et al., 2016c, Brown, 2016), and table 3.4

illustrates how the proposed integration of development and SES domains addresses some of these critiques.

Table 3.4: Addressing key critiques of resilience thinking using the proposed framework

Key critiques of resilience thinking	How integration (3D-Rs) addresses these critiques
Field is dominated by a small network of scholars—"discursive dominance."	The framework is a combination of two schools of thought: resilience thinking and development studies (Bousquet et al., 2016). This integration will enable the connections between the two domains to meet challenges related to food security, poverty, and environment and human health. Resilience is already considered both a boundary and a bridging object (Baggio et al., 2015). This conceptual vagueness allows resilience to blend across disciplines and create more useful frameworks for human development (Strunz, 2012).
Fails to account for power, politics, and agency.	The central idea of 3D framing is capacity. Resourcefulness refers to the use of such capacities with the human agency to govern resources. Rootedness refers to the power of place and identity and the strengths associated with local knowledge. Power-related aspects can be explicitly examined by including resistance as an element of resilience. Power, politics, and agency are central to the suggested 3D-R integrated framework (Béné et al., 2014, Brown, 2016).
Vague and normative; for example, resilience is considered an antonym of vulnerability. A large body of literature does not clearly distinguish resilience and adaptive capacity.	In our framing, resilience is not seen as an "outcome" but as a "capacity" surrounded by agency and power that reflects the "ability" of humans to make decisions involving positive or negative outcomes in their own lives. First, this human "ability" creates the critical distinction between resilience and vulnerability. Bene et al. (2016c: 125) describe vulnerability "as a passive condition that results from people's sensitivity and exposure to shocks and their lack of capacity that prevents them from managing adverse events" and state that "resilience is an active ability to develop and implement strategies/responses in an attempt to counter these vulnerability conditions." Thus, resilience is not merely the inverse of vulnerability. Second, this integrated framework of resilience reflects adaptive capacity as one important element of resilience among many others—explicitly distinguishing adaptive capacity from resilience.
Focus on maintaining the status quo.	Resilience as conceptualized in the framework involves coping (absorbing), adapting, and transforming, challenging the concept of resilience as only maintaining the status quo. In the new understanding, resilience reflects stability, flexibility, and transformational change. The status quo is only one aspect of resilience (bouncing-back version), and the suggested framework caters to a border response to global change aiming at transformational change (a bouncing-forward version of resilience).
A resilience approach underplays the internal or endogenous drivers and focuses on a system disturbed by external or exogenous drivers.	Agency, institutions, local knowledge, and collective action are place-based elements of the integrated framework. This network of elements, together with 3D capacities, can capture a broad range of endogenous and exogenous drivers that are important to the understanding of SES change, as well as to better contributing to human development.

3.4 Case study application of the framework

This section brings together different case study examples from Sri Lanka, Kenya, Bangladesh, India, South East Asia, and the Canadian Arctic to illustrate the applications of each framework characteristic (table 3.5). Case studies were purposively selected to best explain the particular characteristic.

Table 3.5: The extent to which cases address the proposed framework characteristics

Case	Description of methods			Key emphasis on the characteristics of the framework					
	Approach	Data collection methods	Analysis	Place	Human agency	Collective action and collaboration	Institutions	ILK systems	Learning and feedback
Sri Lanka (Galappaththi et al., 2019a)	Qualitative	Participant observations, interviews, focus groups	Content analysis, descriptive statistics, institutional mapping	√	X	√	√	√	X
Kenya (Cinner et al., 2015)	Quantitative	Household surveys, interviews	Statistical analysis, linear mixed models	X	√	X	X	X	X
Bangladesh (Ahmed et al., 2014)	Qualitative	Secondary data	Descriptive statistics, flow diagrams, content analysis	X	X	√	√	X	X
India (Coulthard, 2008)	Mixed	Interviews, focus groups, household surveys	Descriptive statistics, quotes, content analysis	√	√	X	√	√	X
South East Asia (Hiwasaki et al., 2014)	Qualitative	Workshops, focus groups	Observations, documentation, validation, and categorization	X	X	X	X	√	√
Canadian Arctic (Armitage et al., 2011)	Qualitative	Secondary data	Descriptive statistics, network diagrams, content analysis	X	X	X	√	√	√

3.4.1 Place

The case from northwestern Sri Lanka examines how shrimp farmers adapt to the challenges of shrimp disease and climate change by managing their lagoon system (Galappaththi, 2013, Galappaththi et al., 2019a). Using a qualitative narrative approach, this study captures how small-scale shrimp farmers collectively managed their brackish water source, which is a combined system of three lagoons (Puttalam, Mundel, and Chilaw) and a human-made canal named ‘Dutch canal’ that connects all three lagoons. Shrimp farmers rely on this common body of water to get salty water for shrimp farming ponds as well as to release used aquaculture water back into the lagoon system. This practice allows shrimp disease to spread throughout the lagoon system and shrimp farms. Changing climate impacts such as droughts, unusual monsoon patterns, and floods, as well as unexpected temperature fluctuations and changes in lagoon salinity, increase the complexities surrounding shrimp disease control. Thus, climate change becomes a threat to shrimp aquaculture management. This shrimp aquaculture is a small-scale, environmentally friendly operation (for example, protecting a mangrove forest) that does not move from place to place, unlike large-scale commercial operations. This study shows the importance of place to local livelihoods (i.e., shrimp disease spreading along the lagoon system) and place attachments (i.e., managing the lagoon system and protecting the environment) in adaptations to climate change.

3.4.2 Human agency

Cinner et al. (2015) study the changes in the adaptive capacity of Kenyan fishing communities. Using a qualitative approach, they examine the changes, over time, in nine indicators of communities' adaptive capacity with respect to climate-change-related change. Such indicators are: access to credit, occupational mobility, occupational multiplicity, social capital, material style of life, gear diversity, community infrastructure, trust, and human agency. For example, 'Access to credit' is measured according to whether the respondent feels they can access credit through formal institutions or informal means such as family and friends. 'Occupational mobility' is measured in terms of the respondent's experience with job changes, within the past five years, that led to an occupation they preferred (vertical occupational mobility). 'Occupational multiplicity' is the total number of jobs in the household. 'Social capital' is measured as the total number of community groups to which the respondent belongs. This study shows various capacities of individual fishers that help them build adaptive capacity at a community level to face the implications of change, including climate change.

3.4.3 Collective action and collaboration

The case from southwest Bangladesh examines collective action and collaborations surrounding community-based climate change adaptation strategies in integrated prawn-fish-rice farming (Ahmed et al., 2014). Using a qualitative approach, this study explores how prawn-fish-rice culture systems adapt to climate impacts such as floods, drought, sea-level rise, and sea surface temperature. Locals respond to climate change impacts using a bottom-up community-based adaptation approach that employs collective action and collaboration (for example, the promotion of livelihood diversification, floating vegetable gardens, and duck rearing through community-based organizations to increase community adaptive capacities). The translocation of prawn-fish-rice farming from coast to inland is another crucial adaptation strategy implemented using the community-based approach and collaborations among industry stakeholders. This study shows how collaborations and collective action surrounding community-based initiatives support climate adaptation in integrated prawn-fish-rice culture systems.

3.4.4 Institutions

The case from south India's Pulicat lagoon provides insights into how local fisheries institutions are involved in adaptations to environmental and climate change (Coulthard, 2008). Using mixed methods, this study illustrates how a village fisheries society coordinates the management of the lagoon system. The fishing society for the Pulicat lagoon reinforces the 'Padu' system, which regulates lagoon access for fishing and fishing methods. The Padu system gives priority to members of the fishing society in undertaking specific fishing activities in certain fishing spots in the lagoon (Lobe and Berkes, 2004). The Padu system is a context-specific resource management system in small-scale fisheries that helps address local culture and power dynamics, such as the caste system. The Padu system involves making and implementing community-level rules, and it requires majority consent (for example, a lottery system). Most recorded Padu systems in South Asia (for example, stake net fishery, Sri Lanka (Amarasinghe et al., 1997, Gunawardena and Steele, 2008); southern Tamil Nadu, India (Bavinck, 2001)) are managed by local institutions; such institutions play a significant role in managing livelihood vulnerability and adaptation to environmental and climate change (Coulthard, 2008).

3.4.5 Indigenous and local knowledge systems

The case from South East Asian small island communities examines the process of integrating local and Indigenous knowledge with science for climate change adaptation and disaster risk reduction (Hiwasaki et al., 2014). This study presents the process of combining local and Indigenous knowledge of climate change in coastal fishing communities in Indonesia, the Philippines, and Timor-Leste. This process includes observation, documentation, and validation with the participation of local people, and lets them select potential integration with scientific knowledge (for example, consideration of the sky and the environment as a means of predicting strong winds and high waves in Indonesian coastal communities). By promoting knowledge integration and the application of multiple knowledge, systems increase local and Indigenous people's resilience to climate change impacts and ability to adapt to the risk of disaster. For instance, selected local and Indigenous knowledge can be disseminated among policymakers to support high-level climate adaptation decision making. This study shows how different knowledge systems can collectively support adaptations to climate change impacts.

3.4.6 Learning and feedback

The case from the three Canadian Arctic coastal communities examines the role of knowledge co-production as a mechanism that enables learning and adapting (Armitage et al., 2011). Using a qualitative approach, this study draws on narwhal co-management in Arctic Bay, beluga co-management in Husky Lakes, and char co-management in the Western Arctic to understand how knowledge co-production enables learning and adaptation to change, including climate change. In the long term, knowledge co-production within a co-management context leads to positive social and ecological outcomes, while crises (or small errors) play an important role in catalyzing the production of knowledge necessary for implementing change. For instance, one of the policy implications of the char case study is to recognize crises as windows of opportunity for rethinking knowledge and the learning processes for adaptation. This study shows how learning at the community level and sharing such learnings with co-management institutions (i.e., feedback) can influence the long-term climate adaptation process.

Given the concise narratives of multiple case studies, the proposed framework can create additional insights into community adaptations (IPCC, 2014a). For instance, the framework provides insights into the situated nature of small-scale shrimp aquaculture in the Sri Lankan case study. Here, rootedness can refer to how firmly the shrimp farmers are associated with the lagoon system (place), the social value system (protect mangrove), the community-based institutions, and the maintenance of a wide range of ties to the community. In part, this rootedness allows the shrimp farmers to face and live with the changing climate and shrimp disease conditions. Resourcefulness provides insights into accessible natural resources in the community. For instance, in the Indian case study, and sharing fishing sites and fishing days using a rotational system in stake net fishery in Negombo estuary Sri Lanka (Amarasinghe et al.,

1997) manages fishers' access to lagoon fishing spots. These resource management systems are implemented by local institutions (i.e., the village fishing society) with the guidance of government institutions. Shrimp farmers' worldviews (for example, a belief in collective action), along with their capabilities (including local knowledge systems and institutions), are key to the sustainable management of fisheries resources. In the Kenyan case study, resistance provides insights into how fishers use nine human-agency-related capacities (for example, access to credit, occupational mobility, occupational multiplicity, and social capital) to withstand change and shape their strategies against vulnerabilities of climate change impacts. None of the selected cases can address the associated nature of framework characteristics (Table 3.5). Application of the proposed framework can provide additional insights into how such framework characteristics are interconnected for better outputs in terms of climate change adaptation.

Place-based elements and their insights into the 3Rs reflect systems' 3D capacities. This allows us to understand community adaptation pathways. For instance, in Kenyan fishing communities, reliance on short-term credit/loans to continue fishing helps individuals cope with short-term challenges. Bangladesh's prawn-fish-rice systems provide examples of such adaptations as livelihood diversification, floating vegetable gardens, and duck rearing to face climatic challenges like floods. The introduction of effective resource management systems such as the Padu system (India) or the translocation of prawn-fish-rice farming (Bangladesh) can make fundamental changes in these small-scale fisheries systems (transformation).

3.5 Discussion and conclusions

This paper proposes a conceptual framework for evaluating community adaptations to change, including climate change in a fisheries setting. This framework is built primarily on Bene's and Brown's work on development resilience. The notion of resilience is not a single concept, but rather a cluster of multifaceted concepts that are lightly organized and sometimes overlapping (Brand and Jax, 2007, Baggio et al., 2015). The paper uses this characteristic of resilience to develop an integrated framework that represents a wide range of conceptual elements from the domains of human development and resilience thinking. The paper recognizes resilience as a combined result of coping, adapting, and transforming aimed at three capacities (coping, adaptive, and transformative) of resilience—the three dimensions (3D) (Béné et al., 2014, Bahadur et al., 2016, Béné et al., 2016c, Brown, 2016). This understanding is different from the usual definition of resilience as stated by Walker et al. (2004: 6). However, building resilience requires the strengthening of these three components at multiple levels—coping (absorptive) resilience, adaptive resilience, and transformative resilience (Béné et al., 2012). Here, resilience is seen as a "capacity" of a system and as a process.

We proposed this framework for application in context-specific environments, including fisheries, to assess community adaptations to change. The purpose of the integrated framework is to create a better understanding of the SES change and assess adaptations for effective policy development. Basic characteristics of the integrated framework are: i) consists of 3D capacities, 3Rs, and place-based elements (Béné et al., 2012, Béné et al., 2016b, Brown, 2016); ii) pays attention to feedback and connections among capacities and place-based elements (Österblom et al., 2011); iii) recognises resilience as a process and not an outcome (Béné et al., 2014); and iv) is concerned with trajectories of change that eventually lead to policy development (Bousquet et al., 2016). The strengths of this framework are: a) flexibility and adaptability for use in both SES resilience and human development domains to achieve specific (inter)disciplinary goals; b) addresses most of the prevailing critiques of the previous (bounce back) version of resilience, including conceptual aspects undermined in previous versions of resilience thinking (for example, power dynamics, politics, and agency); c) integrates two domains to open doors for collaboration across disciplines, such as resource governance, anthropology, development, vulnerability, and adaptation; and d) provides information for policy development for adaptive governance considering complex human-environment interactions, uncertainties, and processes. This framework can be further developed for specific applications, incorporating specifics related to levels, scale, and "desired state" (Cash et al., 2006, Beymer-Farris et al., 2012).

The proposed framework provided insights into three main areas of adaptation. First, how can local adaptation initiatives be designed (for example, collectively using the participatory approach) and facilitated (for example, through local institutions) so that they are effective and appropriate in unique community environments? Detailed consideration of place-based elements is critical for designing adaptation initiatives for communities (i.e., place, human agency, collective action and collaboration, institutions, Indigenous and local knowledge systems, and learning and feedback). Second, what enables (for example, social media and local institutions) and undermines (for example, loss of local knowledge or inappropriate technology) the effectiveness of community adaptations? Identification of enabling and undermining factors for adaptation initiatives is important for ensuring successful community adaptations (Osbahr et al., 2010, Ford and King, 2015). Third, how can community adaptations be effectively linked with government policy to address national adaptation plans? For instance, local institutions and their leadership play a central role in linking the community and the government. Overall, this proposed framework can create a link between concepts (such as resilience and adaptation) and real-world applications (such as the case examples from Sri Lanka/ Kenya/ Bangladesh/ India/ South East Asia/ the Canadian Arctic).

Why is this proposed integrated conceptual framework important to the advancement of adaptation research? First, a combination of various kinds of knowledge domains will improve adaptive capacity by increasing the range of information available for knowledge co-production (Folke et al., 2003, Tengö et al., 2017). The importance of fostering the complementarity of different knowledge systems is explicitly recognized as one of the key methods of building resilience (Folke et al., 2003). Second, as Folke (2016) argues, human-centered sustainable development actions can benefit from the guidance of development approaches (such as climate adaptation) that seek a better understanding of complex human-environment interactions. Third, collaboration is a timely approach for two selected reasons: 1) increasingly, in certain human development arenas, “use resilience as a unit of analysis” has become a condition for applying for project financing (Bousquet et al., 2016), and 2) collaboration has been triggered with conceptual developments that provide the intellectual tools required for effective integration (for example, 3D and the 3Rs) to create the timely atmosphere; conceptual elements missing from the SES literature are featured in the human development literature (Béné et al., 2016a, Béné et al., 2016c, Bousquet et al., 2016, Brown, 2016, Folke, 2016). Finally, essentially, this collaboration helps address aspects related to key critiques of resilience thinking.

3.6 References

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

ADGER, W. N., HUGHES, T. P., FOLKE, C., CARPENTER, S. R. & ROCKSTRÖM, J. 2005. Social-ecological resilience to coastal disasters. *Science,* 309**,** 1036-1039.

AHMED, N., BUNTING, S. W., RAHMAN, S. & GARFORTH, C. J. 2014. Community-based climate change adaptation strategies for integrated prawn–fish–rice farming in B angladesh to promote social–ecological resilience. *Reviews in Aquaculture,* 6**,** 20-35.

AMARASINGHE, U., CHANDRASEKARA, W. & KITHSIRI, H. 1997. Traditional practices for resource sharing in an artisanal fishery of a Sri Lankan estuary. *Asian Fisheries Science,* 9**,** 311-324.

ARCTIC COUNCIL 2016. Arctic Resilience Report, Arctic Council. *In:* CARSON, M. & PETERSON, G. (eds.). Stockholm: Stockholm Environment Institute and Stockholm Resilience Centre.

ARMITAGE, D., BERKES, F., DALE, A., KOCHO-SCHELLENBERG, E. & PATTON, E. 2011. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change,* 21**,** 995-1004.

AYERS, J. M., HUQ, S., FAISAL, A. M. & HUSSAIN, S. T. 2014. Mainstreaming climate change adaptation into development: a case study of Bangladesh. *Wiley Interdisciplinary Reviews: Climate Change,* 5**,** 37-51.

BAGGIO, J., BROWN, K. & HELLEBRANDT, D. 2015. Boundary object or bridging concept? A citation network analysis of resilience. *Ecology and Society,* 20**,** 2.

BAHADUR, A., LOVELL, E. & PICHON, F. 2016. Effectiveness in Building Resilience: Synthesis report for Oxfam's Resilience Outcome Area. Oxfarm International.

BAHADUR, A. V., PETERS, K., WILKINSON, E., PICHON, F., GRAY, K. & TANNER, T. 2015. The 3As: Tracking resilience across BRACED. *Working and Discussion Papers. London: Overseas Development Institute* 57.

BAVINCK, M. 2001. *Marine resource management: conflict and regulation in the fisheries of the Coromandel Coast, Livelihood and Environment Series 5,* New Delhi, Sage Publications.

BENE, C. 2009. Are fishers poor or vulnerable? Assessing economic vulnerability in small-scale fishing communities. *J. Dev. Stud.,* 45**,** 911-933.

BÉNÉ, C., AL-HASSAN, R. M., AMARASINGHE, O., FONG, P., OCRAN, J., ONUMAH, E., RATUNIATA, R., VAN TUYEN, T., MCGREGOR, J. A. & MILLS, D. J. 2016a. Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and Vietnam. *Global Environmental Change,* 38**,** 153-170.

BÉNÉ, C., ARTHUR, R., NORBURY, H., ALLISON, E. H., BEVERIDGE, M., BUSH, S., CAMPLING, L., LESCHEN, W., LITTLE, D. & SQUIRES, D. 2016b. Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Development,* 79**,** 177-196.

BÉNÉ, C., HEADEY, D., HADDAD, L. & VON GREBMER, K. 2016c. Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. *Food Security,* 8**,** 123-138.

BÉNÉ, C., NEWSHAM, A., DAVIES, M., ULRICHS, M. & GODFREY-WOOD, R. 2014. Review article: resilience, poverty and development. *Journal of International Development,* 26**,** 598-623.

BÉNÉ, C., WOOD, R. G., NEWSHAM, A. & DAVIES, M. 2012. Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. *IDS Working Papers,* 2012**,** 1-61.

BENNETT, E. 2005. Gender, fisheries and development. *Marine policy,* 29**,** 451-459.

BERKES, F. 2006. From community-based resource management to complex systems: the scale issue and marine commons. *Ecology and Society,* 11.

BERKES, F. 2012. *Sacred ecology,* New York, Routledge.

BERKES, F. & ARMITAGE, D. 2010. Co-management institutions, knowledge, and learning: Adapting to change in the Arctic. *Etudes/Inuit/Studies***,** 109-131.

BERKES, F. & ROSS, H. 2013. Community resilience: toward an integrated approach. *Society & Natural Resources,* 26**,** 5-20.

BERKES, F. & ROSS, H. 2016. Panarchy and community resilience: Sustainability science and policy implications. *Environmental Science & Policy,* 61**,** 185-193.

BERKES, F. & TURNER, N. J. 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology,* 34**,** 479.

BERMAN, R., QUINN, C. & PAAVOLA, J. 2012. The role of institutions in the transformation of coping capacity to sustainable adaptive capacity. *Environmental Development,* 2**,** 86-100.

BEYMER-FARRIS, B. A., BASSETT, T. J. & BRYCESON, I. 2012. Promises and pitfalls of adaptive management in resilience thinking: the lens of political ecology. *In:* PLIENINGER, T. & BIELING, C. (eds.) *Resilience and the cultural landscape.* Cambridge: Cambridge University Press.

BOHLE, H.-G., ETZOLD, B. & KECK, M. 2009. Resilience as agency. *IHDP Update,* 2**,** 8-13.

BOUSQUET, F., BOTTA, A., ALINOVI, L., BARRETEAU, O., BOSSIO, D., BROWN, K., CARON, P., D'ERRICO, M., DECLERCK, F. & DESSARD, H. 2016. Resilience and development: mobilizing for transformation. *Ecology and Society,* 21.

BOYD, E. & FOLKE, C. (eds.) 2012. *Adapting institutions: Governance, complexity and social-ecological resilience,* New York: Cambridge University Press.

BRAND, F. S. & JAX, K. 2007. Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and society,* 12**,** 23.

BROWN, K. 2012. 3 Policy discourses of resilience. *Climate Change and the Crisis of Capitalism: A Chance to Reclaim, Self, Society and Nature***,** 37.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

BROWN, K. & WESTAWAY, E. 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual review of environment and resources,* 36**,** 321-342.

CASH, D., ADGER, W. N., BERKES, F., GARDEN, P., LEBEL, L., OLSSON, P., PRITCHARD, L. & YOUNG, O. 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. *Ecology and society,* 11.

CHAMLEE-WRIGHT, E. & STORR, V. H. 2009. “There's no place like New Orleans”: Sense of place and community recovery in the Ninth Ward after Hurricane Katrina. *Journal of Urban Affairs,* 31**,** 615-634.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8**,** 117-123.

CINNER, J. E., HUCHERY, C., HICKS, C. C., DAW, T. M., MARSHALL, N., WAMUKOTA, A. & ALLISON, E. H. 2015. Changes in adaptive capacity of Kenyan fishing communities. *Nature Climate Change,* 5**,** 872-876.

COULTHARD, S. 2008. Adapting to environmental change in artisanal fisheries—Insights from a South Indian Lagoon. *Global Environmental Change,* 18**,** 479-489.

COULTHARD, S. 2012. Can we be both resilient and well, and what choices do people have? Incorporating agency into the resilience debate from a fisheries perspective. *Ecology and Society,* 17**,** 4.

COX, M., ARNOLD, G. & TOMÁS, S. V. 2010. A review of design principles for community-based natural resource management. *Ecology and Society,* 15**,** 38.

DANIELSEN, F., TOPP-JØRGENSEN, E., LEVERMANN, N., LØVSTRØM, P., SCHIØTZ, M., ENGHOFF, M. & JAKOBSEN, P. 2014. Counting what counts: Using local knowledge to improve Arctic resource management. *Polar Geography,* 37**,** 69-91.

DE SILVA, C., WEATHERHEAD, E., KNOX, J. W. & RODRIGUEZ-DIAZ, J. 2007. Predicting the impacts of climate change—A case study of paddy irrigation water requirements in Sri Lanka. *Agricultural Water Management,* 93**,** 19-29.

DEPPISCH, S. & HASIBOVIC, S. 2013. Social-ecological resilience thinking as a bridging concept in transdisciplinary research on climate-change adaptation. *Natural hazards,* 67**,** 117-127.

DEVINE-WRIGHT, P. 2013. Think global, act local? The relevance of place attachments and place identities in a climate changed world. *Global Environmental Change,* 23**,** 61-69.

FAO 2015. Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector, by Cecile Brugère and Cassandra De Young. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, Italy.

FERNÁNDEZ-LLAMAZARES, Á., GARCIA, R. A., DÍAZ-REVIRIEGO, I., CABEZA, M., PYHÄLÄ, A. & REYES-GARCÍA, V. 2017. An empirically tested overlap between Indigenous and scientific knowledge of a changing climate in Bolivian Amazonia. *Regional Environmental Change***,** 1-13.

FISCHER, J., GARDNER, T. A., BENNETT, E. M., BALVANERA, P., BIGGS, R., CARPENTER, S., DAW, T., FOLKE, C., HILL, R. & HUGHES, T. P. 2015. Advancing sustainability through mainstreaming a social–ecological systems perspective. *Current Opinion in Environmental Sustainability,* 14**,** 144-149.

FOLKE, C. 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change,* 16**,** 253-267.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

FOLKE, C., BIGGS, R., NORSTRÖM, A., REYERS, B. & ROCKSTRÖM, J. 2016. Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society,* 21.

FOLKE, C., CARPENTER, S. R., WALKER, B., SCHEFFER, M., CHAPIN, T. & ROCKSTROM, J. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society,* 15**,** 20.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FORD, J., PEARCE, T., MCDOWELL, G., BERRANG-FORD, L., SAYLES, J. & BELFER, E. In Press. Vulnerability and its discontents: The past, present, and future of climate change vulnerability research. *Climatic Change*.

FORD, J. D. & KING, D. 2015. A framework for examining adaptation readiness. *Mitigation and Adaptation Strategies for Global Change,* 20**,** 505-526.

FORD, J. D., SMIT, B. & WANDEL, J. 2006. Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. *Global Environmental Change,* 16**,** 145-160.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2016. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-195.

GALAPPATHTHI, E. 2013. *Community-based Shrimp Aquaculture in Northwestern Sri Lanka.* Master of Natural Resources Management , Winnipeg, University of Manitoba.

GALAPPATHTHI, E. & BERKES, F. 2015a. Drama of the commons in small-scale shrimp aquaculture in northwestern, Sri Lanka. *International Journal of the Commons,* 9**,** 347-368.

GALAPPATHTHI, E., BERKES, F. & FORD, J. In Press. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *FishAdapt: Global Conference on Climate Change Adaptation for Fisheries and Aquaculture.* Rome: FAO.

GALAPPATHTHI, E. K. & BERKES, F. 2014. Institutions for managing common-pool resources: the case of community-based shrimp aquaculture in northwestern Sri Lanka. *Maritime Studies,* 13**,** 1-16.

GALAPPATHTHI, E. K. & BERKES, F. 2015b. Can co-management emerge spontaneously? Collaborative management in Sri Lankan shrimp aquaculture. *Marine Policy,* 60**,** 1-8.

GALAPPATHTHI, E. K., KODITHUWAKKU, S. S. & GALAPPATHTHI, I. M. 2016. Can environment management integrate into supply chain management? Information sharing via shrimp aquaculture cooperatives in northwestern Sri Lanka. *Marine Policy,* 68**,** 187-194.

GIULIANI, M. V. 2003. Theory of attachment and place attachment. *In:* M. BONNES & T. LEE, M. B. (eds.) *Psychological theories for environmental issues* Aldershot: Ashgate.

GUNAWARDENA, A. & STEELE, P. 2008. The stake-net fishery association of Negombo lagoon, Sri Lanka: Why has it survived over 250 years and will it survive another 100 years. *In:* GHATE, R., JODHA, N. S. & MUKHOPADHYAY, P. (eds.) *Promise, trust and evolution: managing the commons of South Asia.* New York: Oxford University Press.

HIWASAKI, L., LUNA, E. & SHAW, R. 2014. Process for integrating local and Indigenous knowledge with science for hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities. *International journal of disaster risk reduction,* 10**,** 15-27.

HOLLING, C. S. 1973. Resilience and stability of ecological systems. *Annual review of ecology and systematics***,** 1-23.

HOMER-DIXON, T., WALKER, B., BIGGS, R., CRÉPIN, A.-S., FOLKE, C., LAMBIN, E., PETERSON, G., ROCKSTRÖM, J., SCHEFFER, M. & STEFFEN, W. 2015. Synchronous failure: the emerging causal architecture of global crisis. *Ecology and Society,* 20.

IPCC 2014a. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014b. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

JEANS, H., CASTILLO, G. E. & THOMAS, S. 2017. Absorb, Adapt, Transform: Resilience capacities. Oxford, UK: Oxfam International.

KEEN, M., BROWN, V. A. & DYBALL, R. 2005. Social Learning: A New Approach to Environmental Management. *In:* DYBALL, R., BROWN, V. A. & KEEN, M. (eds.) *Social Learning in Environmental Management.* London: Earthscan.

KELMAN, I., GAILLARD, J., LEWIS, J. & MERCER, J. 2016. Learning from the history of disaster vulnerability and resilience research and practice for climate change. *Natural Hazards,* 82**,** 129-143.

KNAPP, C. N. & TRAINOR, S. F. 2013. Adapting science to a warming world. *Global environmental change,* 23**,** 1296-1306.

KOFINAS, G., CLARK, D., HOVELSRUD, G., ALESSA, L., AMUNDSEN, H., BERMAN, M., BERKES, F., CHAPIN III, F., FORBES, B. & FORD, J. 2013. Adaptive and transformative capacity. *Arctic Council. Arctic Resilience Interim Report. Stockholm Environment Institute and Stockholm Resilience Centre. Stockholm***,** 71-91.

KORALAGAMA, D., GUPTA, J. & POUW, N. 2017. Inclusive development from a gender perspective in small scale fisheries. *Current Opinion in Environmental Sustainability,* 24**,** 1-6.

LAZARUS, R. S. 1966. *Psychological stress and the coping process,* New York, NY, US, McGraw-Hill.

LEBEL, L. 2013. Local knowledge and adaptation to climate change in natural resource-based societies of the Asia-Pacific. *Mitig. Adapt. Strateg. Glob. Change,* 18**,** 1057-1076.

LOBE, K. & BERKES, F. 2004. The padu system of community-based fisheries management: change and local institutional innovation in south India. *Marine Policy,* 28**,** 271-281.

LYON, C. 2014. Place systems and social resilience: A framework for understanding place in social adaptation, resilience, and transformation. *Society & Natural Resources,* 27**,** 1009-1023.

MANSEAU, M., PARLEE, B. & AYLES, B. 2005. A place for traditional ecological knowledge in resource management. *In:* BERKES, F., HUEBERT, R., HELEN, F. & MANSEAU, M., DIDUCK, ALAN (eds.) *Breaking Ice: Renewable resource and ocean management in the Canadian North.* Calgary, Alberta, Canada: Calgary University Press.

MARTIN-BREEN, P. & ANDERIES, J. M. 2011. Resilience: A literature review.

MAYUNGA, J. S. 2007. Understanding and applying the concept of community disaster resilience: a capital-based approach. *Summer academy for social vulnerability and resilience building, Munich, Germany,* 1**,** 16.

MCCLANAHAN, T., ALLISON, E. H. & CINNER, J. E. 2015. Managing fisheries for human and food security. *Fish and Fisheries,* 16**,** 78-103.

MCLAUGHLIN, P. & DIETZ, T. 2008. Structure, agency and environment: Toward an integrated perspective on vulnerability. *Global Environmental Change,* 18**,** 99-111.

MCPHERSON, J. M., SAMMY, J., SHEPPARD, D. J., MASON, J. J., BRICHIERI-COLOMBI, T. A. & MOEHRENSCHLAGER, A. 2016. Integrating traditional knowledge when it appears to conflict with conservation: lessons from the discovery and protection of sitatunga in Ghana. *Ecology and Society,* 21.

MOSS, R. H., MEEHL, G., LEMOS, M. C., SMITH, J., ARNOLD, J., ARNOTT, J., BEHAR, D., BRASSEUR, G. P., BROOMELL, S. & BUSALACCHI, A. 2013. Hell and high water: practice-relevant adaptation science. *Science,* 342**,** 696-698.

MUNOZ, S.-A., STEINER, A. & FARMER, J. 2015. Processes of community-led social enterprise development: learning from the rural context. *Community Development Journal,* 50**,** 478-493.

NAKASHIMA, D., GALLOWAY MCLEAN, K. G., THULSTRUP, H., RAMOS CASTILLO, A. & RUBIS, J. T. 2012. Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation.

OSBAHR, H., TWYMAN, C., ADGER, W. & THOMAS, D. 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society,* 15.

ÖSTERBLOM, H., SISSENWINE, M., SYMES, D., KADIN, M., DAW, T. & FOLKE, C. 2011. Incentives, social–ecological feedbacks and European fisheries. *Marine Policy,* 35**,** 568-574.

OSTROM, E. 1990. *Governing the commons: The evolution of institutions for collective action,* New York, Cambridge University Press.

OSTROM, E. 2014. Collective action and the evolution of social norms. *Journal of Natural Resources Policy Research,* 6**,** 235-252.

OVIEDO, A. F. & BURSZTYN, M. 2016. The Fortune of the Commons: Participatory Evaluation of Small-Scale Fisheries in the Brazilian Amazon. *Environmental management,* 57**,** 1009-1023.

PARRY, M., ARNELL, N., HULME, M., NICHOLLS, R. & LIVERMORE, M. 1998. Adapting to the inevitable. *Nature,* 395**,** 741-741.

PEARCE, T., FORD, J., WILLOX, A. C. & SMIT, B. 2015. Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic,* 68**,** 233.

PIELKE, R., PRINS, G., RAYNER, S. & SAREWITZ, D. 2007. Climate change 2007: lifting the taboo on adaptation. *Nature,* 445**,** 597-598.

REEDY, D., SAVO, V. & MCCLATCHEY, W. 2014. Traditional Climatic Knowledge: Orchardists' perceptions of and adaptation to climate change in the Campania region (Southern Italy). *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology,* 148**,** 699-712.

ROBINSON, L. W. & BERKES, F. 2011. Multi-level participation for building adaptive capacity: Formal agency-community interactions in northern Kenya. *Global Environmental Change,* 21**,** 1185-1194.

SCANNELL, L. & GIFFORD, R. 2010. Defining place attachment: A tripartite organizing framework. *Journal of environmental psychology,* 30**,** 1-10.

SEGGEL, A. & DE YOUNG, C. 2016. Climate change implications for fisheries and aquaculture: summery of the findings of the Intergovernmental Panal on Climate Change fifth assessment report. *FAO Fisheries and aquaculture technical paper.* Rome: Food and Agriculture Organization of the United Nations.

SELIM, S. A., BLANCHARD, J. L., BEDFORD, J. & WEBB, T. J. 2016. Direct and indirect effects of climate and fishing on changes in coastal ecosystem services: a historical perspective from the North Sea. *Regional Environmental Change,* 16**,** 341-351.

SHERMAN, M., BERRANG-FORD, L., LWASA, S., FORD, J., NAMANYA, D. B., LLANOS-CUENTAS, A., MAILLET, M. & HARPER, S. 2016. Drawing the line between adaptation and development: a systematic literature review of planned adaptation in developing countries. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 707-726.

SHYAM, S. S., SHRIDHAR, N. & FERNANDEZ, R. 2017. Climate change and need for proactive policy initiatives in Indian marine fisheries sector. *Climate Change,* 3**,** 20-37.

SIMONOVIC, S. P. 2017. Adaptation to climate change: risk management. *In:* KOLOKYTHA, E., OISHI, S. & TEEGAVARAPU, R. S. V. (eds.) *Sustainable Water Resources Planning and Management Under Climate Change.* Singapore: Springer.

SMIT, B. & WANDEL, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global environmental change,* 16**,** 282-292.

STRUNZ, S. 2012. Is conceptual vagueness an asset? Arguments from philosophy of science applied to the concept of resilience. *Ecological Economics,* 76**,** 112-118.

TALEB, N. N. 2007. *The black swan: The impact of the highly improbable,* US, Random House.

TALEB, N. N. 2012. *Antifragile: Things that gain from disorder,* New York, Random House Incorporated.

TENGÖ, M., HILL, R., MALMER, P., RAYMOND, C. M., SPIERENBURG, M., DANIELSEN, F., ELMQVIST, T. & FOLKE, C. 2017. Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. *Current Opinion in Environmental Sustainability,* 26**,** 17-25.

WALKER, B., HOLLING, C. S., CARPENTER, S. R. & KINZIG, A. 2004. Resilience, adaptability and transformability in social--ecological systems. *Ecology and society,* 9**,** 5.

Preface to Chapter 4

In the literature, the examination of climate adaptation in Indigenous fisheries is limited mostly to tropical coastal communities. In Chapter 3 of this thesis, I proposed a conceptual framework for assessing community adaptation to climate change in a fisheries context. Chapter 4 uses the conceptual framework to assess the climate adaptation practices of an Inuit fishing community in the Canadian Arctic to examine the ways in which Inuit experience and respond to climate change impacts. This empirical chapter is based on intensive fieldwork in the Canadian Arctic over the last three years. This chapter identifies that most of the prevailing changes experienced by Inuit are related to climate change impacts, such as sea ice condition changes and weather changes. Three community-level adaptive strategies are diversification, technology adoption, and the management of fishery resources using the co-management approach. Further, the chapter identifies place-specific attributes that shape the adaptation process, such as Inuit-owed institutions, Inuit worldviews and culture, and knowledge systems.

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Chapter 4. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada

Abstract

Coastal fishery systems in the Arctic are undergoing rapid change. This paper examines the ways in which Inuit fishers experience and respond to such change, using a case study from Pangnirtung, Canada. The work is based on over two years of fieldwork, during which semi-structured interviews (n=62), focus group discussions (n=6, 31 participants) and key informant interviews (n=25) were conducted. The changes that most Inuit fishers experience are: changes in sea-ice conditions, Inuit people themselves, the landscape and the seascape, fish-related changes, and changes in weather conditions, markets and fish selling prices. Inuit fishers respond to change individually as well as collectively. Fishers' responses were examined using the characteristics of a resilience-based conceptual framework focusing on place, human agency, collective action and collaboration, institutions, Indigenous and local knowledge systems, and learning. Based on results, this paper identified three community-level adaptive strategies, which are diversification, technology use and fisheries governance that employs a co-management approach. Further, this work recognised four place-specific attributes that can shape community adaptations, which are Inuit worldviews, Inuit-owned institutions, a culture of sharing and collaborating, and Indigenous and local knowledge systems. An examination of the ways in which Inuit fishers experience and respond to change is essential to better understand adaptations to climate change. This study delivers new insights to communities, scientists, and policymakers to work together to foster community adaptation.

4.1 Introduction

Inuit communities in northern Canada are undergoing profound changes, in part because of changing climatic conditions (Arctic Council, 2016, AMAP, 2018, Ford et al., 2019). The region warmed by 1.6°C during the period 1948-2014, a rate at least twice the global average; this has been accompanied by a loss of sea-ice, reduced snow cover, a loss of lake/river ice, permafrost degradation, warmer seas that hasten the melting of glaciers and ice sheets, and species shifts

(Duerden, 2004, Ford, 2009b, Ford, 2009a, Ford and Beaumier, 2011, Ford et al., 2013, Ford, 2014, Ford et al., 2015b, Arctic Council, 2016, Clark et al., 2016b, AMAP, 2018, Ford et al., 2018c, Ford et al., 2019). These changes have had implications for fisheries, affecting fish availability, abundance and health, as well as access due to impacts on transportation networks. These changes present both risks and opportunities, the impacts of which will be determined not only by climate change, but also by social, cultural, and economic conditions and processes (Arctic-Council, 2013, Arctic Council, 2016, AMAP, 2018). Identifying ways to adapt, and thereby reduce the risks posed by climate change, as well as to take advantage of new opportunities, is emerging as a focus area in terms of decision making in northern Canada. Understanding how communities are experiencing and responding to the observed rapid change in climate is important for supporting such processes (Galappaththi et al., 2019d).

While the empirical assessment of how communities adapt to change is an active area of research in the Arctic, limited work has been done in a fisheries context (with exceptions (2001, Ford et al., 2006)). Those studies that do have a fisheries angle tend to focus only on subsistence-based fisheries as part of a suite of harvesting activities, such as hunting, trapping and traveling. Against this backdrop, here we assess community adaptations to climate change among Inuit fisher communities, using a case study from Pangnirtung, Baffin Island, Nunavut. The paper has two objectives: 1). to examine the ways in which Inuit fishers experience change, including climate change, and 2). to investigate the ways in which Inuit fishers respond to and adapt to such change. The study reveals various means by which Inuit fishers build resilience and minimise vulnerability (i.e. adapt) to the impacts of climate change. Finally, the paper identifies potential community adaptive strategies and key attributes that shape community adaptations in fisheries.

4.2 Methods

4.2.1 Study location

Pangnirtung is an Inuit community located on Baffin Island, in the Canadian territory of Nunavut, with a resident population of 1,481 (2016 census) (figure 4.1). Pangnirtung Inuit have historically lived around the Cumberland Sound area in multiple settlements called ‘outpost camps.' This is an isolated community accessible only by aircraft, and by boat during the summer for supplies. Travel in and out of the community is extremely expensive. Residents have to cope with unique challenges including high rates of food insecurity, housing shortages, and low rates of high school graduation, comparable to other small Nunavut settlements (Ruiz-Castell et al., 2015, Arctic Council, 2016, Collings et al., 2016, Huet et al., 2017). The community is a hotspot for climate change, with documented changes and impacts including changes in sea-ice conditions, severe weather conditions, permafrost thaw, emerging landscape hazards, and stresses to wildlife population dynamics. Pangnirtung is experiencing these changes more quickly and acutely than other places in the region, perhaps in part because of the popularity of the community for tourists, for whom Pangnirtung is the access place for visiting Auyuittuq national park (Egeland et al., 2009, Spinney, 2010, Diemer et al., 2011, Laidler et al., 2011, Short et al., 2011, Peacock et al., 2013, Moore et al., 2014, AMAP, 2018).

Pangnirtung is one of the few communities in Nunavut that has significant commercial *and* subsistence fisheries activity. A fish processing plant, Pang Fisheries Ltd., ('fish plant') located in the community is an Inuit-owned private entity operating since 1992. This fish plant serves two key fisheries, an Arctic char (*Salvelinus alpinus*) fishery and a turbot/halibut (*Reinhardtius hippoglossoides*) fishery. These are commercial *and* subsistence fisheries. Inuit have been more dependent on char as a food source for many generations and on turbot as a source of seasonal revenue. The fish plant exports about 90% of its turbot to East Asia (Japan, South Korea, Taiwan, China, and Vietnam), while the rest goes to Chinese communities in Canada, mainly in Toronto and Vancouver and the U.S. The market for Arctic char has shrunk since about 2008 and most of the Arctic char presently goes to buyers in Nunavut (for example, Iqaluit).

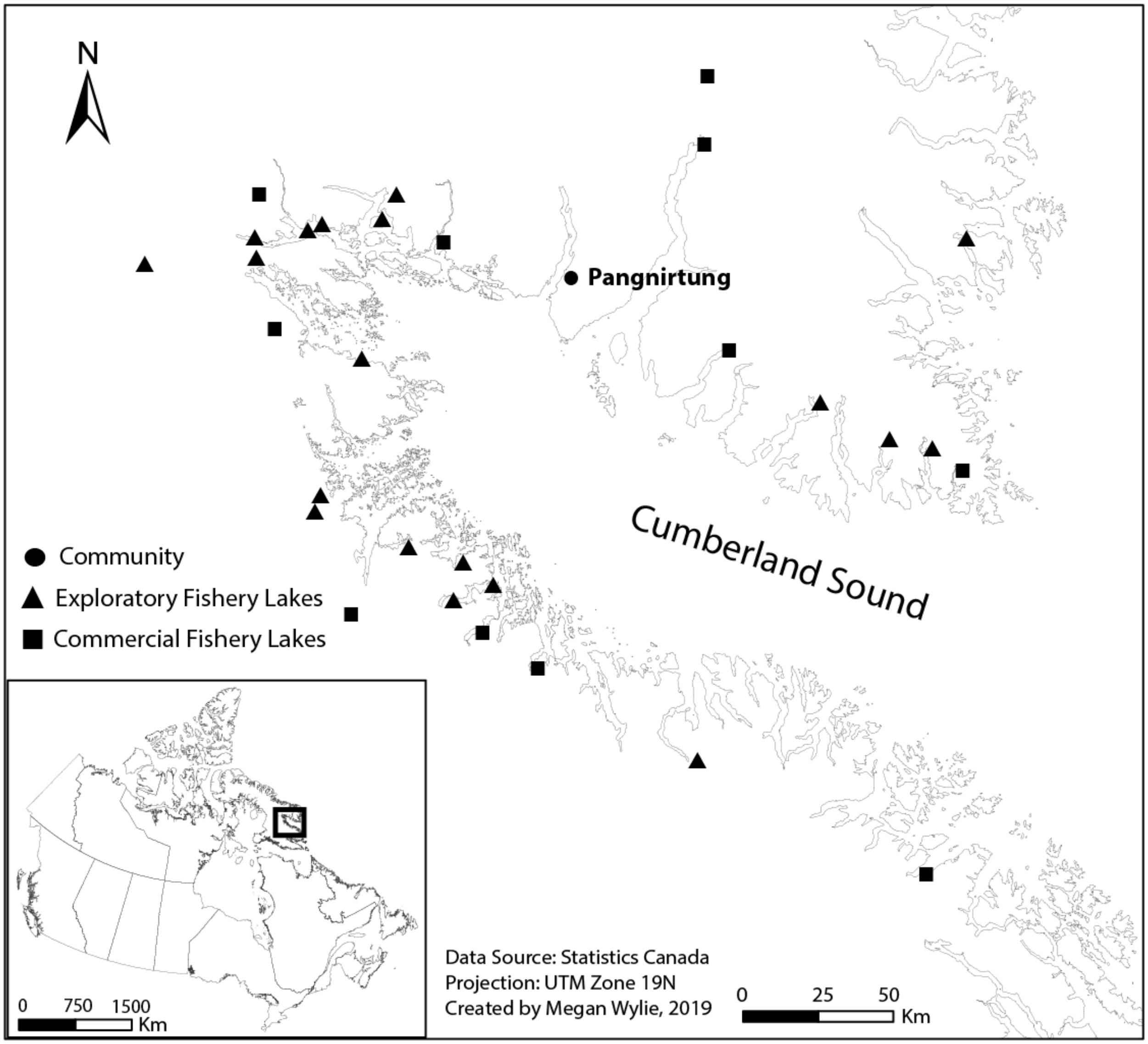

Figure 4.1: Location of the Pangnirtung (the community) and Cumberland Sound (water body) in Baffin Island, Canada. Pangnirtung Inuit use the surrounding lakes for winter Arctic char fishing for both exploratory and commercial purposes.

Pangnirtung Inuit have an intimate connection to the surrounding Cumberland Sound area for fishing and hunting, and a detailed knowledge of species (Idrobo and Berkes, 2012). Caribou, seals, and Arctic char are the most important food sources for the community (figure 4.2). Several other seasonal resources, such as turbot, ptarmigan, eiders, polar bear, kelp, arctic hare, clams, and beluga, are also important to health, culture, and wellbeing. Inuit fishers/hunters go out ‘on the land’ and spend days outside the community. During the winter and spring turbot fishing seasons, fishers drive snowmobiles for about 50-100 km on the frozen ocean and spend several days on the sea-ice in the Cumberland Sound area.

Arctic char is an anadromous species, feeding in the sea and overwintering in lakes. During the winter, people travel on frozen inland lakes around the community for Arctic char fishing. Fishing/hunting for local 'country food' is an essential part of Inuit culture and way of life. The community's two grocery stores (co-op and Northern store) provide some alternative food sources, yet Inuit still consider country food to be their main food source as opposed to the expensive, less nutritious processed food from the store. Thus, changes in country food availability can have a large impact on Inuit diet. The study area was a good caribou hunting ground before the caribou migrated to western Nunavut lands, resulting in an increased reliance on the ocean for food security (Poole et al., 2010, Le Corre et al., 2017) (Appendix B-Box B1).

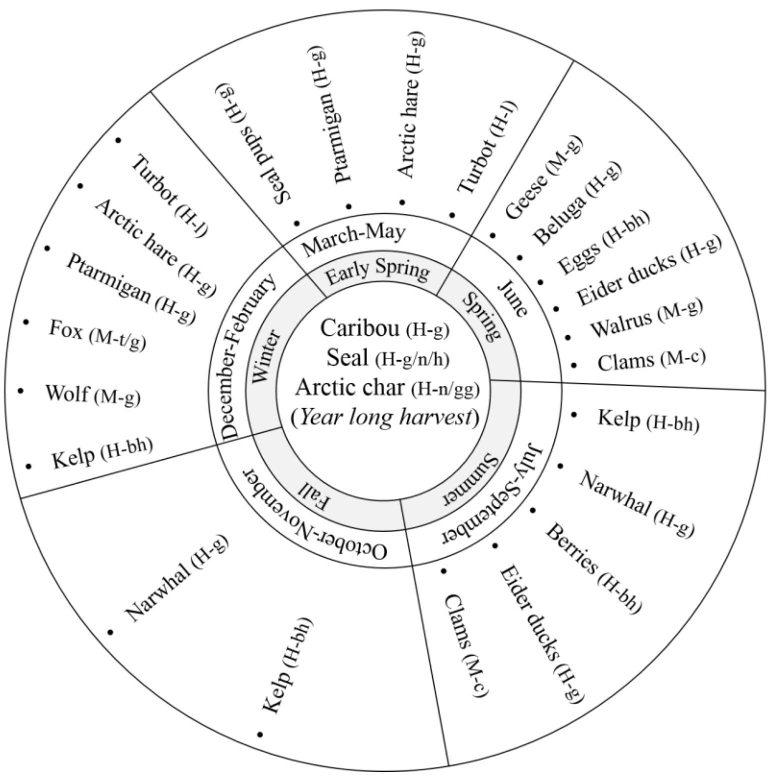

Figure 4.2: Seasonal food calendar for Pangnirtung (building on Egeland et al. (2009)).

Intensity of harvesting activity: High (H), Medium (M), Low (L). Hunting equipment: Gun (g), Gillnet/seal net (n), Traps (t), By-hand (bh), Long line (l), Collecting tool (c), Gigging (gg), Harpoon (h).

4.2.2 Conceptual approach

A social-ecological systems (SES) framing underpins our conceptual approach for understanding the nature of integrated Inuit and the Arctic sub-systems (Berkes et al., 1998, Berkes et al., 2003). The integrated social-ecological system (SES) is the unit of study. Economic systems and markets are not treated as separate but nested in the SES, allowing for an understanding of the complexities inherent to the Pangnirtung Inuit fishery -- a 'complex adaptive fishery system' (Mahon et al., 2008, Folke, 2016, Arlinghaus et al., 2017). Here we use the term 'fisheries systems' to refer to the coupled sub-systems of Pangnirtung Inuit and their land/water and associated socio-economic and cultural aspects related to fisheries activities.

This paper uses the characteristics of a resilience-based conceptual framework (2019d) to identify and assess the adaptations of Pangnirtung Inuit towards stressors of the fisheries system. The framework has six characteristics used to create a better understanding of the SES change and of the human responses to such change: place, human agency, collective action and collaboration, institutions, Indigenous and local knowledge (ILK) systems, and learning (table 4.1). This framework provides indicators that guide the assessment process, and the results are structured around the indicators under each framework characteristic. A conceptualisation of resilience as a function of coping, adapting, and transformative capacities (Béné et al., 2014, Brown, 2016) permits the capture of macro-level understanding of adaptation, with micro-level comprehensive details in fishing communities. This conceptual tool was developed based on an integration of the two scholarship areas of resilience thinking and development studies (Galappaththi et al., 2019d). Use of this framework allows for the assessment of the process of community adaptation in Arctic fisheries systems, and for insights into adaptation needs and relevant policy.

Table 4.1: Definitions of characteristics of the resilience-based framework (Galappaththi et al., 2019).

Characteristic	Definition	Indicators
Place	Social and physical space that has attachment to Inuit. Attachment to place is understood as the bonding that occurs between people and their meaningful environments (livelihoods, culture, and wellbeing).	1) Number of species available for fishing. 2) Level of fishery resource availability. 3) Level of vulnerabilities for fishing operations such as climatic uncertainties. 4) Changes in livelihood activities relative to place (hunting/fishing). 5) Culture, including belief systems and perceptions that link to place.

Human agency	Inuit (individual or collective) capacity to act independently in making their own decisions as part of the process of the Inuit way of life.	1) Ownership of or access to fishing gear (boats, nets, engines). 2) Fishing gear diversity (number of different items of fishing gear used). 3) Occupational mobility (number of different fishing operations practiced). 4) Occupational multiplicity (total number of jobs in the household). 5) Access to credit (loans) and insurance. 6) Use of technological advancements.
Collective action and collaboration	Action taken together (or shared) by a group of two or more people to meet a common desired objective.	1) Sharing of fish. 2) Sharing of fishing gear. 3) Spreading of weather information. 4) Sharing of information related to fishing operations (fish prices, quotas, fishing techniques/management practices). 5) Social networks.
Institutions	Local organizations that facilitate collective action that meets local goals (for example, co-managed institutions).	1) The aim of institutions (for example, contribution to local fishing activities). 2) Ownership (communal, local/Indigenous, private). 3) Decision-making power. 4) Existence of partnerships.
Indigenous and local knowledge systems	Co-evolving cumulative body of knowledge and practice (observations, experience, lessons, skills) related to Inuit fisheries systems (or a place) and handed down through generations by cultural transmission; reflects the Inuit cultural identity.	1) Application of such knowledge. 2) Co-production of knowledge (combining Indigenous knowledge with other kinds of knowledge such as local knowledge and/or modern technical knowledge). 3) Weakening of local/Indigenous/ traditional knowledge through the SES change.
Learning	Social learning, which itself refers to collective action and reflection that occurs among Inuit as they work to improve the management of human-environment interactions.	1) Extent of the practice of learning-by-doing in the fishing way of life. 2) Number of opportunities for learning. 3) Ways in which local philosophical worldviews are compatible with adaptive thinking.

4.2.3 Data collection methods

A community-based participatory research approach (Magee, 2013) was used to guide the research to ensure community engagement to shape knowledge production. The study continually received feedback from the community through the Pangnirtung municipality, key informants including elders, and research assistants (Appendix B-Box B2). During the field data collection, the researcher relied on three language translators (Inuktitut-English) and four local research assistants. All field data was collected according to the McGill Research Ethics Board Certificate of Ethical Acceptability of Research Involving Humans (file number: 52-0617) and the Scientific Research License from the Nunavut Research Institute (file number: 02 015 18R-M).

To understand the ways in which Inuit fishers experience and respond to change, including climate change, a qualitative mixed-methods research design was utilized, including participant observations (PO), semi-structured interviews (SSI), key informant interviews (KII) and focus group discussions (FGD) (Berg, 2016, Laurier, 2016, Longhurst, 2016) (Appendix B-Box B3). Through participation and observation of Inuit fisheries' way of life over 14 weeks of fieldwork, participant observations (PO) obtained contextual knowledge about the ways in which Inuit experience and respond to change. From May 2016 to February 2019, four research visits were made to the community. The field period featured an extensive amount of time spent with Inuit fishers in the form of attending community events and meetings, visiting local institutions, and making fishing trips (n=6) to Cumberland Sound to experience summer Arctic char fishing and winter turbot fishing. The researcher participated in and experienced most of the fishing activities to develop an understanding of the conditions that fishers confront.

Sixty-two face-to-face semi-structured interviews (SSI) (Longhurst, 2016) were conducted with Inuit fishers to document the changes being observed in the region, and identify and characterize how they are being responded to (Appendix B-Table B1). A snowball sampling technique was used to select participants, beginning with multiple snowballs (4) to overcome the recruiting of all respondents from a very narrow circle of like-minded people. Participants were recruited until saturation, at which interviewees provided no new information (Bowen, 2008). Interviews were conducted, audio-recorded and transcribed in the community of Pangnirtung during May 2017-April 2018 (Appendix B-Table B2). The SSI questioning focused on "change" in general so as not to bias answers and to keep interviews open-ended, focusing on what issues and changes that Inuit viewed as most important. SSI helped obtain richer insights about the 'place' and its meanings and attachments (Williams and Patterson, 2008, Kaján, 2014). All the interview questions related to 'change' referred to "about 30 years back" in fishers' lives in the geographical area of Pangnirtung and the surrounding Cumberland Sound area.

Twenty-five key informant interviews (KII) were conducted with individuals related to Inuit fisheries to examine areas of knowledge that were not accessible via PO and SSI, such as data related to the fish plant (for example, market portfolios), government institutions (for example, subsidy programs) and key people such as elders. The researcher conducted interviews with representatives from the HTA Hunters and Trappers Association (n=4), the fish plant (n=3), DFO Department of Fisheries and Oceans (n=1), NWMB Nunavut Wildlife Management Board (n=1), the hamlet office (n=6), Nunavut territorial government agencies (n=6), the soup kitchen (n=1), the community weather station (n=1) and Baffin fisheries (n=2). Further, KII helped validate and create an understanding of the connection among data gathered using other methods.

Six focus group discussions (FGD) (Carey and Asbury, 2016) were carried out to build thematic areas related to changes that fishers experience, and the key ways in which fishers respond to such changes. Inuit fisher groups of four to eight individuals participated in the FGDs, organised during the latter stage of the data collection process. The first FGD (n=4) focused on the theme of 'changes in Pangnirtung fisheries' and discussed questions such as what change means to Inuit, how change can affect ways of life, and what the key changes are. The second (n=5) and third (n=8) FGDs were organised under the theme of 'how Pangnirtung adapt to change'. The discussions built on questions such as how Inuit are responding to change and the key areas of response. The fourth (n=4) and fifth (n=4) FGDs aimed at Arctic char and turbot fisheries, respectively. The final FGD (n=6) was organized to reengage with the community and disseminate/validate the results.

Qualitative interview data were translated into English (where required), transcribed, and then analysed using content analysis (Yow, 2014, Hancock and Algozzine, 2015, Berg, 2016, Clifford et al., 2016). Almost all analysis was completed by a single team member; however, multiple times throughout the project, the data analysis process was supplemented with feedback from community members. The key techniques used were 'manifest' and 'latent' content analysis supplemented with 'critical discourse analysis' (Fairclough, 2013, Van Dijk, 2015, Van Leeuwen, 2015) to develop themes and patterns related to the ways in which Inuit experience and respond to change. To express the original point of view of respondents, direct quotations are also used. We used exact phrases from respondents but removed irrelevant text from the quotes. Microsoft Excel 2013 was used to analyse interview data with the purpose of creating descriptive statistics such as percentages, mean and SD. Percentages were calculated based on the data frequency. Percentages in the text refer to the number of respondents from the immediately mentioned sub-sample who made that particular statement. Initially, the study recorded 32 types of change that Inuit fishers experienced. Of these, the six most recorded changes were selected (based on data frequency and intensity of experience) for further analysis. The results were supplemented with selected quotes (from SSI/KII) based on the latent content analysis. The linkages among the selected changes were identified using data from PO and SSI and validated through KII and FGD. Data related to the ways in which Inuit fishers respond to change was collected primarily through the PO (research diary, photos, and researcher's first-hand experience) and SSI data, supplemented with KII and FGD. Data were presented and analysed using the conceptual framework (Galappaththi et al., 2019d).

4.3 Results

4.3.1 Experiencing Arctic change

Inuit fishers experience change in many ways, and this process of change is integrated into their way of life. Table 4.2 provides quotes that describe specific details about the ways in which change is experienced, its impacts, and previous studies documenting similar changes. Change in sea-ice conditions was the predominant theme discussed by participants. The other changes related to the people themselves; the landscape and seascape; fish including Arctic char, turbot, and capelin (*Mallotus villosus*); the weather conditions; and fish selling prices and markets. These changes were among the most recorded changes and this knowledge will help answer key questions such as: What are the key stressors and shocks in the Arctic region? How do climate change impacts affect Inuit way of life? How can such changes relate to adaptation to climate change?

Table 4.2: Fishers' quotes describing how Arctic change is experienced (n=62).

Nature of change: "selected quotes from fishers"	Impacts	Previous studies
Sea-ice conditions: *"Fishing season get shorter each year. Ice break up faster now. Last year ice was weak … once we boat in December … so strange … no cold … ice doesn't break at right time."* *"Ice conditions are different now. We have to be more careful. We see more thin ice … black ice here and there."*	Shorter fishing season because sea-ice melts and breaks faster and new ice forms more slowly (85%). Safety concerns because sea-ice is thinner and weaker than it used to be (46%). Changes in sea-ice conditions are linked to changes in weather conditions and Inuit people.	(Nichols et al., 2004, Laidler et al., 2008, Laidler et al., 2009, Laidler et al., 2010, Screen and Simmonds, 2010)

Inuit people: *"Some people [Inuit] starting to act like strangers to each other, yet knowing they are related…"* *"Back then Inuit were healthier than now. Now they [Inuit] can easily get sick. …back then we [Inuit] never had big bellies like now. There [Inuit] were more old people before we move here from outpost camps. Now few old people [Inuit] in Pang."* *"Values of the people [Inuit] are still the same as back then."*	Weaker bonding among family members and community (38%). People are more money-oriented and reliant on the world outside the community (25%). Now people can easily get sick and have more health issues; back then Inuit were stronger (19%). Changers in people are linked to all other areas of change identified in this study.	(Condon, 1990, Charbonneau-Roberts et al., 2007, Lehti et al., 2009, Kral, 2012, Dowsley, 2015)
Landscape and seascape: *"…we live nearby the river and mountains up there … our view is moving, and I think our land is moving…"* *"…our river moves a lot last couple of years … maybe permafrost is gone."* *"During the spring we see more water than before, glacier melting. After they melt we see more water running all over the place."* *"Now ice moves in different directions, we are not used to that."*	Economic damage to infrastructure (house, bridge, winter trails) due to changes in river and mountain landscape (29%). Melting glaciers around the community can affect the community's aesthetic value (25%). Safety concerns related to fishing as sea-ice (masses) moves to different areas of Cumberland Sound during summer (8%). Changes in landscape and seascape are linked to changes in Inuit and weather conditions.	(Nelson et al., 2002, Ford and Smit, 2004, Ford et al., 2010)
Arctic char, turbot and capelin: *"Arctic char meat is white now. It's not red anymore, not sure why … most of them are smaller than back then…"* *"The[re] were no capelin back then, it showed up lately, now they are many … grandmother said that the reason for Arctic char flesh turning white."* *"Relatively less Arctic char when compare[d] to the days we went camping back then (up to 30 years ago)."*	Food security concerns are due to changes in char color and texture (83%). Most elders (74%) do not like to eat whiter and softer Arctic char; 33% of elders suspect that the reason for the whiter flesh is the emergence of capelin. The char moving patterns seem to have changed, as the time when char come in summer is later now (25%). Some Inuit believe char populations are lower (17%). Changes in fish are linked to weather/climate.	(Grebmeier et al., 2006, Harwood et al., 2015)
Weather conditions: *"Now summer comes more often."* *"I used to go [to] Iqaluit every year April. Now when we Ski-Doo we hit rocks because of less snow in April."* *"In January, people from other communities coming here and they [wear] 'Parka', they are saying it is warm here in Pang."* *"Now we got more warm winds and it breaks ice … air is so dry … we lost our shack last year, during the fishing, wind blew it."* *"We get unusually high wind now. Last year we got 140km/hr. I found some plastic bags in sea while fishing, it can damage my motor. Wind can bring plastic anywhere."*	Safety concerns are raised: a) extreme weather (storms, rain) and uncertainty (73%), b) more frequent extreme windy weather (55%), c) unusually warm weather that can affect fishing activities (45%). Sand and dust storm conditions during the summer due to extreme winds. Wind brings plastic and garbage items to the sea and surrounding mountains; fishers found plastic in the Cumberland Sound sea, which can damage boat motors. Changes in weather conditions are directly linked to all other identified changes, except for changes in markets and fish selling prices.	(Laidler et al., 2011, Giles et al., 2014)
Markets and fish selling prices: *"…back then turbot prices about \$1.75/lb and now about \$1.20/lb. Arctic char is \$2-3/lb and now about \$2/lb. …back then [1980-90s] there were two fish*	Prices have dropped over the last 30 years and fishers have only one place to sell their catch (80%). Market for Arctic char has shrunk during the last five years partly because buyers such	(Lange and Consortium, 2003, Campbell and Bergeron,

plants but now we have one. We don't have option to sell anywhere else." *"In winter time, some fishers sell to Iqaluit via plane."* *"Char is more profitable for us (Inuit fishers)."*	as US restaurants are getting supplies from fish farms. Changes in market and fish selling prices are linked to the changes in Inuit fishing and external global economy.	2012)

Note: Percentages were calculated based on the data frequency—the percentage of respondents who mentioned a particular change at least once.

4.3.2 Responding to Arctic change

This section examines the ways Pangnirtung Inuit respond to identified changes using the six characteristics of a resilience-based conceptual framework. Tables B3 and B4 in the appendix B illustrate Inuit adaptive responses against the framework indicators and provide specific quotes that describe details about how Inuit adapt to Arctic change, respectively.

4.3.2.1. Place

Place-specific conditions such as unique weather and resources availability can influence community adaptive capacity and adaptation processes (Amundsen, 2015, Adger, 2016). Arctic char and turbot are co-existing fisheries systems in Pangnirtung that help people cope with change. Arctic char is the staple food in the community and a popular subsistence fish as in many other parts of the North. However, Pangnirtung also has a commercial fishery on Arctic char during the summer. Only a few (15 in 2017) commercial char licences are issued, selected through a lottery system managed by the HTA. During the summer when Pangnirtung fiord is clear of ice, fishers start boating into Cumberland Sound waters for char, using gill nets. During the winter and spring after the formation of strong sea-ice, fishers travel via snowmobile to surrounding lakes to fish Arctic char using a short stick and a line with bait (referred to as 'jigging').

Commercial turbot fishing is popular because it brings a relatively large amount of money into the community. It is carried out during the winter and spring. Strong and thick sea-ice is essential to starting winter turbot fishing, as it requires travelling to the Cumberland Sound sea-ice and spending longer hours (sometimes days) on the ice. Turbot fishers travel on the frozen ocean between multiple (1-4) turbot fishing spots (ice holes). This is a high-risk fishing operation due to continuous darkness, extreme cold (<-40°C with wind-chill), and the fact that the Greenland shark is a potential by-catch for turbot long-lines (Idrobo and Berkes, 2012). Nevertheless, more Inuit are becoming involved in turbot fishing each year due to its seasonal money-making potential.

The community fish plant processes fish nearly throughout the year. The plant processes Arctic char in both summer and winter. The catch data for each year varies and some of the records are not accessible. The turbot catch has been showing an increasing trend over the years (figure 4.3). Turbot provides considerable employment in processing. The total spent on wages in Canadian dollars was 789,262 (2013); 846,488 (2014); and 842,369 (2017).

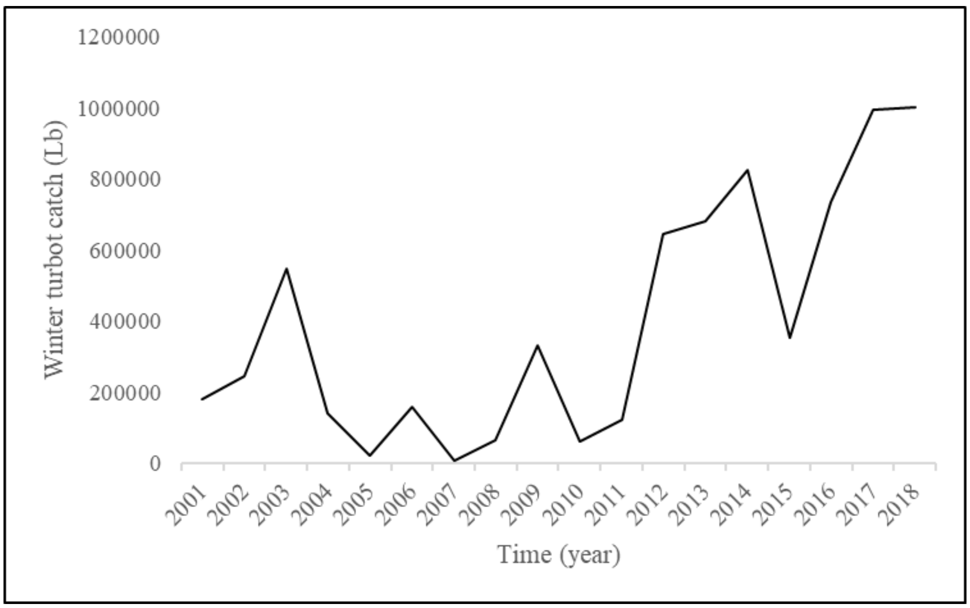

Figure 4.3: Growth in turbot fish catch.
Data source: The fish plant. (via KII)

Some 79% of respondents were involved in commercial fishing (Arctic char and/or turbot), 95% were involved in char fishing for subsistence purposes, while 15% engaged in commercial Arctic char fishing. Spending so much time on the land/sea for fishing and hunting shows Inuit attachment to, and reliance upon, their environment (or place). Sixty-nine percent of Inuit fishers indicated that no matter how much the environment and climate changed, they did not want to move away from Pangnirtung.

4.3.2.2. Human agency

Human agency is an essential component of assessing community adaptation as it relates to the adaptive capacity of the community's households (Cinner et al., 2015, Galappaththi et al., 2019d). A high level of human agency can indicate a high adaptive capacity to change (Cinner et al., 2015). We use four indicators of human agency to understand the adaptive capacities of fishers (table 4.3).

Table 4.3: Indicators of human agency (n=62)

Indicators	Description	Mean	Standard deviation	How does it relate to adaptive capacity?
*Occupational multiplicity	Total number of jobs in the household.	0.7	0.8	Increases a range of income options available to cope with adverse conditions.
Access to assets	Access to number of assets required for fishing operations. Total of five assets: snowmobile; boat; fishing gear; qamutik (sled); truck.	3.8	1.1	Increases ability to go out to land/sea for adequate hunting and fishing that allows Inuit to earn more money and have required amount of food.
Fishing gear diversity	Number of different fishing gear used by each fisher. Total of six types of fishing gear: long line; gill net; jigging; fishing rod; clam digging tool; spear.	4.0	0.9	Increases the potential/ capacity to harvest range of country food options that help feed Inuit families.
Occupational mobility	Participation in the number of different kinds of fishing in the past year, total of four: char summer fishing; char winter fishing; turbot winter fishing; other fish.	2.6	0.5	Increases earning potential as well as fish harvest (for food), which improves buying power and food availability.

* Inuit have many other casual income-generating activities, such as selling seal skin, selling artwork, tourism-related activities, translating and research-related activities, and income support from the government.

Fishing constitutes a significant part of livelihoods in Pangnirtung, as 49% of fishers identified their occupation multiplicity as zero and most of fishers have less than one (0.7) total number of jobs in the household. Over 85% of fishers declared that they owned or had access to assets required for year-round fishing. Most (75%) had access to four to six types of fishing gear. Fishers have adopted technology such as Global Positioning Systems (GPSs) (56%), VHF radios (68%) and advanced rifles (19%) for fishing/hunting activities. Yet some (16%) prefer not to rely on technology, as they have limited access to service/repairs due to the community's isolated nature. Fishers have limited opportunities to obtain loans for the purchase of equipment such as snowmobiles and fishing gear, but they do have some access to credit/loans through Pang-Fisheries (13%) and Nunavut government (10%).

Some fishers were especially innovative. For instance, one fisher made a fly-proof food preserving box to save excess food (for example, Arctic char and beluga meat). Some fishers (11%) engaged in activities related to painting, craft work and carvings that bring extra income. Twenty-three percent of fishers save some money from turbot fishing to buy more long-lines or other equipment.

4.3.2.3. Collective action and collaboration

Collective action and collaboration can shape the community adaptation process by improving community cohesion and unity, which helps them cope with changes (Adger, 2003, Armitage, 2005, Pelling et al., 2008). This section examines collective action and collaboration, using qualitative indicators such as sharing of fish, fishing gear, information related to fishing operations, and use of social networks. Inuit fishers respond to change both individually and collectively. Almost all fishers share their catch with relatives and elders, especially those who cannot fish and hunt themselves. Fishers and hunters (except those who support their families with food) often share, going on the radio and saying, "Look, I got a seal; come on over and help yourself." Thirty-four percent of fishers do not 'go public' and share with their extended family. The community offers organised food sharing events, while local institutions (for example, HTA, the soup kitchen) collaboratively facilitate such events.

Community members help each other mainly by communicating via local radio and internet-based social media, such as through the community Facebook page. For instance, they report vehicle or boat engine breakdowns, offer rides to the airport, share fishing equipment and offer to babysit so that the parents can go hunting/fishing. Thirty-nine percent of respondents share and/or are willing to share their hunting and fishing equipment (boat engine, sleds and snowmobiles). Hunting and fishing equipment is expensive, and 47% of fishers are reluctant to share due to previous experiences with lost or damaged equipment. People readily share weather-related information (for example, satellite images, wind conditions and storms) with fishers and hunters. However, three elders (5%) recalled that Inuit used to gather in the past before they went fishing or hunting; even at present Inuit have specific places where fishers meet before spreading out for winter seal hunting or turbot fishing.

4.3.2.4. *Institutions*

The engagement of local institutions with fishery resource management approaches and their effective collaborations with stakeholder institutions can minimize vulnerabilities related to the use of natural resources by enhancing the community's adaptive capacity. Here we unpack key institutions involved in collaborative decision-making related to fisheries.

Both the DFO (Department of Fisheries and Oceans) and the HTA (Hunters and Trappers Association), along with the NWMB (Nunavut Wildlife Management Board) and other designated Inuit organizations, are co-managers of the fisheries in Nunavut, as outlined in the Nunavut Agreement Article 5. Table 4.4 illustrates all co-management partner institutions that directly relate to the Pangnirtung fisheries co-management. Quotas are based on a combination of the best available science advice and traditional knowledge and must be approved by the NWMB and DFO.

Table 4.4: Key co-management institutions related to Pangnirtung co-existing fisheries.

Co-management partners	Aim/role	Ownership/ management approach	Decision-making
HTA	Co-manages fisheries with DFO and NWMB; selection of licence holders for char commercial fishery using a lottery system.	Inuit of Pangnirtung	Board of directors
DFO	Issues fishing licenses; monitors quotas; issues closer notices and monitors compliance concerns.	Federal government	Consultations (public, HTA, and other co-management partners)
NWMB	Co-manages fisheries with DFO and HTA.	NU territorial government	Board of directors
GN (Government of Nunavut)	Focuses on economic development and funding aspects for fishers and fisheries activities.	NU territorial government	Board of directors
RWO (Regional Wildlife Organization)	Overlooks harvesting practices of HTA and represents 'Inuit rights.'	Article 5 of the Nunavut Land Claim Agreement	Board of directors
NTI (Nunavut Tunngavik Incorporated)	Advocates and makes decisions as Inuit stakeholder. Represents 'Inuit rights.'	Article 5 of the Nunavut Land Claim Agreement	Board of directors
Fish plant	Buys fish and provides seasonal job opportunities in processing and shipping. Contributes to community events and	Private --100% Inuit owned	Board of directors

	supports Pang soup kitchen.

Note: See Appendix-Figure B1 for the co-management structure for Pangnirtung Arctic char and turbot fisheries (building on (Armitage et al., 2009)).

4.3.2.5. Indigenous and local knowledge (ILK) systems

ILK systems are recognised as a source of resilience, as well as a means of measuring the understanding of adaptations, as they underpin adaptive capacity to deal with change (Folke et al., 2003, Galappaththi et al., 2019a, Galappaththi et al., 2019d). This section describes applications of ILK, the combining of different kinds of knowledge, and the possible weakening of ILK through the process of change. Pangnirtung Inuit possess various kinds of knowledge accumulating and evolving over the generations (Idrobo and Berkes, 2012) , and shared among friends and peer groups. This knowledge is essential for harvesting, as well as adapting to environment and climate change (Berkes and Jolly, 2001). For example, it includes survival skills on ice, knowledge of Arctic char, turbot fishing techniques, and fish processing and marketing. Table 4.5 illustrates selected types of knowledge that turbot and Arctic char fishers use.

Table 4.5: Types of knowledge adopted by Inuit fishers.

Type of knowledge	Description
Place specific knowledge of Arctic char	-Arctic char migration patterns; knowledge of overwintering lakes. -Knowledge of fishing techniques and good fishing spots in the Cumberland Sound. .
Turbot fishing techniques	-The Pangnirtung Inuit learned turbot fishing techniques from the Greenland Inuit during the mid-1980s. -This knowledge continues to evolve from generation to generation.
Turbot fish processing and marketing knowledge	-Inuit owned fish plant holds much of the processing, selling, and marketing-related knowledge. -'fish plant' informed Inuit fishers about on-ice post-harvest practices.
Local environmental knowledge	-Fishing in high-risk conditions such as extreme cold, darkness, and Greenland shark that comes up as a long-line by-catch. -Knowledge about weather changes, tides, and water currents. -Knowledge about Cumberland Sound fish species.
Co-produced knowledge	-By working together and sharing and learning from each other, and working together with DFO and HTA, fishers combine and co-produce new knowledge.

Note: This knowledge information is derived from PO and FGD.

Focus group discussions highlighted the fact that some kinds of Inuit knowledge are getting weaker. In particular, young Inuit have poor knowledge of practices such as survival skills on ice, reading the sky, sewing seal skin and handling dog teams. Many elders possess such knowledge but have not necessarily done it themselves:

> *I have watched my mother do it. They were basically teaching from what they remembered, not from what they did. We have lost teachers who know how to do [things]. We have teachers who know about the past, but even that generation is aging quickly.* -- Elder (KII)

Thus, the weakening of traditional knowledge is an important influence on the way in which Inuit respond to present-day changes such as climate change (Pearce et al., 2015, Ford et al., 2016c). On the other hand, young Inuit are taking advantage of technology and technical know-how to elaborate new knowledge and skills, such as using satellite images, drones to discover ice conditions, and underwater cameras to determine where the fish are.

4.3.2.6. Learning

Social learning is a key characteristic of community adaptation (Galappaththi et al., 2019d). This section describes the extent to which Inuit practice learning-by-doing in their fishing way of life, the number of opportunities available for learning, and the ways in which local worldviews are compatible with adaptive thinking that supports the local adaptation process. Inuit fishers have various opportunities to learn about and adapt to change. During individual interviews, a large majority (84%) identified learning from elders and/or extended family members as a key means of learning about fishing. Thirteen percent of the respondents identified learning-by-doing while practicing fishing operations as a key means of learning. Apart from their first-hand experience, fishers communicate in close networks with friends and relatives, and incorporate their experience. During all the turbot fishing trips in which the researcher participated, fishers met and talked with other fishers on the way to their own "fishing hole". During focus group discussions, Inuit fishers agreed that both learning from elders as young Inuit and learning-by-doing are equally critical for adaptation to change.

Young Inuit are inspired by technology and readily utilize it. The elders say, "Now we need young people to teach us." Internet and school education are the means by which Inuit learn. When the researcher asked one Inuit fisher about Inuit turbot fish recipes, he replied, "Google it," with a smile. Only 29% of fishers have access to the internet at home and/or on their mobile devices. The remainder (71%) do not have access mainly because: a) they are not familiar with the internet (48%), b) it is too expensive (43%) or c) they are not aware of the internet (9%). In terms of education levels, 30% of fishers did not reach the junior high school level. Thirty-nine percent attended junior high; 19 percent reached the senior high level, but only 8% of fishers graduated from high school, and a further 2% have a community college diploma.

4.4 Discussion

This paper assesses how Pangnirtung Inuit experience and respond to change in a fisheries context. Climate change was identified as the most prominent change, and is perceived as being a real phenomenon by Inuit fishers and occurring in an unprecedented way (Ford et al., 2015c, Ford et al., 2019). The study illustrates six key items of change (i.e., stressors and shocks) related to: sea-ice conditions, Inuit people, the landscape and sea scape, fish, weather conditions, and markets and fish selling prices. The major ways in which fishers experience change can be characterized as: (a) the Arctic SES is being impacted by multiple stressors simultaneously; (b) climate change has mixed/interconnected implications for Inuit fishing way of life; (c) Inuit themselves are changing over time due to the Arctic SES change; (d) many of the changes related to climate change are clearly noticeable in the Arctic; and (e) changes related to the market economy (fishing industry) mean that Inuit have to rely on outside economies. Table 4.6 explores the implications of change experienced by Inuit fishers, potential outcomes (in the context of existing literature), and community responses.

Table 4.6: Implications of change and community responses.

Implications of change	Potential outcomes	Community responses
Shorter fishing seasons	Limit the window of opportunity for fishing—can result in food insecurity and disturb Inuit livelihoods (Islam et al., 2014, McCubbin et al., 2015, Savo et al., 2017).	Two co-existing fisheries provide opportunities; the turbot fishery provides additional income, which is not the case in most other Arctic communities.
Safety concerns while traveling on ice for fishing/hunting	Exposure to accidents can limit the ability to engage in fishing activities and can diminish human capacity/agency (Clark et al., 2016a, Clark et al., 2016b).	Use of technology minimises vulnerabilities related to travelling on ice (GPS, powerful snowmobiles, VHF radios, satellite maps and weather updates via social media).
Weaker bonding among family members	Can weaken community cohesion (Armitage et al., 2011, Huntington et al., 2017, Cinner et al., 2018b).	Community events such as food sharing events improve community cohesion. At such events, Inuit cook country food, eat, play games and share stories.
Lessening of workdays as their	Concern about food insecurity because people rely highly on fish as a critical	Fishers share their catch with relatives and elders, especially those who are unable to

health does not allow them to engage in their fishing activities	source of protein (Collings et al., 2016, Huet et al., 2017).	fish and hunt. Income assistance is available for some Inuit (about 25% of the community population).
Inuit perceptions about reducing char fish population	Threat to the sustainability of char fishing (Roux et al., 2018).	The HTA and DFO along with the NWMB co-manage the char fishery (as outlined in the Nunavut Agreement Article 5).
Lessening aesthetic value of the community	Can affect the tourist/researchers' attraction of community (König, 2018).	Livelihoods are diversified and there is more reliance on fisheries.
Shrinking Arctic char market portfolio in fish plant	Can be a threat to the char commercial fishery (Cline et al., 2017).	There is a more diverse and stronger market portfolio for the turbot fishery, which creates more confidence in growing the turbot fishery.

Our work identified three key adaptive strategies of Pangnirtung Inuit that dominate community responses. First, 'diversification' is a common strategy in the areas of fisheries, country food, fish export markets, and livelihood activities. A wide range of food, income, and market options can improve the adaptive capacity of the fisheries system mainly through: a) year-round distributed income-generating activities that allow Inuit to afford alternative food sources (purchase from store), b) access to a wide range of country food will minimise vulnerability in terms of health issues and food insecurity, and c) multiple markets will improve the resilience of the local fishing industry in terms of adapting to changes in global trade. Diversification could be further improved, creating price choices/options among fishers in terms of selling their fish (for example, opening up a second fish buying unit). Nurturing diversity in a changing SES can increase creativity and adaptive capacity and set the system to reorganization and renewal (Folke et al., 2003, Folke, 2016). Also, diversity is identified as a source of systems resilience and a means of adaptation in the context of small-scale fisheries (Galappaththi et al., 2019a).

Second, the use of technology for fisheries activities is a strategy employed mainly in response to safety-related vulnerabilities (Clark et al., 2016a, Clark et al., 2016b). For example, most fishers use GPS to mark good turbot fishing spots and as a direction guide for travelling on ice. Almost all fishers use VHF radios to communicate with the base station (community) for help while travelling on ice or on the sea for fishing. Furthermore, many Inuit use internet-based social media for weather updates, such as satellite images and changes in wind direction. Younger fishers and hunters who do not have a good knowledge of ice or the land are prone to take risks and go out ill-prepared. But because most young Inuit can use such technology, this potentially moderates knowledge gaps by improving human agency and enhancing adaptive capacity

(Larsen and Fondahl, 2015, Brown, 2016, Folke, 2016), as also found in some Nordic countries and in Russian fisheries (Keskitalo et al., 2011).

Third, we recognise fisheries co-management as an adaptive strategy (Berkes and Armitage, 2010), mainly for dealing with changing fishing seasons by achieving a shared consensus of multiple stakeholders (Berkes and Armitage, 2010, Armitage et al., 2011). The co-management approach has multiple characteristics (Carlsson and Berkes, 2005, d'Armengol et al., 2018): partnerships between the government and local groups; vertical linkages for governance; the sharing of authority, responsibility and power; and learning-by-doing and adaptive management. Together these characteristics advance adaptation through a division of labour based on the respective comparative advantages for each partner. Achieving the shared interest of multiple parties minimises conflicts among partners (Armitage et al., 2008a, Berkes and Armitage, 2010, Armitage et al., 2011, Galappaththi and Berkes, 2015b, Fidelman et al., 2017). Used as a resource management approach in northern Canada for decades, particularly with Indigenous groups (Armitage et al., 2008a, Berkes and Armitage, 2010, Armitage et al., 2011), co-management as an adaptive strategy provides flexibility (Cinner et al., 2018b) and other characteristics that a resource management system needs to deal with change (Appendix B-Table B5).

Diversification, adoption of advanced technology and co-management are adaptive strategies that build resilience in Arctic fisheries systems to manage shocks and stressors associated with changes, and to adapt to climate change. In addition to these three key adaptive strategies, we identify four place-specific attributes that support adaptive strategies and shape community adaptation: Inuit worldviews, Inuit institutions, a culture of sharing and collaboration, and ILK systems (Appendix B-Table B6). Each attribute has the ability to support adaptation under given circumstances. The combination of these four attributes will reduce system vulnerability and help build resilience of Inuit fisheries systems by increasing adaptive capacity. Four attributes, together or in combination with adaptive strategies, collectively influence the community's process of adaptation to change. For example, the implications of climate change impacts (such as changing sea-ice conditions that lead to limiting harvests) will be partly addressed by a broad range of adaptive responses such as the use of money saved from past turbot fishing, the selling of seal skins to the HTA, the hunting of caribou/fox and waiting patiently until conditions return to normal.

4.5 Conclusion

This paper examines the ways in which Indigenous fishers experience and respond to change by assessing community adaptations of the Pangnirtung Inuit. Climate change creates multiple changes in Arctic fisheries systems; Inuit show multiple responses to adapt to these changes. The findings highlight three adaptive strategies (diversification, technology, and co-management) as well as the place-specific attributes (worldviews, institutions, culture of sharing, and ILK) that shape community adaptation. The study provides new insights for communities, scientists, and policymakers that may facilitate them to work together to support community adaptation. First, an understanding of the ways in which fishers experience and respond to change is essential to better understand adaptations; to carry out such an assessment, the resilience-based conceptual framework (place, human agency, collective action, institutions, ILK, learning) may be used. Second, the information required to link community adaptation realities to government plans to develop better fisheries adaptation policy may be explored under a co-management setting. Third, from the community perspective, an understanding of community adaptations can enable self-evaluation of community adaptation processes for future planning and adjustments.

4.6 References

ADGER, W. N. 2003. Social capital, collective action, and adaptation to climate change. *Economic Geography,* 79**,** 387-404.

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

AMAP 2018. Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xvi-354pp.

AMUNDSEN, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment,* 20**,** 257-276.

ARCTIC-COUNCIL 2013. Arctic Resilience Interim Report 2013. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm.

ARCTIC COUNCIL 2016. Arctic Resilience Report, Arctic Council. *In:* CARSON, M. & PETERSON, G. (eds.). Stockholm: Stockholm Environment Institute and Stockholm Resilience Centre.

ARLINGHAUS, R., ALÓS, J., BEARDMORE, B., DAEDLOW, K., DOROW, M., FUJITANI, M., HÜHN, D., HAIDER, W., HUNT, L. & JOHNSON, B. 2017. Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. *Reviews in Fisheries Science & Aquaculture,* 25**,** 1-41.

ARMITAGE, D. 2005. Adaptive capacity and community-based natural resource management. *Environmental management,* 35**,** 703-715.

ARMITAGE, D., BERKES, F., DALE, A., KOCHO-SCHELLENBERG, E. & PATTON, E. 2011. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change,* 21**,** 995-1004.

ARMITAGE, D., MARSCHKE, M. & PLUMMER, R. 2008. Adaptive co-management and the paradox of learning. *Global environmental change,* 18**,** 86-98.

ARMITAGE, D. R., PLUMMER, R., BERKES, F., ARTHUR, R. I., CHARLES, A. T., DAVIDSON-HUNT, I. J., DIDUCK, A. P., DOUBLEDAY, N. C., JOHNSON, D. S. & MARSCHKE, M. 2009. Adaptive co-management for social–ecological complexity. *Frontiers in Ecology and the Environment,* 7**,** 95-102.

BÉNÉ, C., NEWSHAM, A., DAVIES, M., ULRICHS, M. & GODFREY-WOOD, R. 2014. Review article: resilience, poverty and development. *Journal of International Development,* 26**,** 598-623.

BERG, B. L. 2016. *Qualitative research methods for the social sciences,* Boston, Pearson Education.

BERKES, F. & ARMITAGE, D. 2010. Co-management institutions, knowledge, and learning: Adapting to change in the Arctic. *Etudes/Inuit/Studies***,** 109-131.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F., FOLKE, C. & COLDING, J. (eds.) 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience,* Cambridge, UK: Cambridge University Press.

BERKES, F. & JOLLY, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology,* 5**,** 18.

BOWEN, G. A. 2008. Naturalistic inquiry and the saturation concept: a research note. *Qualitative research,* 8**,** 137-152.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

CAMPBELL, D. & BERGERON, J. 2012. Natural revegetation of winter roads on peatlands in the Hudson Bay lowland, Canada. *Arctic, Antarctic, and Alpine Research,* 44**,** 155-163.

CAREY, M. A. & ASBURY, J.-E. 2016. *Focus group research,* London, Routledge.

CARLSSON, L. & BERKES, F. 2005. Co-management: concepts and methodological implications. *Journal of environmental management,* 75**,** 65-76.

CHARBONNEAU-ROBERTS, G., YOUNG, K. & EGELAND, G. M. 2007. Inuit anthropometry and insulin resistance. *International journal of circumpolar health,* 66**,** 129-134.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8**,** 117-123.

CINNER, J. E., HUCHERY, C., HICKS, C. C., DAW, T. M., MARSHALL, N., WAMUKOTA, A. & ALLISON, E. H. 2015. Changes in adaptive capacity of Kenyan fishing communities. *Nature Climate Change,* 5**,** 872-876.

CLARK, D. G., FORD, J. D., BERRANG-FORD, L., PEARCE, T., KOWAL, S. & GOUGH, W. 2016a. The role of environmental factors in search and rescue incidents in Nunavut, Canada. *Public health,* 137**,** 44-49.

CLARK, D. G., FORD, J. D., PEARCE, T. & BERRANG-FORD, L. 2016b. Vulnerability to unintentional injuries associated with land-use activities and search and rescue in Nunavut, Canada. *Social Science & Medicine,* 169**,** 18-26.

CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. 2016. *Key methods in geography,* London, Sage.

CLINE, T. J., SCHINDLER, D. E. & HILBORN, R. 2017. Fisheries portfolio diversification and turnover buffer Alaskan fishing communities from abrupt resource and market changes. *Nature communications,* 8**,** 14042.

COLLINGS, P., MARTEN, M. G., PEARCE, T. & YOUNG, A. G. 2016. Country food sharing networks, household structure, and implications for understanding food insecurity in Arctic Canada. *Ecology of food and nutrition,* 55**,** 30-49.

CONDON, R. G. 1990. The rise of adolescence: Social change and life stage dilemmas in the Central Canadian Arctic. *Human Organization***,** 266-279.

D'ARMENGOL, L., CASTILLO, M. P., RUIZ-MALLÉN, I. & CORBERA, E. 2018. A systematic review of co-managed small-scale fisheries: Social diversity and adaptive management improve outcomes. *Global environmental change,* 52**,** 212-225.

DIEMER, K. M., CONROY, M. J., FERGUSON, S. H., HAUSER, D. D., GRGICAK-MANNION, A. & FISK, A. T. 2011. Marine mammal and seabird summer distribution and abundance in the fjords of northeast Cumberland Sound of Baffin Island, Nunavut, Canada. *Polar biology,* 34**,** 41-48.

DOWSLEY, M. 2015. Identity and the evolving relationship between Inuit women and the land in the eastern Canadian Arctic. *Polar Record,* 51**,** 536-549.

DUERDEN, F. 2004. Translating climate change impacts at the community level. *Arctic,* 57**,** 204-212.

EGELAND, G. M., CHARBONNEAU-ROBERTS, G., KULUGUQTUQ, J., KILABUK, J., OKALIK, L., SOUEIDA, R. & KUHNLEIN, H. V. 2009. Back to the future: using traditional food and knowledge to promote a healthy future among Inuit. *Indigenous Peoples' Food Systems.* Food and Agriculture Organization of the United Nations, Centre for Indigenous Peoples' Nutrition and Environment, Rome 2009.

FAIRCLOUGH, N. 2013. Critical Discourse Analysis: The Critical Study of Language.

FIDELMAN, P., VAN TUYEN, T., NONG, K. & NURSEY-BRAY, M. 2017. The institutions-adaptive capacity nexus: Insights from coastal resources co-management in Cambodia and Vietnam. *Environmental Science & Policy,* 76**,** 103-112.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FORD, J., MCDOWELL, G. & PEARCE, T. 2015a. The adaptation challenge in the Arctic. *Nature Clim. Change,* 5**,** 1046-1053.

FORD, J. D. 2009a. Sea ice, climate change, and community vulnerability in northern Foxe Basin, Canada. *Clim. Res.,* 38**,** 137-154.

FORD, J. D. 2009b. Vulnerability of Inuit food systems to food insecurity as a consequence of climate change: a case study from Igloolik, Nunavut. *Regional Environmental Change,* 9**,** 83-100.

FORD, J. D. 2014. Adapting to the effects of climate change on Inuit health. *Am. J. Public Health,* 104**,** e9-e17.

FORD, J. D. & BEAUMIER, M. 2011. Feeding the family during times of stress: experience and determinants of food insecurity in an Inuit community. *The Geographical Journal,* 177**,** 44-61.

FORD, J. D., BELL, T. & ST-HILAIRE-GRAVEL, D. 2010. Vulnerability of community infrastructure to climate change in Nunavut: a case study from Arctic Bay. *Community adaptation and vulnerability in arctic regions.* Springer.

FORD, J. D., CAMERON, L., RUBIS, J., MAILLET, M., NAKASHIMA, D., WILLOX, A. C. & PEARCE, T. 2016. Including Indigenous knowledge and experience in IPCC assessment reports. *Nature Clim. Change,* 6**,** 349-353.

FORD, J. D., CLARK, D., PEARCE, T., BERRANG-FORD, L., COPLAND, L., DAWSON, J., NEW, M. & HARPER, S. L. 2019. Changing access to ice, land and water in Arctic communities. *Nature Climate Change,* 9**,** 335-339.

FORD, J. D., COUTURE, N., BELL, T. & CLARK, D. G. 2018. Climate change and Canada's north coast: research trends, progress, and future directions. *Environmental Reviews,* 26**,** 82-92.

FORD, J. D., MCDOWELL, G. & PEARCE, T. 2015b. The adaptation challenge in the Arctic. *Nature Climate Change,* 5**,** 1046-1053.

FORD, J. D., MCDOWELL, G., SHIRLEY, J., PITRE, M., SIEWIERSKI, R., GOUGH, W., DUERDEN, F., PEARCE, T., ADAMS, P. & STATHAM, S. 2013. The dynamic multiscale nature of climate change vulnerability: an Inuit harvesting example. *Annals of the Association of American Geographers,* 103**,** 1193-1211.

FORD, J. D. & SMIT, B. 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic***,** 389-400.

FORD, J. D., SMIT, B. & WANDEL, J. 2006. Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. *Global Environmental Change,* 16**,** 145-160.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2018. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C., eds. FishAdapt: The Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, 2018 Bangkok. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO.

GALAPPATHTHI, E. K. & BERKES, F. 2015. Can co-management emerge spontaneously? Collaborative management in Sri Lankan shrimp aquaculture. *Marine Policy,* 60**,** 1-8.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GILES, A. R., LYNCH, M., STADIG, G. S., DOUCETTE ISSALUK, M., DARROCH, F. & STRACHAN, S. 2014. Using a Public Health Approach to Understand "Skipping"

Snowmobiles in Pangnirtung, Nunavut, Canada. *International Journal of Aquatic Research and Education,* 8**,** 6.

GREBMEIER, J. M., OVERLAND, J. E., MOORE, S. E., FARLEY, E. V., CARMACK, E. C., COOPER, L. W., FREY, K. E., HELLE, J. H., MCLAUGHLIN, F. A. & MCNUTT, S. L. 2006. A major ecosystem shift in the northern Bering Sea. *Science,* 311**,** 1461-1464.

HANCOCK, D. R. & ALGOZZINE, B. 2015. *Doing case study research: A practical guide for beginning researchers,* London, Teachers College Press.

HARWOOD, L., SMITH, T., GEORGE, J., SANDSTROM, S., WALKUSZ, W. & DIVOKY, G. 2015. Change in the Beaufort Sea ecosystem: diverging trends in body condition and/or production in five marine vertebrate species. *Progress in Oceanography,* 136**,** 263-273.

HUET, C., FORD, J. D., EDGE, V. L., SHIRLEY, J., KING, N. & HARPER, S. L. 2017. Food insecurity and food consumption by season in households with children in an Arctic city: a cross-sectional study. *BMC public health,* 17**,** 578.

HUNTINGTON, H. P., BEGOSSI, A., GEARHEARD, S. F., KERSEY, B., LORING, P. A., MUSTONEN, T., PAUDEL, P. K., SILVANO, R. A. & VAVE, R. 2017. How small communities respond to environmental change: patterns from tropical to polar ecosystems. *Ecology and Society,* 22.

IDROBO, C. J. & BERKES, F. 2012. Pangnirtung inuit and the Greenland shark: co-producing knowledge of a little discussed species. *Human Ecology,* 40**,** 405-414.

ISLAM, M. M., SALLU, S., HUBACEK, K. & PAAVOLA, J. 2014. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change,* 14**,** 281-294.

KAJÁN, E. 2014. Community perceptions to place attachment and tourism development in Finnish Lapland. *Tourism Geographies,* 16**,** 490-511.

KESKITALO, E. C. H., DANNEVIG, H., HOVELSRUD, G. K., WEST, J. J. & SWARTLING, Å. G. 2011. Adaptive capacity determinants in developed states: examples from the Nordic countries and Russia. *Regional Environmental Change,* 11**,** 579-592.

KÖNIG, U. 2018. Climate change and snow tourism in Australia. *Geographica Helvetica,* 54**,** 147-157.

KRAL, M. J. 2012. Postcolonial suicide among Inuit in arctic Canada. *Culture, medicine, and psychiatry,* 36**,** 306-325.

LAIDLER, G. J., DIALLA, A. & JOAMIE, E. 2008. Human geographies of sea ice: freeze/thaw processes around Pangnirtung, Nunavut, Canada. *Polar Record,* 44**,** 335-361.

LAIDLER, G. J., ELEE, P., IKUMMAQ, T., JOAMIE, E. & APORTA, C. 2010. Mapping Inuit sea ice knowledge, use, and change in Nunavut, Canada (Cape Dorset, Igloolik, Pangnirtung). *In:* KRUPNIK I., APORTA C., GEARHEARD S., LAIDLER G. & L., K. H. (eds.) *SIKU: Knowing our ice.* Dordrecht: Springer.

LAIDLER, G. J., FORD, J. D., GOUGH, W. A., IKUMMAQ, T., GAGNON, A. S., KOWAL, S., QRUNNUT, K. & IRNGAUT, C. 2009. Travelling and hunting in a changing Arctic: assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. *Climatic change,* 94**,** 363-397.

LAIDLER, G. J., HIROSE, T., KAPFER, M., IKUMMAQ, T., JOAMIE, E. & ELEE, P. 2011. Evaluating the Floe Edge Service: how well can SAR imagery address Inuit community concerns around sea ice change and travel safety? *The Canadian Geographer/Le Géographe canadien,* 55**,** 91-107.

LANGE, M. & CONSORTIUM, B. 2003. The Barents Sea impact study (BASIS): methodology and first results. *Continental shelf research,* 23**,** 1673-1694.

LARSEN, J. N. & FONDAHL, G. 2015. Arctic human development report: Regional processes and global linkages. Rosendahls-Schultz Grafisk, Denmark: Nordic Council of Ministers.

LAURIER, E. 2016. Participant and Non-participant Observation. *In:* CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. (eds.) *Key methods in Geography.* London: Sage.

LE CORRE, M., DUSSAULT, C. & CÔTÉ, S. D. 2017. Weather conditions and variation in timing of spring and fall migrations of migratory caribou. *Journal of Mammalogy,* 98**,** 260-271.

LEHTI, V., NIEMELÄ, S., HOVEN, C., MANDELL, D. & SOURANDER, A. 2009. Mental health, substance use and suicidal behaviour among young Indigenous people in the Arctic: a systematic review. *Social Science & Medicine,* 69**,** 1194-1203.

LONGHURST, R. 2016. Semi-structured Interviews and Focus Group. *In:* CLIFFORD, N., COPE, M., GILLESPIE, T. & FRENCH, S. (eds.) *Key Methods in Geography.* 3 ed. London: Sage.

MAGEE, T. 2013. *A field guide to community based adaptation,* London, Routledge.

MAHON, R., MCCONNEY, P. & ROY, R. N. 2008. Governing fisheries as complex adaptive systems. *Marine Policy,* 32**,** 104-112.

MCCUBBIN, S., SMIT, B. & PEARCE, T. 2015. Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu. *Global Environmental Change,* 30**,** 43-55.

MOORE, J. S., LOEWEN, T., HARRIS, L. & TALLMAN, R. 2014. Genetic analysis of sympatric migratory ecotypes of Arctic charr Salvelinus alpinus: alternative mating tactics or reproductively isolated strategies? *Journal of fish biology,* 84**,** 145-162.

NELSON, F. E., ANISIMOV, O. A. & SHIKLOMANOV, N. I. 2002. Climate change and hazard zonation in the circum-Arctic permafrost regions. *Natural Hazards,* 26**,** 203-225.

NICHOLS, T., BERKES, F., JOLLY, D., SNOW, N. B. & HARBOUR, C. O. S. 2004. Climate change and sea ice: local observations from the Canadian Western Arctic. *Arctic***,** 68-79.

PEACOCK, E., TAYLOR, M. K., LAAKE, J. & STIRLING, I. 2013. Population ecology of polar bears in Davis Strait, Canada and Greenland. *The Journal of Wildlife Management,* 77**,** 463-476.

PEARCE, T., FORD, J., WILLOX, A. C. & SMIT, B. 2015. Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic,* 68**,** 233.

PELLING, M., HIGH, C., DEARING, J. & SMITH, D. 2008. Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations. *Environment and Planning A,* 40**,** 867-884.

POOLE, K. G., GUNN, A., PATTERSON, B. R. & DUMOND, M. 2010. Sea ice and migration of the Dolphin and Union caribou herd in the Canadian Arctic: an uncertain future. *Arctic***,** 414-428.

ROUX, M.-J., TALLMAN, R. F. & MARTIN, Z. A. 2018. Small-scale fisheries in Canada's Arctic: Combining science and fishers knowledge towards sustainable management. *Marine Policy,* xxx**,** xxx-xxx.

RUIZ-CASTELL, M., MUCKLE, G., DEWAILLY, É., JACOBSON, J. L., JACOBSON, S. W., AYOTTE, P. & RIVA, M. 2015. Household crowding and food insecurity among Inuit families with school-aged children in the Canadian Arctic. *American Journal of Public Health,* 105**,** e122-e132.

SAVO, V., MORTON, C. & LEPOFSKY, D. 2017. Impacts of climate change for coastal fishers and implications for fisheries. *Fish and Fisheries,* 18**,** 877-889.

SCREEN, J. A. & SIMMONDS, I. 2010. The central role of diminishing sea ice in recent Arctic temperature amplification. *Nature,* 464**,** 1334.

SHORT, N., LEBLANC, A. M., SLADEN, W. E., CARBONNEAU, A. S. & ALLARD, M. 2011. Seasonal Surface Displacement Derived from InSAR, Pangnirtung, Nunavut; Geological Survey of Canada, Canadian Geoscience Map 67, 2012; 1 sheet; 1 CD-ROM, doi: 10.4095/289607.

SPINNEY, J. A. 2010. *Perceptions of Vulnerability to" severe" Weatehr in Pangnirtung, Nunavut.* School of Graduate and Postdoctoral Studies, University of Western Ontario.

VAN DIJK, T. A. 2015. Critical discourse analysis. *In:* TANNEN, D., HAMILTON, H. E. & SCHIFFRIN, D. (eds.) *The handbook of discourse analysis.* New Delhi, India: John Wiley & Sons, Inc.

VAN LEEUWEN, T. 2015. Critical discourse analysis. *The International Encyclopedia of Language and Social Interaction***,** 1-7.

WILLIAMS, D. R. & PATTERSON, M. E. 2008. Place, leisure, and well-being. *In:* EYLES, J. & WILLIAMS, A. (eds.) *Sense of place, health and quality of life.* Surrey, UK: Ashgate.

YOW, V. R. 2014. *Recording oral history: A guide for the humanities and social sciences,* New York, Rowman & Littlefield.

Preface to Chapter 5

The previous chapter examined Inuit adaptation to climate change in the Canadian Arctic, using the resilience-based conceptual framework. In chapter 5, I apply the same framework to assess community adaptations to climate change among Coastal-Vedda in Sri Lanka. This chapter aims to examine how the Coastal-Vedda population experiences and responds to change in a tropical setting. This empirical work is based on intensive fieldwork in Sri Lanka over the last three years. The chapter identifies climate change impacts that co-exist with the non-climatic drivers that are dominant among the prevailing changes faced by Coastal-Vedda over the last three decades. Three community-level adaptive strategies are adaptive institutions with a multi-level institutional structure, the diversification of livelihoods, and the use of aquaculture. Further, the chapter identifies place-specific attributes that shape the adaptation process, such as Indigenous identity and worldviews, co-management of aquaculture, flexibility, and knowledge systems and learning.

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Chapter 5. Climate change and adaptation to social-ecological change: The case of Indigenous people and culture-based fisheries in Sri Lanka

Abstract

Rural coastal fishery systems in tropical island nations are undergoing rapid change. Using a case study from eastern Sri Lanka, this paper examines the ways in which Indigenous Coastal-Vedda fishers experience and respond to such change. We conducted semi-structured interviews (n=74), focus group discussions (n=17, 98 participants), and key informant interviews (n=38) over a two year period (2016-2019). The changes that most Coastal-Vedda fishers experience are: disturbance from Sri Lankan ethnic war, changes in climate and the frequency and severity of natural disasters, increased frequency of human-elephant conflicts, increasingly unpredictable weather patterns, and transformation of the Coastal-Vedda due to social modernisation. We used a resilience-based conceptual framework focusing on place, human agency, collective action and collaboration, institutions, Indigenous and local knowledge systems, and learning to examine fishers' responses to rapid changes. We identified three community-level adaptive strategies used by the Coastal-Vedda: adaptive institutions with a multi-level institutional structure that facilitates collective action and collaboration, the use of culture-based fisheries (CBF), and diversification of livelihoods. We also recognised four place-specific attributes that shaped community adaptations: cultural identity and worldviews, co-management of CBF, flexibility in choosing adaptive options, and Indigenous and local knowledge systems and learning. These adaptive strategies and place-specific attributes provide new insights for scientists, policymakers, and communities in the region, enabling them to more effectively work together to support community adaptation.

5.1 Introduction

While environmental change is global, its effects are felt most directly by local communities. Rural Coastal-Vedda communities in Sri Lanka are undergoing complex changes including climate change impacts (e.g., frequent extreme weather events leading to floods and droughts) (Esham and Garforth, 2013, Truelove et al., 2015), civil war (1983-2009) (Aaronson, 2016, Zoysa, 2018), tsunami devastation (2004) (Lehman, 2014), and globalization. These changes have profound impacts on Coastal-Vedda communities, altering their livelihoods, culture, and lifestyle, and creating risks and opportunities (Pelling et al., 2015). Coastal-Vedda communities are also likely to be amongst those most exposed to and impacted by climate change. Identifying ways to reduce, through adaptation, the risks that global and local changes pose is an emerging topic in research on decision-making in natural resource management sectors including fisheries and aquaculture (Cinner et al., 2018b, Galappaththi et al., 2019d). Understanding how fisheries and aquaculture communities experience and respond to rapid change is essential for supporting adaptation processes.

While empirical assessment of communities' adaptation to change is an increasingly active area of research, little work focuses on Indigenous peoples and culture-based fisheries (CBF)[1], particularly climate change in eastern Sri Lanka. Studies do focus on other aspects of CBF (Amarasinghe and Nguyen, 2009, Pushpalatha and Chandrasoma, 2010, Amarasinghe and Wijenayake, 2015, Wijenayake et al., 2016) and climate change impacts (Yamane, 2003, De Silva et al., 2007, Esham and Garforth, 2013) in Sri Lanka. The eastern part of the island has received limited attention due mainly to its three decades of civil unrest (Lehman, 2014). Against this backdrop, we use a case study from the Kunjankalkulam community in eastern Sri Lanka to assess community adaptations to climate change in Coastal-Vedda fisher communities. The paper has two objectives: i) examine how Coastal-Vedda fishers experience change, including climate change; and ii) investigate how Coastal-Vedda fishers respond and adapt to such change. In the next section, we describe Coastal-Vedda within the context of the Indigenous populations of Sri Lanka, and the study's conceptual and methodological approach. Following the 'methods' section, we reveal means by which Coastal-Vedda fishers build resilience and minimise vulnerability (i.e. adapt) to the impacts of climate change. Finally, we identify potential community adaptive strategies and attributes that shape community adaptations in a CBF setting.

[1] CBF are essentially a form of extensive aquaculture, or a farming practice conducted in small water bodies (generally less than 100 ha). These water bodies would not be able to support a capture fishery due to a lack of adequate natural recruitment of suitable species. Artificial water bodies, not built for fishery/aquaculture purposes (such as village tanks) but often built for irrigation purposes, can be used (De Silva et al. 2006: 11).

5.2 Methods

5.2.1 Indigenous peoples in Sri Lanka

Sri Lanka's Indigenous populations refer to themselves as *Wanniya-laeto*[2] ('people of the forest') (Lund, 2000: 102). Most Sri Lankans use '*Vedda*'[3] to identify the country's Indigenous populations (Seligmann and Seligmann, 1911, Lund, 2000, Attanapola and Lund, 2013). This term means 'the person who uses bows and arrows', referring to their practices of shifting cultivation, hunting, and trapping and of collecting forest products (Dharmadasa, 1993). The *Wanniya-laeto* have their own culture, way of life, and personality (Seligmann and Seligmann, 1911). In determining geographical boundaries, they recognise only natural landmarks. They also protect the forest they inhabit, as they believe their ancestors' spirits belong to it (Lund, 2000). However, from ancient times (including the war period), the *Wanniya-laeto* have peacefully co-existed with the island's majority Singhalese and Tamil populations (Seligmann and Seligmann, 1911, Brow, 1978, Dharmadasa, 1993).

Throughout the 19th and 20th centuries, the *Wanniya-laeto* were marginalised and forced to relocate (Lund, 2000: 102) mainly because of (post)colonialism and development activities (Attanapola and Lund, 2013). The Sri Lankan government is primarily responsible for marginalising and disempowering the Indigenous population, mainly by weakening the population's knowledge systems and capacities (Lund, 2000, Attanapola and Lund, 2013). Thus, the locals have lost their connection to ancestral lands (Lund, 2000). The *Wanniya-laeto* have rapidly and inconsistently adapted to new social, cultural, and political contexts, including the new administrative structure and market economic system (Lund, 2000, Attanapola and Lund, 2013). They appear to be at a crossroads between traditional and modern systems (Latour, 2012, Attanapola and Lund, 2013).

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[2] '*Wanniya-laeto*' is the plural term and '*Wanniya-laeta*' (masculine) or 'Wanniya-laeti' (feminine) is the singular term.

[3] '*Vedda*' is the singular term and '*Veddas*' is the plural.

In this paper, we study 'Coastal-Vedda'[4], a group of *Wanniya-laeto* who migrated to eastern Sri Lanka's coastal areas. Historically, Costal-Vedda moved within the forest in the eastern coastal belt, fishing and cultivating vegetables around their huts and in clearings in the jungle (slash, burn, and shifting to another area)—known as 'Chena cultivation' (Dharmadasa, 1993, Childs, 2017). They cultivated maize, pumpkin, and other easy-to-grow crops. Later, Coastal-Vedda mixed with the Tamil populations in the eastern area[5]. The main livelihood of the Coastal-Veddas living on the seaboard was fishing in the sea or in lagoons (Seligmann and Seligmann, 1911, Dharmadasa, 1993). The others fished in tanks, rivers, and streams, using methods such as emptying water courses, and using poisonous leaves and creepers. They used traditional fishing gear like *karaka* and *kemana*, as well as made their own, such as cast nets, spears, and bifid iron spearheads. Coastal-Vedda also use arrows as harpoons for fishing (Seligmann and Seligmann, 1911).

Currently, Coastal-Vedda live in four villages in the eastern region. They have lived in Kunjankalkulam since the 1960s, after the government built the village tank to promote irrigation (rice farming). The national Coastal-Vedda Chief resides in Kunjankalkulam (population = 193) (Figure 5.1). The Kunjankalkulam *Wanniya-laeto* population has Indigenous cultural practices and values similar to inland *Wanniya-laeto*. Kunjankalkulam is a remote, isolated community accessible only by a gravel road. People use bicycles, motorbikes, and tractors to commute. The inhabitants face unique challenges including food insecurity, a lack of drinking water and infrastructure (roads and housing), and low high school graduation rates (Herath and Joseph, 2016, Gunatilaka, 2017). This region was affected by the Sri Lankan civil war (1983-2009), tsunami devastation (2004), and climate change impacts such as droughts, floods, and tropical storms (De Jong et al., 2002, Yamada et al., 2006, Esham and Garforth, 2013), which increases the complexities of the Coastal-Vedda way of life and the natural environment.

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[4] 'Coastal-Vedda', refer to themselves as '*Muhudu-Vedda*', meaning '*Wanniya-laeto* of the cost'. The term 'Coastal-Vedda' is the standard translation of '*Muhudu-Vedda'*.

[5] Eastern Sri Lanka used to be a Tamil-dominated area but presently Muslim populations are becoming more dominant in terms of population growth and culture, including building architecture.

Figure 5.1: Study location. (a) Eastern Sri Lanka, (b) Location of the Kunjankalkulam community, (c) Reservoir, village settlements, and rice farms.

Kunjankalkulam is one of the few Coastal-Vedda communities in the region with a high level of fisheries activity and high non-fisheries livelihood diversity. Coastal-Vedda use a village tank (reservoir) to raise fish (i.e., reservoir aquaculture[6]) as a main community livelihood activity. The community is in a dry climatic zone where reservoir aquaculture is challenging. The north-eastern tropical monsoon and the weather dynamics in the Bay of Bengal influence the region's weather. Eastern Sri Lanka gets rain and high winds between October and January and remains dry for the remaining months (especially May through September). Rice farming is another essential livelihood activity, though unexpected climate changes (mainly extended droughts) do not allow Coastal-Vedda to farm consistently. Human-wild elephant conflicts are common; protecting the rice harvest from elephants is another challenge facing Coastal-Vedda. Furthermore, Coastal-Vedda use the surrounding forest for livelihood activities such as collecting wild honey, medicinal/edible plants, fruits, and wood for selling, as well as trapping/hunting.

5.2.2 Conceptual approach

We took a social-ecological systems (SES) approach to understanding the interconnected but partly distinct nature of integrated 'Coastal-Vedda' and 'Kunjankalkulam' sub-systems (Berkes et al., 1998, Berkes et al., 2003). The SES approach emphasizes neither purely ecosystems nor societies; rather, the SES and the connections between the system's ecological and social

[6] Coastal-Vedda's operation in the village reservoir is arguably closer to culture-based fisheries (CBF), which is a form of extensive aquaculture. For CBF, fish fingerlings are stocked after monsoonal rains fill the reservoir and are harvested before the reservoir dries up. However, in Kunjankalkulam, Coastal-Vedda engage in reservoir fishing throughout the year, irrespective of the water level. Further, this reservoir is equipped with a pen culture system. Therefore, throughout this paper, we use the term 'reservoir aquaculture' instead of CBF.

components are the focus. Economic systems and markets are not treated separately but as deeply nested in an SES approach, creating understanding of the complexities in Coastal-Vedda aquaculture—what can be termed 'complex adaptive aquaculture systems' (Mahon et al., 2008, Folke, 2016, Arlinghaus et al., 2017). 'Aquaculture systems' refers to the coupled sub-systems of Kunjankalkulam Coastal-Vedda and their forest/land/water and associated socio-economic and cultural aspects related to CBF activities.

We use a resilience-based conceptual framework (Galappaththi et al., 2019d) to identify and assess the adaptations of Kunjankalkulam Coastal-Vedda towards stressors of the aquaculture system. The framework has six characteristics that develop an understanding of SES change and human responses to such change: place, human agency, collective action and collaboration, institutions, Indigenous and local knowledge (ILK) systems, and learning (Table 5.1). This framework provides indicators that guide the assessment process. Results are structured around such indicators under each framework characteristic. A unique conceptualisation of resilience (as a function of coping, adapting, and transformative capacities) (Béné et al., 2014, Brown, 2016) permits a macro-level understanding of adaptation with micro-level comprehensive details in fishing communities. This conceptual tool was developed through an integration of resilience thinking and development studies (Galappaththi et al., 2019d). We used this framework to assess the community adaptation process in Coastal-Vedda aquaculture systems and obtain insights into adaptation needs and relevant policy.

Table 5.1: Definitions of characteristics of the resilience-based framework (Galappaththi et al., 2019).

Characteristic	Definition	Indicators
Place	Social and physical space with attachments to Coastal-Vedda and social processes. Attachment to place is understood as bonding that occurs between people and their meaningful environments (e.g., livelihoods, culture, and well-being).	1) Number of species available for fishing. 2) Level of fishery/aquaculture resource availability. 3) Level of vulnerabilities for fishing operations such as climatic uncertainties. 4) Changes in livelihood activities relative to place (hunting/fishing). 5) Culture, including belief systems and perceptions linked to place.
Human agency	Coastal-Vedda (individual or collective) capacity to act independently in making decisions as part of the Coastal-Vedda way of life.	1) Ownership of or access to fishing gear (canoes, nets). 2) Fishing gear diversity (number of different items of fishing gear used). 3) Occupational mobility (number of different fishing operations practiced). 4) Occupational multiplicity (number of jobs in the

		household). 5) Access to credit (loans) and insurance. 6) Use of technological advancements.
Collective action and collaboration	Action taken together (or shared) by a group of two or more people to meet a common desired objective.	1) Sharing of fish. 2) Sharing of fishing gear. 3) Spreading of weather information. 4) Sharing of information about fishing operations (selling prices, production quotas, and techniques/management practices). 5) Social networks.
Institutions	Local organizations that facilitate collective action meeting a local goal (e.g., co-managed institutions).	1) The aim of institutions (e.g., contribution to local aquaculture activities). 2) Ownership (communal, local/Indigenous, private). 3) Decision-making power. 4) Existence of partnerships.
ILK systems	Co-evolving cumulative body of knowledge (including observations, experience, lessons, and skills) belonging to Coastal-Vedda aquaculture systems (or a place) and handed down through generations by cultural transmission; reflects Coastal-Vedda cultural identity.	1) Application of such knowledge. 2) Co-production of knowledge (combining Indigenous knowledge with other kinds of knowledge such as local knowledge and/or traditional knowledge). 3) Weakening of local/Indigenous/ traditional knowledge throughout SES change.
Learning	Social learning, which itself is collective action and reflection among Coastal-Vedda as they work to improve the management of human-environment interactions.	1) Extent of the practice of learning-by-doing in the fishing way of life. 2) Number of learning opportunities. 3) Ways local philosophical worldviews are compatible with adaptive thinking.

5.2.3 Data collection methods

We used a community-based participatory research approach (Magee, 2013) to ensure community engagement in shaping knowledge production. The study received community feedback through the national Coastal-Vedda Chief, informants from local institutions (e.g., NAqDA-National Aquaculture Development Authority, Batticaloa), and research assistants. During field data collection, the researcher relied on five language translators (Tamil/Coastal-Vedda language to English) and three local research assistants. All field data were collected according to the McGill Research Ethics Board Certificate of Ethical Acceptability of Research Involving Humans (file number: 52-0617) as well as under the consensus of the (Coastal) Vedda Chief of Sri Lanka.

We used a qualitative research design for primary data collection to understand how Coastal-Vedda fishers experience and respond to SES change, including climate change, in Kunjankalkulam. Field data were collected using multiple methods: participant observations

(PO), semi-structured interviews (SSI), key informant interviews (KII), and focus group discussions (FGD) (Berg, 2016, Laurier, 2016, Longhurst, 2016). PO helped us obtain contextual knowledge about Coastal-Vedda experiences and responses to change. As of March 2019, we had conducted 24 weeks of in-field PO during three visits to Kunjankalkulam and the surrounding area. The first visit was in August 2016 and involved reconnaissance, preliminary data collection, and the gathering of community feedback. The second visit was from September-December 2017 and involved the collection of data about the Coastal-Vedda's CBF and how locals cope with the rainy season. The third visit was from April-July 2018 and involved the collection of data about the changes Coastal-Vedda face during the dry season and their adaptations. The researcher's daily-updated field diary helped track PO data. The researcher spent much time with Coastal-Vedda fishers, attending community events, meetings, and community-based institutions. The researcher also made >20 fishing trips to the village reservoir and participated in most activities (e.g., fish stocking, net setting, harvesting, and fish landing site activities).

Seventy-four face-to-face semi-structured interviews (SSI) (Longhurst, 2016) were conducted with Coastal-Vedda fishers to document changes in the region and identify/characterize the response to them (Appendix-Table S1-key themes of the interview guide). A snowball sampling technique was used to select participants (3). Initially, the Coastal-Vedda leader introduced the researcher to the community; the researcher made most appointments via cell phones and sometimes by walking in. We recruited participants until saturation, when interviewees provided no new relevant information (Bowen, 2008). These interviews were conducted, audio-recorded, and transcribed in Kunjankalkulam from September 2017 through July 2018 (Appendix-Table S2-sample profiles). The SSI questioning focused on "change" in general to prevent bias and to keep the interviews open-ended, focusing on the issues and changes that Coastal-Vedda viewed as most important. This sample consisted of Coastal-Vedda fishers who permanently live in Kunjankalkulam. SSI obtained richer insights into 'place' and its meanings/attachments (Williams and Patterson, 2008, Kaján, 2014). All the interview questions relating to 'change' referred to "about 30 years back" in Coastal-Vedda's lives.

Thirty-eight key informant interviews (KIIs) were conducted and included questions about Coastal-Vedda, climate change, and CBF. The goal was to examine topics not accessible via PO and SSI, such as the Coastal-Vedda population (national Indigenous chief and Ministry of Cultural Affairs to find/verify the Coastal-Vedda community), co-management of CBF (e.g., NAqDA), and adaptive responses (e.g., NGOs—non-governmental organizations) in the community. The researcher conducted interviews with representatives from NAqDA (n=4), the Ministry of Cultural Affairs (n=4), the Department of Fisheries-Batticaloa (n=2), the Divisional Secretariat Office-Vakarai (n=1), the Ministry of *Mahaweli* Development and Environment-Colombo (n=6), the Department of Meteorology-Batticaloa (n=1), the World Vision International Zonal Office-Vakarai (n=1), the *Sabaragamuwa* University of Sri Lanka (n=1), and the University of the Visual and Performing Arts-Colombo (n=1), as well as individuals with knowledge of Coastal-Vedda (n=17). KII helped validate and describe data gathered using other methods.

Seventeen focus group discussions (FGD) (Carey and Asbury, 2016) were undertaken with 98 respondents to build thematic areas related to changes that Coastal-Vedda fishers experience (e.g., climate extremes, unpredictable weather patterns, increased human-elephant conflicts during the post-war period) and to identify how Coastal-Vedda respond to such changes (e.g., collective action and collaborations, community-based institutions, knowledge systems, and aquaculture). Coastal-Vedda groups of four to eight individuals participated in the FGD, organised throughout the data collection process (Appendix-Table S3-Details of FGDs). Further, FGD validated the data collected using other methods.

5.2.4 Data analysis

Qualitative interview data were translated into English and transcribed, then analysed using content analysis (Yow, 2014, Hancock and Algozzine, 2015, Berg, 2016, Clifford et al., 2016). The key techniques were manifest and latent content analysis (Vaismoradi et al., 2016, Krippendorff, 2018) supplemented with critical discourse analysis (Van Dijk, 2015, Wodak and Meyer, 2015) to develop themes and patterns related to Coastal-Vedda's experience and response to change. We also used direct quotations to support the results. We used Microsoft Excel 2013 to create descriptive statistics (e.g., percentages, mean values, standard deviations). Percentages in the text refer to the number of respondents from the immediately mentioned sub-sample who made that statement. Initially, the study recorded 16 types of changes that Coastal-

Vedda fishers experienced. We selected the five most-recorded areas of change (based on the data frequency) for further analysis. The results were supplemented with selected quotes (from SSI/KII) based on the latent content analysis. We identified links among the selected changes using data from PO and SSI and validated them through KII and FGD. Data relating to Coastal-Vedda fishers' response to change were mostly fed through the PO data (research diary, photos, and the researcher's first-hand experience), supplemented with SSI and KII.

5.3 Results

5.3.1 Experiencing SES change

Coastal-Vedda experience change in many ways. Key changes are: continued disturbances resulting from the civil war, extreme weather and natural disasters (e.g., cyclones, floods, drought), increased human-elephant conflicts, increasingly unpredictable weather patterns, social pressure from transformations towards modernization, materialistic values, and wellbeing. Some changes (e.g., human-elephant conflicts (Fernando et al., 2005, Santiapillai et al., 2010)) are more widely documented than others, yet certain changes are described as more important than others. These are profiled in Table 5.2.

Table 5.2: Fishers' quotes describing how Coastal-Vedda experience change (n=74).

Nature of change: "selected quotes from fishers"	Impacts	Implications
Continued disturbances to Coastal-Vedda way of life during the ethnic war (1983-2009) (86%): ***"…we [Coastal-Vedda] used to have more animals such as cattle, goats, chicken…but during the war we lost most of them [animals]…organised groups of people stole our village during fights...once we were back…our valuables are gone…including our animals."*** ***"…before war…we [Coastal-Vedda] had traditional hunting equipment [bow and arrow, spear] but during the war we got weapons…it was easy to hunt but after war we are not allow[ed] to keep guns anymore…and now we almost lost our traditional way of hunting."***	Coastal-Vedda lost livelihoods, lives, and assets during the war, disrupting the traditional way of life (hunting, cattle, chena cultivation) and weakening Coastal-Vedda's ILK systems. Now Coastal-Vedda cannot return to their old ways in terms of culture, education, and livelihoods.	-Loss of livelihoods. -Unsafe and high-risk living conditions. -New lifestyle and social transformation.
Extreme climate and natural disasters including cyclones, floods, and droughts (64%): ***"…fishing is not safe when the tank floods…women***	Shorter favorable climate for CBF (fish stocking) and fishing activities because of drought,	-Shorter aquaculture season. -Fewer fishing

don't fish in floods…" ***"…we [Coastal-Vedda] can grow larger fish if we have more water [in reservoir] in dry season…[fish buyers] don't pay much for smaller fish…"*** ***"…during dry season…cannot find water even for drinking."*** ***"…our [Coastal-Vedda] road completely eroded after heavy rains."***	floods, and stormy conditions. Unfavourable conditions diminish fish growth (lack of water) and lessen fishing time (floods).	days/hours. -Unsafe and high-risk living conditions.
Increasing in human-elephant conflicts during the post-war period (57%): ***"…wild elephants are scared of shell sounds…but after war…they return to this [village]…they destroyed our house."*** ***"…electric fence around the village to protect us [Coastal-Vedda] from wild elephants is not working for long time [over 15 years]…"***	The wild elephant threat creates an unsafe environment in the village and limits night-time fishing hours.	-Fewer fishing days/hours. -Unsafe and high-risk living conditions.
An increase in unpredictable weather patterns (30%): ***"…we cannot predict weather anymore…it's raining when it supposed to [be] sunny and it's drying when it supposed to rain."*** ***"last three years we [Coastal-Vedda] didn't receive monsoon rain as we expected…we lost our rice crop…same with fish fingerling stocking."***	Unpredictable weather decreases Coastal-Vedda's ability to prepare for fishing and other livelihood activities; it also complicates Coastal-Vedda's way of life.	-Shorter aquaculture season. -Fewer fishing days/hours. -Unsafe and high-risk living conditions. -Loss of livelihoods.
Coastal-Vedda transformation due to social modernization (Latour, 2012), development of materialistic values, and wellbeing (Singh, 2009)(28%): ***"…World Vision [NGO] help[ed] us build new cement house…"*** ***"…they [NGO] gave us [fishing] nets and fiberglass canoes…"*** ***"…gentlemen from NGO teach us how to save money…"*** ***"…I [young Coastal-Vedda fisher] want to [live] like other people in town…"***	Coastal-Vedda's culture and value system are influenced by popular culture and the social modernisation process. Coastal-Vedda moved to new cement housing funded by post-war/tsunami development programs and began to adapt to the cash economy and CBF/aquaculture. They are shifting to a materialistic-centered value system.	-New lifestyle and social transformation. -Loss of livelihoods.

5.3.2 Responding to SES change

This section examines how Coastal-Vedda respond to identified changes using the resilience-based conceptual framework. It is structured around the themes of place, human agency, collective action, institutions, knowledge systems, and learning (Galappaththi et al., 2019d).

5.3.2.1. Place

Place-specific conditions such as water availability for aquaculture, climatic conditions, and wildlife threats to livelihood activities can influence community adaptive capacity and processes (Amundsen, 2015, Adger, 2016). CBF supplies food for Kunjankalkulam year-round and is a key source of protein. This minor-non-perennial[7] reservoir (110 ha) was built during the 1960s to meet the demand for water to cultivate rice but currently is used primarily for CBF activities. This reservoir can no longer accommodate the seasonal water demand for rice farming due to extended droughts. The reservoir is close to village housing and rice farms. With the support of the government, fisheries and aquaculture institutions, and NGOs, an annual stock of eight varieties of fish fingerlings (Appendix-Table S4-aquaculture species) grows in the natural reservoir system. In 2017 this reservoir was stocked with 250k-300k fish fingerlings (tilapia, carp, and Indigenous fish) and 100k-150k freshwater prawn postlarvae. The estimated harvest for the year was 5-7k MT fish and prawns. The peak season for fish harvesting is March-September; the offseason begins with the heavy rains in October. In 2018 this reservoir received a pen culture system stocked with 100k fish fingerlings.

Coastal-Vedda practice two types of fishing activities. During the day, fisherwomen enter the water to fish using rods (Appendix-Figure S1-photos). They fish mainly for subsistence purposes. These locations change based on the reservoir water levels, which themselves depend on weather conditions. The most commonly caught fish are tilapia and Indigenous fish. During the day, fishermen rest or engage in other livelihood activities. Fishermen go fishing in the early morning (2-3 am) in deep areas of the reservoir, using canoes and gill nets. They look for commercial species (e.g., freshwater prawns, well-grown carp and tilapia). They use some of the harvest (small fish) for food purposes while selling large, high-quality fish to fish collectors (i.e., middlepersons who collect fish every morning and supply it to large markets in urban areas).

The Coastal-Vedda fisheries system has place-specific vulnerabilities. Wild elephant attacks affect the community's fishing activities and peak during rainy seasons. To repel elephants, fishers use special firecrackers and create fires. The community also has an inoperable electrified

[7] Most of the reservoirs used for CBF/aquaculture are minor-non-perennial reservoirs (50-200 ha at full water supply level) in Sri Lanka.

fence. The need to spend time and energy on wild elephants affects nighttime commercial fishing activities.

5.3.2.1. Human agency

A high level of human agency can indicate a high adaptive capacity to change (Cinner et al., 2015, Galappaththi et al., 2019d). This section uses livelihood diversification, access to credit, occupational multiplicity, access to assets, fishing gear diversity, and occupational mobility to understand the adaptive capacities of Coastal-Vedda fishers (Table 5.3).

Table 5.3: Indicators of human agency (n=74).

Indicators	Description	Mean	Standard deviation	How to improve adaptive capacity?
Occupational multiplicity	Total number of livelihood activities practiced in the household.	3.8	1.3	Increase the range of income options to cope with adverse conditions.
Access to assets	Access to number of assets required for fishing operations. We studied four assets: canoe; cycle; pen structure; fishing gear. The pen structure belongs to the community aquaculture institution (RFO).	2.3	0.9	Increase people's ability to engage in fishing activities; this allows Coastal-Vedda to earn more money and obtain enough food to survive.
Fishing gear diversity	Number of types of fishing gear used by each fisher. We studied five types of fishing gear: gill net; thread net; led net; fishing rod; pen structure.	3.2	1.8	Increase the potential/ capacity to harvest a range of large fish/prawns, which results in a higher income.
Occupational mobility	Number of fishing operations practiced during the past year per fisher. We studied four fishing activities: reservoir fishing (commercial); reservoir fishing (subsistence); pen culture; beach seine fishing.	2.1	0.4	Increase earning potential as well as the fish harvest (for food), which improves food availability and buying power.

Coastal-Vedda fishers engage in many livelihood activities to increase their income options in adverse conditions (Figure 5.2). Some activities were historically practiced (*collecting* wild honey/fruits/wood, hunting/trapping, chena/rice cultivation), while others are recent additions (aquaculture, beach seine fishing, *selling* wild honey/fruits/wood, income support). These activities reduce Coastal-Vedda reliance on CBF (or one specific livelihood activity) for food security. Livelihood diversification decreases the opportunity cost of Coastal-Vedda's dependence on CBF for food. Almost all (100%) the respondents were involved in CBF; 62% engaged in fishing for commercial aquaculture and 38% were involved in subsistence aquaculture. Almost all fishers involved in subsistence aquaculture were female. Gender roles are clearly set among Coastal-Vedda; women are not directly involved in commercial activities including night-time CBF.

> *…now we [Coastal-Vedda] save money, and women even have saving clubs … learnt that [saving money] from an NGO program…*—Young Coastal-Vedda
>
> *It's hard during dry season and flood season, but we do multiple activities [livelihoods] … I go fishing early morning and garden during the daytime … sometimes going to forest [to collect honey, fruits, or wood] instead [of gardening] … sometimes we buy rice or meat from town and make a vegetable and fish curry … I have options [livelihoods] now and I don't need to miss any meals anymore…*—Elder Coastal-Vedda

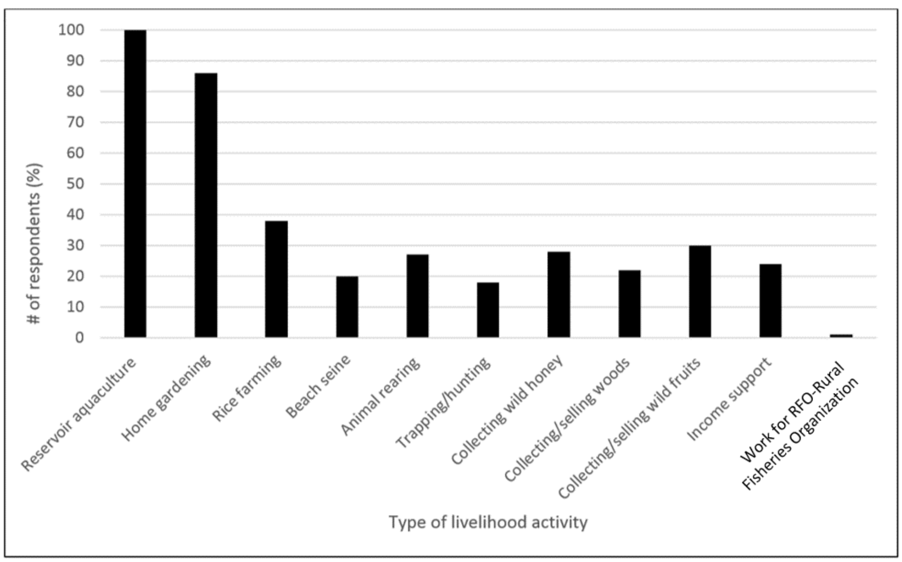


Figure 5.2: Type of livelihood activities of Coastal-Vedda.

We observed limited or no modern or advanced technology in CBF operations among Coastal-Vedda. However, particularly after the war, Coastal-Vedda have been undergoing rapid social modernisation (Latour, 2012), including the use of money (cash economy), modern clothing, cement housing, a non-mobile lifestyle, cell phone use, aquaculture, and fish selling activities (Childs, 2017, Ranasinghe and Cheng, 2018). Coastal-Vedda have limited access to credit (personal loans) for CBF activities but can borrow money from informal money lenders. Coastal-

Vedda's CBF operation doesn't involve major expenses, with the exception of fish fingerling stocking, which is funded by RFO, NGOs, and the government. Furthermore, through fisher compensation programs, Coastal-Vedda can obtain low-cost canoes and fishing gear.

5.3.2.2. Collective action and collaboration

Collective action and collaboration shape community adaptation by improving community cohesion and unity, which helps members cope with common changes through enhanced collective adaptive capacity (Adger, 2003, Armitage, 2005, Pelling et al., 2008). Collective action is embedded in Coastal-Vedda's way of life. An example is fisherwomen's daytime subsistence fishing operation. All the fish are collected into one sack and distributed equally among the families. This fishing operation is led by the village first-lady (spouse of the Coastal-Vedda chief). A rotational system determines who fishes on a particular day (similar to the *Padu* system (Lobe and Berkes, 2004) but in this case, the catch is shared). The fishing time can vary from two to five hours depending on the fishing spot and the community's needs. Fisherwomen usually remain in one fishing area for at least five days. This routine changes due to weather, the need to engage in other livelihood activities, or cultural priorities.

Also, groups of two to four Coastal-Vedda fishermen gather at night for commercial fishing operations; they set their nets and share their income. A majority (over 90%) of fishermen said they don't share large fish (of marketable size); however, they share small fish for food purposes. Most fishermen (52%) will not share their fishing gear (gillnets, canoe). Only 15% of fishermen said they would share. Within the sample of fisherwomen, 64% said they would share their gear (fishing rods), while 25% said they would not.

Coastal-Vedda use informal social networks to share important information about CBF activities. People—especially women—gather around the water well and drinking water tank to share daily updates, including fisheries-related information (e.g., the quality of the fish harvest, who went fishing/is planning to fish, and changes in fish prices) and non-fisheries-related information (e.g., alerts about wild animals). People also use informal social networks to share information about extreme weather events. Most (89%) fishermen have cell phones. Among fisherwomen, 46% use cell phones for communication. Informal social networks allow Coastal-Vedda to spread information more quickly than formal methods of information sharing (e.g., monthly fisheries cooperative meetings). Such information can be less precise but useful for a small society that does not rely on the internet.

5.3.2.3. Institutions

Local institutions can boost a community's adaptive capacity by engaging with fishery resource management approaches and collaborating with stakeholder institutions to minimize vulnerabilities in the use of natural resources. Kunjankalkulam's CBF is co-managed by a multi-level institutional structure with diverse stakeholder organizations that manage stress and change by sharing knowledge, identifying barriers, and learning from each other (Figure 5.3). RFO (Rural Fisheries Organisation) is the key fisheries institution managing community-level CBF. It has annually appointed officers: a (vice) president, a secretary, and a treasurer appointed by RFO members (i.e., Coastal-Vedda fishers). The treasurer has the only paid full-time job. He must visit the landing site twice daily and record the number of canoes that entered the reservoir as well as how many fish was brought to the landing-site (landing-site management). Every commercial fisher must pay a fee to RFO based on their catch. Occasionally, RFO buys all the fish from the fishers and sells it back to the local market/vendors, depending on prevailing market prices. Currently, Kunjankalkulam RFO is one of 22 RFOs in the region (eastern fisheries division).

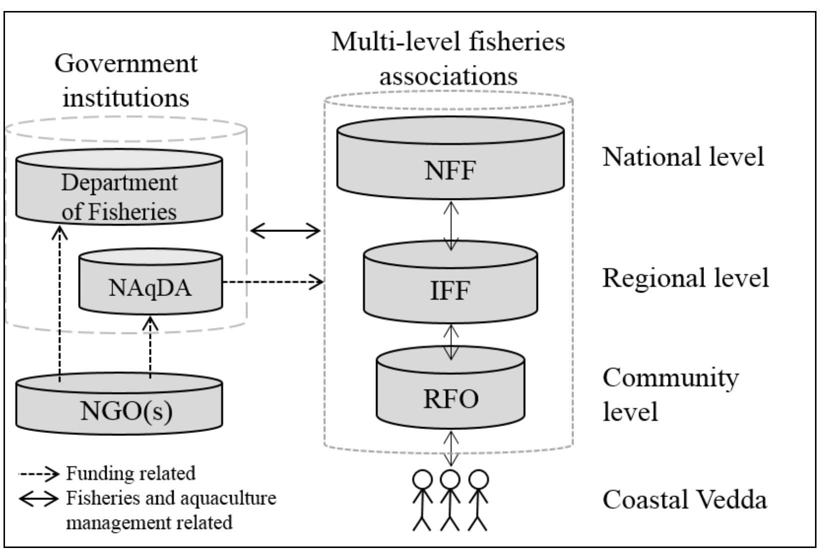


Figure 5.3: Multi-level institutional structure for aquaculture co-management.

The Inland Fisheries Federation (IFF) is the regional-level aquaculture industry organisation. IFF has significant control over the inland fish market price. The organization consists of leaders from 22 RFOs (e.g., the president). IFF charges RFOs a membership fee based on the reservoir size (Sri Lankan Rupee equivalent to C$23 for minor, C$38 for medium, and C$76 for major). IFF also has annually appointed leadership positions: (vice) president, secretary, and treasurer. The president is part of the National Fisheries Federation (NFF), which oversees national-level fisheries and aquaculture concerns.

The Batticaloa regional center of the National Aquaculture Development Authority of Sri Lanka (NAqDA) directly supports the community adaptation process through co-management of CBF. NAqDA is the national-level government institution for inland fisheries and aquaculture management. Extension officers of NAqDA work closely with RFOs to ensure that fishers follow regulations and procedures. The extension officers attend most RFO meetings and offer administrative support. For example, fishers must meet three key requirements to become involved in commercial CBF: a) obtain an 'operating licence' from NAqDA (with no fees) for recording purposes so that NAqDA will know who the full-time fishers are (those who fish three or more times per week), b) register their canoe (number) with the Department of Fisheries, Batticaloa, and c) obtain fisher insurance (C$8/year) from Ceylinco General Insurance Limited to mitigate fishers' health-related risks such as hospital bills and death during fishing-related activities.

NGOs play a key role in funding the CBF co-management process. The fish fingerling stocking process is partly funded through various NGOs (e.g., World Vision, FAO, Care, and USAID) and the government. RFO also contributes. For example, in 2018 Coastal-Vedda started an experimental pen culture project in the reservoir to increase the community's annual fish production. Furthermore, in 2017 Kunjankalkulam RFO received fishing gear and canoes as NGO donations. Additionally, Coastal-Vedda use many non-fisheries/aquaculture-related community-based institutions to cope with common challenges (Appendix box S1). Each institution is led by different Coastal-Vedda, which allows for collective leadership at the community level, improving the community's adaptive capacity.

Figure 3 shows the multi-level institutional structure of vertically integrated fisheries associations and government and non-governmental organisations (NGOs). Multi-level fisheries associations are horizontally integrated with government institutions primarily for fisheries and aquaculture management-related aspects (solid-line arrows) and with NGOs for specific project financing aspects (dotted-line arrows). RFO is the key community institution representing Costal-Vedda with respect to CBF.

> *Now reservoir aquaculture is our main way of living … we are planning to further increase our fish production with the help of NAqDA and … local NGOs … I am glad they [NAqDA] help and consult us with technical expertise … Today … […] NGO donate five canoes and gillnets for our fishers, they [NGO] have being helping us over the last year…*—Coastal-Vedda chief

5.3.2.4. ILK systems

ILK systems are a source of resilience and a means of measuring the understanding of adaptations in a fisheries and aquaculture setting (Folke et al., 2003, Galappaththi et al., 2018, Galappaththi et al., 2019d). This section describes Coastal-Vedda applications of ILK, the combining of different types of knowledge, and the weakening of ILK systems throughout SES change.

Coastal-Vedda use various types of knowledge to cope with SES change. Table S5 in the appendix illustrates selected types of knowledge that Coastal-Vedda fishers use. We have identified various knowledge systems surrounding fishing spots, CBF operation, weather predictions, collective action, and climate adaptation responses. Furthermore, we have recognised essential knowledge for surviving in the ‘place’, such as knowledge about wild elephants and disaster/emergency practices. All acknowledged types of knowledge are currently practiced by Coastal-Vedda fishers and have been developed over the past three decades. Specific types of knowledge developed due to Coastal-Vedda’s exposure to long-term stresses such as climate change impacts (adaptation knowledge) and war conditions (knowledge about disaster or emergency situations). Another sub-set of knowledge (weather predictions) has been used and is evolving.

Moreover, Coastal-Vedda believe that aspects of their ILK system are weakening, partly due to ethnic conflict and social modernization. Coastal-Vedda still possess specific knowledge that they have gained over the generations but do not often practice it. For example, a lack of traditional fishing and hunting activities results in weakened knowledge about making/using traditional weapons (e.g., bow and arrow, spear). However, new knowledge about aquaculture can mitigate the livelihood impacts of weakened knowledge, enhancing Coastal-Vedda's capacity to adapt to SES change.

> *Now everything [has] changed. It is hard to predict weather, animals, even forest … but we need to live. The government and NGOs [are] giving us new knowledge that help to develop reservoir aquaculture*— Elder Coastal-Vedda

5.3.2.5. Learning

Learning is a key characteristic of community adaptation (Galappaththi et al., 2019d). This section describes how Coastal-Vedda practice learning-by-doing in their fishing way of life, the available learning opportunities, and the ways Coastal-Vedda co-learning supports the local adaptation process.

Coastal-Vedda have various opportunities to learn and adapt to change (Appendix-Table S6). Identified learning opportunities are: learning-by-doing (65%), local institutions such as RFO (53%), external stakeholders such as NGOs (32%), and parents and elders (28%). In FGDs, all respondents agreed that by combining all learning opportunities, Coastal-Vedda co-learn in the context of CBF. 'Learning-by-doing' is a common application across multiple learning opportunities (e.g., RFO and NGO settings). Collective action and collaboration are key mechanisms for co-learning. Local institutions and community-based organizations facilitate Coastal-Vedda's co-learning process. Co-learning could lead to new knowledge such as aquaculture technology (e.g., pen culture to increase fish production).

Coastal-Vedda have access to formal education through a public-school system. Coastal-Vedda children attend the nearest primary school (up to grade three) in nearby communities. Over the last three decades, ethnic conflicts have disturbed Coastal-Vedda education. Because they live in a geographically isolated rural fishing community, Coastal-Vedda fishers concentrate on identified opportunities for learning.

> *This effort [the co-management of CBF] is teamwork, we tried many aquaculture activities over the last years …we need patience ... and especially learning from our past mistakes is important to strongly face this change*—Elder Coastal-Vedda

5.4 Discussion

We assessed Coastal-Vedda community adaptation by examining how Coastal-Vedda experience and respond to change in a small-scale aquaculture context (i.e., CBF). We illustrated five key stressors and shocks: the Sri Lankan ethnic war; extreme weather and natural disasters including cyclones, floods, and droughts; human-elephant conflicts; an increase in unpredictable weather patterns; and social pressure from modernization (Latour, 2012). Compared to other small-scale fisheries systems (Arimi, 2014, Paprocki and Cons, 2014, Khan et al., 2018), Coastal-Vedda have experienced a unique combination of changes over the last three decades. We discovered four characteristics of how Coastal-Vedda fishers experience change: (i) Coastal-Vedda's culture-based fisheries systems are undergoing multiple stressors, indicating that change is non-linear; (ii) climate change is perceived as one of many changes with mixed/interconnected implications for Coastal-Vedda fisheries; (iii) Coastal-Vedda themselves (culture, economy, lifestyle) are transforming within the SES change over time; and (iv) responding to identified changes over a long period has made Coastal-Vedda more resilient to SES change.

Table 4 illustrates the implications of specific changes that Coastal-Vedda fishers experience, their potential outcomes, and community responses to them. Furthermore, Table 5.4 describes the conceptual link between the listed implication of change and the respective community responses. To advance the understanding of adaptive responses, we must investigate how Coastal-Vedda address the implications of changes differently from other documented small-scale fisheries systems. An aquaculture-centered livelihood equipped with multi-level mixed governance institutions is the collective strategy that fosters community adaptation.

Table 5.4: Implications of changes and community responses.

Implication of change	Potential outcomes	Community responses	Description
Shorter aquaculture season	-Limit fish growth and fishers will get lower income (Islam et al., 2014)	-Obtaining aquaculture knowledge from NAqDA (Table S5, S8, S9, S10) -Livelihood diversification (Table S8, Figure 2)	To minimise the impacts of a shorter fish culture period (e.g., smaller fish size), Coastal-Vedda obtain technical knowledge from government aquaculture institutions (e.g., specific gillnet mesh sizes for the dry season). Further, livelihood diversification acts as a backup source of food/income (e.g., seasonal fruit/firewood collection). When Coastal-Vedda get low income/fish from the reservoir, that gap is minimised through other income/food sources, which minimises vulnerability to food insecurity.
Fewer fishing days as extreme weather does not allow for fishing in reservoir	-Skipping meals due to limited fish available for food (Béné et al., 2016a) -Can result in food insecurity and disturbed livelihoods (Béné et al., 2015, Béné et al., 2016c)	-Use saved money to buy food (Table S6) -Consume vegetables and fruits from home gardening (Table S8)	Through local NGOs, Coastal-Vedda learn to save money for use in difficult periods (rainy days). This saved money is used to buy certain food items (usually meat or rice) that can be supplemented with vegetables from their gardens. This combination helps minimise the practice of skipping meals and advances food security.
Unsafe, high-risk living conditions due to wild elephants, lack of infrastructure (road access) and drinking water, and unpredictable weather	-Dismantling of Coastal-Vedda traditional way of life (Agrawal, 1995) -Difficult to maintain rice farming (staple food) and CBF activities (fingerling stocking) (Béné et al., 2016a, Béné et al., 2016b)	-Livelihood diversification (Table S8, Figure 2) -Use diverse knowledge systems to confront unfavourable conditions (Table S5) -Learning-by-doing and co-learning through diverse organizations from multi-level institution structure (Table S6) -Place-attachments (Table S10) -Effective social-networks	Due to the war, wild elephants, and other scarcities, high-risk living has been a part of Coastal-Vedda's SES, particularly over the last three decades. Livelihood diversification combines with various knowledge systems, co-learning, place attachments, and social networks to build resilience among Coastal-Vedda living with the changes.
Loss of livelihoods (chena cultivation, cattle, hunting)	-More reliance on CBF/aquaculture for food security (Blanchard et al., 2017)	-More reliance on aquaculture and expansion of aquaculture with support of (non)government	CBF provides a consistent supply of fish to Coastal-Vedda throughout the year. This aquaculture system has relatively high adaptability as compared to other identified

		organizations	livelihood options (including rice farming), as a combined result of new knowledge, learning opportunities, and resource support of stakeholders.
New lifestyle (cash economy, CBF/ aquaculture, cement housing) positions Coastal-Vedda between 'traditional' and 'modern'—middle of social transformation	-Lack of self-esteem and confidence among Coastal-Vedda (Ingold, 2006, Latour, 2012, Ingold, 2015) -Risk of extinction of Coastal-Vedda in near future (Latour, 2012, Latour, 2014)	-Various community-based institutions to promote Coastal-Vedda culture, art, and youth projects (Box S1) -Increase cohesiveness of Coastal-Vedda through local institutions (Box S1)	The social transformation of Coastal-Vedda is inevitable. This social process is shaped by local Indigenous organisations and Coastal-Vedda leadership. The social-cohesiveness and oneness of Coastal-Vedda help them effectively face all the common challenges while adapting to changing conditions.

We identified three key adaptive strategies of Kunjankalkulam Coastal-Vedda that construct the community responses to SES change. First, we recognised CBF (or aquaculture) itself as an adaptation strategy. Coastal-Vedda once had wild capture fisheries and engaged in chena cultivation and rice farming; now they are involved primarily in CBF (De Silva et al., 2006, Amarasinghe and Nguyen, 2009). This aquaculture is the best fit for the changes surrounding Coastal-Vedda's SES, such as climate (e.g., cyclones, floods, and droughts) and way of life (e.g., non-mobile lifestyle). CBF can build more resilience among Coastal-Vedda than can other livelihoods, as it: (i) reduces food insecurity by supplying consistent protein sources (Amarasinghe and Nguyen, 2009), (ii) does not involve major investments (compared to intensive large-scale aquaculture operations), with the cost of fingerling stocking borne by multiple funders (RFO, NGOs, government) (Chandrasoma and Pushpalatha, 2018), and (iii) creates opportunities to collaborate and co-learn with external information/knowledge sources. Globally, aquaculture is identified as an adaptive strategy for climate change impacts and is included in some countries' national natural resources strategies (e.g., Solomon Islands, Vanuatu, Timor-Leste, Fiji, and Vietnam) (Bosma et al., 2012, Dey et al., 2016a, Dey et al., 2016b, Rosegrant et al., 2016).

Second, adaptive institutions with a multi-level institutional structure are the heart of community adaptation. The key features of Coastal-Vedda adaptive institutions (Boyd and Folke, 2012, Galappaththi et al., 2018) are: (i) RFO is the key community institution for CBF, representing all

Coastal-Vedda fishers, (ii) the presence of multi-level institutions (RFO—community, IFF—regional, NFF—national) (Galappaththi and Berkes, 2014), (iii) the existence of mixed regimes of community, government, and NGOs to fund culture-based fisheries systems (Galappaththi and Berkes, 2015a), (iv) the bottom-up nature of functioning (feedback escalated from the community level to the national level) (Galappaththi and Berkes, 2014), and (v) adaptive nature—multi-level industry association structure collaborates/links with various stakeholder organizations (NAqDA, Department of Fisheries, NGOs) based on need (e.g., connect with NAqDA for general aquaculture management, with the Department of Fisheries for canoe licensing, and with NGOs for funding community projects).

These adaptive institutions facilitate the co-management of CBF and allow Coastal-Vedda to co-learn with each other by practicing collective action and collaboration. Table S9 in the appendix highlights the characteristics of the co-management process of the Coastal-Vedda's CBF and the ways in which it advances adaptation. Furthermore, these local institutions create social space for the co-production of knowledge (Armitage et al., 2011) and the emergence of collective leadership (Lichtenstein and Plowman, 2009, Friedrich et al., 2016) required for community adaptation. Moreover, these adaptive institution levels and institutional robustness are similar to those found in other reservoirs in Sri Lanka where farmer organizations (small village reservoirs of under the jurisdiction of Agrarian Development Department; (Kularatne et al., 2009)) and perennial reservoirs (Kulatilake et al., 2010). The present study based on a resilience-based conceptual framework indicates the uniqueness of the Vedda communities, whose norms are based on their traditional culture, which are rapidly disappearing due to external forces.

Third, diversification is a common strategy across Coastal-Vedda responses in the aquaculture and fisheries setting, livelihoods, institutions, knowledge systems, and learning opportunities. (Table S8 in the appendix explains how types of diversification advance adaptation.) For example, in broader developing context, households diversify income sources for two reasons: (a) people are too poor (finances, power, skills, innovations) to specialize, and (b) people are wealthy enough to invest and expand their portfolio of income (O. T. Coomes, pers. comm.). However, Coastal-Vedda transformation in the face of livelihood distractions, social-marginalization, and disempowerment due to governmental mega development projects and civil war hints at the complexity of reasons for livelihood diversification. Also, diversification is a broad application known to be a source of systems resilience and a means of adaptation in the context of climate change impacts (e.g., small-scale shrimp farmers in northwestern Sri Lanka) (Galappaththi et al., 2018). Nurturing diversity in a changing SES can increase creativity and adaptive capacity as well as set the system for reorganization and renewal (Folke et al., 2003, Folke, 2016). We identified diversification as an adaptive strategy used in combination with other strategies in a Coastal-Vedda fisheries and aquaculture setting.

In addition to the three identified community adaptive strategies, we identified four place-specific attributes that support adaptive strategies and shape community adaptation: Coastal-Vedda's cultural identity and worldviews (Escobar, 2008), co-management of CBF (Galappaththi and Berkes, 2015b), flexibility towards adaptation (Cinner et al., 2018b), and ILK systems and learning (Rodríguez et al., 2019) (Appendix—Table S10). Each attribute can support adaptation under the given circumstances; e.g., Coastal-Vedda's cultural identity and flexibility in working with diverse aquaculture stakeholders help support community CBF. Combined, these four attributes will reduce systems' vulnerability and build the Coastal-Vedda fisheries system's resilience by increasing adaptive capacity. Four attributes, together or in combination with identified adaptive strategies, collectively influence the community's process of adaptation to change. For instance, during the rainy season, Coastal-Vedda incur more damage from wild elephants, which can be addressed in part by a broad range of adaptive responses such as: more reliance on CBF (for food), the use of saved money to buy food, and the earning of money from other identified livelihood activities.

5.5 Conclusion

In this paper, we examine how Indigenous fishers experience and respond to environmental and social stressors, including climate change, socio-economic change, and political change, by assessing community adaptations of the rural Coastal-Vedda population in Sri Lanka. Coastal-Vedda have multiple responses that help them adapt to these stressors. Our findings highlight three adaptive strategies (adaptive multi-level institutional structure, aquaculture/CBF, and diversification) as well as four place-specific attributes (worldviews, co-management, flexibility, and ILK/learning) that shape community adaptation. Our study provides key insights for communities, scientists, and policymakers to improve community adaptation to increasing rates of global change: (1) Understanding how tropical Indigenous fishers experience and respond to change is essential to improving adaptation; we suggest that such assessments can be carried out using the six characteristics of the resilience-based conceptual framework (place, human agency, collective action, institutions, ILK, and learning) that we developed. (2) Recognizing information required to link community adaptation realities to government plans (e.g., the National Adaptation Plan of Sri Lanka) can result in the development of a better fisheries adaptation policy (e.g., multi-level institutional structure) under the co-management of the CBF setting. (3) Understanding community adaptations can enable communities to self-evaluate their adaptation and adjust as needed. This may be particularly important for Indigenous populations undergoing social transformation. Overall, the case study helps fill the empirical knowledge gap in climate change adaptation in the context of rural Indigenous people and their small-scale aquaculture systems, as well as in how they respond to SES change until they find their new system equilibrium.

5.6 References

AARONSON, S. A. 2016. Repression, Civil Conflict, and Leadership Tenure:The Sri Lanka Case Study, Institute for International Economic Policy Working Paper Series, Elliott School of International Affairs, The George Washington University. Washington, D.C.

ADGER, W. N. 2003. Social capital, collective action, and adaptation to climate change. *Economic Geography,* 79**,** 387-404.

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

AGRAWAL, A. 1995. Dismantling the divide between Indigenous and scientific knowledge. *Development and change,* 26**,** 413-439.

AMARASINGHE, O. & BAVINCK, M. 2017. Furthering the Implementation of the Small-Scale Fisheries Guidelines: Strengthening Fisheries Cooperatives in Sri Lanka. *The Small-Scale Fisheries Guidelines.* Springer.

AMARASINGHE, U. & DE SILVA, S. 1999. Sri Lankan reservoir fishery: a case for introduction of a co-management strategy. *Fisheries management and ecology,* 6**,** 387-400.

AMARASINGHE, U., KUMARA, P. A. & ARIYARATNE, M. 2002. Role of non-exploited fishery resources in Sri Lankan reservoirs as a source of food for cage aquaculture. *Management and Ecology of Lake and Reservoir Fisheries***,** 332-343.

AMUNDSEN, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment,* 20**,** 257-276.

ARIMI, K. S. 2014. Determinants of climate change adaptation strategies used by fish farmers in Epe Local Government Area of Lagos State, Nigeria. *Journal of the Science of Food and Agriculture,* 94**,** 1470-1476.

ARLINGHAUS, R., ALÓS, J., BEARDMORE, B., DAEDLOW, K., DOROW, M., FUJITANI, M., HÜHN, D., HAIDER, W., HUNT, L. & JOHNSON, B. 2017. Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. *Reviews in Fisheries Science & Aquaculture,* 25**,** 1-41.

ARMITAGE, D. 2005. Adaptive capacity and community-based natural resource management. *Environmental management,* 35**,** 703-715.

ARMITAGE, D., BERKES, F., DALE, A., KOCHO-SCHELLENBERG, E. & PATTON, E. 2011. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change,* 21**,** 995-1004.

ATTANAPOLA, C. T. & LUND, R. 2013. Contested identities of Indigenous people: Indigenization or integration of the Veddas in Sri Lanka. *Singapore Journal of Tropical Geography,* 34**,** 172-187.

BÉNÉ, C., AL-HASSAN, R. M., AMARASINGHE, O., FONG, P., OCRAN, J., ONUMAH, E., RATUNIATA, R., VAN TUYEN, T., MCGREGOR, J. A. & MILLS, D. J. 2016a. Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and Vietnam. *Global Environmental Change,* 38**,** 153-170.

BÉNÉ, C., ARTHUR, R., NORBURY, H., ALLISON, E. H., BEVERIDGE, M., BUSH, S., CAMPLING, L., LESCHEN, W., LITTLE, D. & SQUIRES, D. 2016b. Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Development,* 79**,** 177-196.

BÉNÉ, C., BARANGE, M., SUBASINGHE, R., PINSTRUP-ANDERSEN, P., MERINO, G., HEMRE, G.-I. & WILLIAMS, M. 2015. Feeding 9 billion by 2050–Putting fish back on the menu. *Food Security,* 7**,** 261-274.

BÉNÉ, C., HEADEY, D., HADDAD, L. & VON GREBMER, K. 2016c. Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. *Food Security,* 8**,** 123-138.

BÉNÉ, C., NEWSHAM, A., DAVIES, M., ULRICHS, M. & GODFREY-WOOD, R. 2014. Review article: resilience, poverty and development. *Journal of International Development,* 26**,** 598-623.

BERG, B. L. 2016. *Qualitative research methods for the social sciences,* Boston, Pearson Education.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F., FOLKE, C. & COLDING, J. (eds.) 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience,* Cambridge, UK: Cambridge University Press.

BEVERIDGE, M. & PHILIPPS, M. Aquaculture in reservoirs. Reservoir fishery management and development in Asia: proceedings of a workshop held in Kathmandu, Nepal, 23-28 Nov. 1987, 1988. IDRC, Ottawa, ON, CA.

BLANCHARD, J. L., WATSON, R. A., FULTON, E. A., COTTRELL, R. S., NASH, K. L., BRYNDUM-BUCHHOLZ, A., BÜCHNER, M., CAROZZA, D. A., CHEUNG, W. W. & ELLIOTT, J. 2017. Linked sustainability challenges and trade-offs among fisheries, aquaculture and agriculture. *Nature ecology & evolution,* 1**,** 1240.

BOSMA, R. H., NHAN, D. K., UDO, H. M. & KAYMAK, U. 2012. Factors affecting farmers' adoption of integrated rice–fish farming systems in the Mekong delta, Vietnam. *Reviews in Aquaculture,* 4**,** 178-190.

BOWEN, G. A. 2008. Naturalistic inquiry and the saturation concept: a research note. *Qualitative research,* 8**,** 137-152.

BOYD, E. & FOLKE, C. (eds.) 2012. *Adapting institutions: Governance, complexity and social-ecological resilience,* New York: Cambridge University Press.

BROW, J. 1978. *Veddha Villages of Anuradhapura: The Anthropological History of a Community in Sri Lanka.,* Seattle, WA, University of Washington Press.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

CAREY, M. A. & ASBURY, J.-E. 2016. *Focus group research,* London, Routledge.

CHILDS, K. 2017. Culture and life: The last Veddas of Sri Lanka. *Guardian (Sydney)***,** 10.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8**,** 117-123.

CINNER, J. E., HUCHERY, C., HICKS, C. C., DAW, T. M., MARSHALL, N., WAMUKOTA, A. & ALLISON, E. H. 2015. Changes in adaptive capacity of Kenyan fishing communities. *Nature Climate Change,* 5**,** 872-876.

CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. 2016. *Key methods in geography,* London, Sage.

DE JONG, K., MULHERN, M., FORD, N., SIMPSON, I., SWAN, A. & VAN DER KAM, S. 2002. Psychological trauma of the civil war in Sri Lanka. *Lancet,* 359**,** 1517-1518.

DE SILVA, C., WEATHERHEAD, E., KNOX, J. W. & RODRIGUEZ-DIAZ, J. 2007. Predicting the impacts of climate change—A case study of paddy irrigation water requirements in Sri Lanka. *Agricultural Water Management,* 93**,** 19-29.

DEY, M. M., GOSH, K., VALMONTE-SANTOS, R., ROSEGRANT, M. W. & CHEN, O. L. 2016a. Economic impact of climate change and climate change adaptation strategies for fisheries sector in Fiji. *Marine Policy,* 67**,** 164-170.

DEY, M. M., GOSH, K., VALMONTE-SANTOS, R., ROSEGRANT, M. W. & CHEN, O. L. 2016b. Economic impact of climate change and climate change adaptation strategies for fisheries sector in Solomon Islands: Implication for food security. *Marine Policy,* 67**,** 171-178.

DHARMADASA, K. N. O. 1993. Vedda: the 'Adivasi' of Sri Lanka. SOBA 4:3, 7–11. Ministry of Environment and Parliamentary Affairs, Sri Lanka.

ESCOBAR, A. 2008. *Territories of difference: place, movements, life, redes,* Durham and London, Duke University Press.

ESHAM, M. & GARFORTH, C. 2013. Climate change and agricultural adaptation in Sri Lanka: a review. *Climate and Development,* 5**,** 66-76.

FERNANDO, P., WIKRAMANAYAKE, E., WEERAKOON, D., JAYASINGHE, L., GUNAWARDENE, M. & JANAKA, H. 2005. Perceptions and patterns of human–elephant conflict in old and new settlements in Sri Lanka: insights for mitigation and management. *Biodiversity & Conservation,* 14**,** 2465-2481.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FRIEDRICH, T. L., GRIFFITH, J. A. & MUMFORD, M. D. 2016. Collective leadership behaviors: Evaluating the leader, team network, and problem situation characteristics that influence their use. *The Leadership Quarterly,* 27**,** 312-333.

GALAPPATHTHI, E. & BERKES, F. 2015a. Drama of the commons in small-scale shrimp aquaculture in northwestern, Sri Lanka. *International Journal of the Commons,* 9**,** 347-368.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2018. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C., eds. FishAdapt: The Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, 2018 Bangkok. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO.

GALAPPATHTHI, E. K. & BERKES, F. 2014. Institutions for managing common-pool resources: the case of community-based shrimp aquaculture in northwestern Sri Lanka. *Maritime Studies,* 13**,** 1-16.

GALAPPATHTHI, E. K. & BERKES, F. 2015b. Can co-management emerge spontaneously? Collaborative management in Sri Lankan shrimp aquaculture. *Marine Policy,* 60**,** 1-8.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GUNATILAKA, A. 2017. Water security and related issues in Sri Lanka: the need for integrated water resource management (IWRM). *Journal of the National Science Foundation of Sri Lanka,* 36.

HANCOCK, D. R. & ALGOZZINE, B. 2015. *Doing case study research: A practical guide for beginning researchers,* London, Teachers College Press.

HERATH, T. & JOSEPH, J. 2016. Prevalence of Risk Factors of Under-Nutrition Among Children 1 to 5 Years in Eastern, Sri Lanka. *Journal of Food and Nutrition Sciences,* 4**,** 103-107.

INGOLD, T. 2006. Rethinking the animate, re-animating thought. *Ethnos,* 71**,** 9-20.

INGOLD, T. 2015. *The life of lines,* New York, Routledge.

ISLAM, M. M., SALLU, S., HUBACEK, K. & PAAVOLA, J. 2014. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change,* 14**,** 281-294.

KAJÁN, E. 2014. Community perceptions to place attachment and tourism development in Finnish Lapland. *Tourism Geographies,* 16**,** 490-511.

KHAN, F. N., COLLINS, A. M., NAYAK, P. K. & ARMITAGE, D. 2018. Women's perspectives of small-scale fisheries and environmental change in Chilika lagoon, India. *Maritime Studies,* 17**,** 145-154.

KRIPPENDORFF, K. 2018. *Content analysis: An introduction to its methodology,* London, Sage publications.

LATOUR, B. 2012. *We have never been modern,* Cambridge, Massachusetts, Harvard University Press.

LATOUR, B. 2014. Agency at the Time of the Anthropocene. *New Literary History,* 45**,** 1-18.

LAURIER, E. 2016. Participant and Non-participant Observation. *In:* CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. (eds.) *Key methods in Geography.* London: Sage.

LEHMAN, J. 2014. Expecting the sea: The nature of uncertainty on Sri Lanka's East coast. *Geoforum,* 52**,** 245-256.

LICHTENSTEIN, B. B. & PLOWMAN, D. A. 2009. The leadership of emergence: A complex systems leadership theory of emergence at successive organizational levels. *The Leadership Quarterly,* 20**,** 617-630.

LOBE, K. & BERKES, F. 2004. The padu system of community-based fisheries management: change and local institutional innovation in south India. *Marine Policy,* 28**,** 271-281.

LONGHURST, R. 2016. Semi-structured Interviews and Focus Group. *In:* CLIFFORD, N., COPE, M., GILLESPIE, T. & FRENCH, S. (eds.) *Key Methods in Geography.* 3 ed. London: Sage.

LUND, R. 2000. Geographies of eviction, expulsion and marginalization: stories and coping capacities of the Veddhas, Sri Lanka. *Norsk Geografisk Tidsskrift,* 54**,** 102-109.

MAGEE, T. 2013. *A field guide to community based adaptation,* London, Routledge.

MAHON, R., MCCONNEY, P. & ROY, R. N. 2008. Governing fisheries as complex adaptive systems. *Marine Policy,* 32**,** 104-112.

PAPROCKI, K. & CONS, J. 2014. Life in a shrimp zone: aqua-and other cultures of Bangladesh's coastal landscape. *Journal of Peasant Studies,* 41**,** 1109-1130.

PELLING, M., HIGH, C., DEARING, J. & SMITH, D. 2008. Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations. *Environment and Planning A,* 40**,** 867-884.

PELLING, M., O'BRIEN, K. & MATYAS, D. 2015. Adaptation and transformation. *Climatic Change,* 133**,** 113-127.

RANASINGHE, R. & CHENG, L. 2018. Tourism-induced mobilities and transformation of Indigenous cultures: where is the Vedda community in Sri Lanka heading to? *Journal of Tourism and Cultural Change,* 16**,** 521-538.

RODRÍGUEZ, M. V., DAVIDSON-HUNT, I. & BERKES, F. 2019. Social-ecological memory and responses to biodiversity change in a Bribri Community of Costa Rica. *Ambio-Biodiversity Change and Human Adaptation***,** 1-12.

ROSEGRANT, M. W., DEY, M. M., VALMONTE-SANTOS, R. & CHEN, O. L. 2016. Economic impacts of climate change and climate change adaptation strategies in Vanuatu and Timor-Leste. *Marine Policy,* 67**,** 179-188.

SANTIAPILLAI, C., WIJEYAMOHAN, S., BANDARA, G., ATHURUPANA, R., DISSANAYAKE, N. & READ, B. 2010. An assessment of the human-elephant conflict in Sri Lanka. *Ceylon Journal of Science (Biological Sciences),* 39.

SELIGMANN, C. G. & SELIGMANN, B. (eds.) 1911. *The veddas,* Cambridge: Cambridge University Press.

SINGH, S. J. 2009. Complex Disasters: The Nicobar Islands in the Grip of Humanitarian Aiod. *Geographische Rundschau International Edition,* 5**,** 48-56.

TRUELOVE, H. B., CARRICO, A. R. & THABREW, L. 2015. A socio-psychological model for analyzing climate change adaptation: A case study of Sri Lankan paddy farmers. *Global Environmental Change,* 31**,** 85-97.

VAISMORADI, M., JONES, J., TURUNEN, H. & SNELGROVE, S. 2016. Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice,* 6**,** 100-110.

VAN DIJK, T. A. 2015. Critical discourse analysis. *In:* TANNEN, D., HAMILTON, H. E. & SCHIFFRIN, D. (eds.) *The handbook of discourse analysis.* New Delhi, India: John Wiley & Sons, Inc.

WIJENAYAKE, W., JAYASINGHE, U., AMARASINGHE, U., ATHULA, J., PUSHPALATHA, K. & DE SILVA, S. 2005. Culture-based fisheries in non-perennial reservoirs in Sri Lanka: production and relative performance of stocked species. *Fisheries Management and Ecology,* 12**,** 249-258.

WILLIAMS, D. R. & PATTERSON, M. E. 2008. Place, leisure, and well-being. *In:* EYLES, J. & WILLIAMS, A. (eds.) *Sense of place, health and quality of life.* Surrey, UK: Ashgate.

WODAK, R. & MEYER, M. 2015. *Methods of critical discourse studies,* London, Sage.

YAMADA, S., GUNATILAKE, R. P., ROYTMAN, T. M., GUNATILAKE, S., FERNANDO, T. & FERNANDO, L. 2006. The Sri Lanka tsunami experience. *Disaster Management & Response,* 4**,** 38-48.

YAMANE, A. Rethinking vulnerability to climate change in Sri Lanka. 9th International conference on Sri Lanka Studies, 28th–30th November, 2003.

YOW, V. R. 2014. *Recording oral history: A guide for the humanities and social sciences,* New York, Rowman & Littlefield.

ZOYSA, S. R. 2018. *Fishing, Mobility and Settlerhood, Coastal Socialites in Postwar Sri Lanka,* MARE Publication Series 20, Springer international Publishing AG, part of Springer Nature.

Preface to Chapter 6

The previous two chapters presented the empirical case studies of Inuit and Coastal-Vedda fisheries systems. Both empirical assessments were guided by the resilience-based conceptual framework proposed in chapter 3. Using the same conceptual framework, in chapter 6, I conduct a comparative analysis of community adaptations to climate change in Inuit and Coastal-Vedda fisheries systems to gain a broader understanding of opportunities for climate adaptation in the Indigenous fisheries context. This chapter is the result of the conceptual, empirical, and comparative approaches of this study. The chapter identifies two commonly used adaptive strategies in a community-based adaptation setting and eight ways to build resilience in small-scale fisheries and Indigenous populations. Further, it identifies definitive characteristics of successful adaptation in Indigenous fisheries. This chapter offers policy insights by helping to create a better understanding of what successful adaptation looks like in remote communities as well as ways to address barriers to community-based climate adaptation in Indigenous fisheries.

This chapter is currently being prepared for *Global Environmental Change*.

Chapter 6. Adapting to climate change in small-scale fisheries: Insights from Indigenous communities in the global north and south

Abstract

Climate change and its associated impacts on small-scale fisheries (SSFs) can have significant impacts on global fish production as well as on small-scale producers' livelihoods, nutrition, and food security. We compared two uniquely different climate-sensitive SSFs (i.e., Inuit of Canadian Arctic and Coastal-Vedda of Sri Lanka) to broaden our understanding of how fisheries- and aquaculture-dependent Indigenous communities respond and adapt to climate change impacts. We used a three-tier methodological approach to guide the study, developing a resilience-based conceptual framework to empirically assess adaptations in two Indigenous SSF communities (Inuit and Coastal-Vedda). We identified eight sources of resilience from across these two case studies that can build adaptive capacity in SSF communities: i) use of diverse kinds of knowledge; ii) practice of different ways of learning; iii) use of community-based institutions; iv) efforts to improve human agency; v) unique worldviews; vi) specific cultural attributes that keep up with adaptation; vii) effective social networks; and viii) a high level of flexibility. The two key common adaptive strategies identified in SSF are diversification and adaptive co-management. We identified definitive characteristics of a successful community adaptation process. They are: a) continuous learning through knowledge co-production; b) capacity-building to improve human agency; c) a place-specific nature (rootedness); d) collective action and partnerships through community-based institutions; and e) flexibility. Our findings inform policy development as it uncovers a deeper understanding of what successful adaptation looks like in a broader Indigenous context, and the ways to overcome common barriers in the adaptation process towards sustainable SSF.

6.1 Introduction

Small-scale fisheries (SSFs) are mainstays of livelihoods and food systems in diverse regions globally. Adapting to rapidly changing conditions is a key challenge in fostering the sustainability of global SSF systems (d'Armengol et al., 2018). Climate change is one of the most critical challenges that increase stress, randomness, uncertainty, and disorder in SSFs

(Galappaththi et al., 2019c, Keys et al., 2019). The recent IPCC special report on the impacts of the 1.5°C global warming highlights the need for more policy attention on climate adaptation, particularly in fisheries and aquaculture (IPCC, 2018a, Galappaththi et al., 2020a). The report identifies the associated impacts of climate change that result in drastic changes in coastal resources and that reduce the productivity of aquatic systems. Beyond fishing, these changing SSF communities are meaningful 'places' to fishers, whose identities are shaped by an intimate relationship with nature as a means of earning a livelihood, shaping culture, and underpinning food security (Cunsolo-Willox and Ellis, 2018, Tschakert et al., 2019, Ford et al., In Press). In this context, adaptation efforts must focus on sustainable SSFs while addressing impending shocks and stressors and their undesirable consequences.

Successful adaptation to changing conditions requires a comprehensive understanding of the unique characteristics of communities and SSF systems to inform policy (Adger et al., 2005, Osbahr et al., 2010, Galappaththi et al., 2019c). Adger et al. (2005) argued that adaptation operates at various spatial and societal scales and that its success or sustainability depends on the capacity to adapt and on the distribution of the capacity within a society. Later, Osbahr et al. (2010) defined 'success' as those actions which promote system resilience and legitimate institutional change, and, hence, generate and sustain collective action in the context of evaluating livelihood adaptation to climate variability. More recently, Piggott-McKellar et al. (2019) identified the most common barriers to successful community-based adaptation to be cognitive and behavioral; government structure and governance; communication and language; inequality, power, and marginalisation; resources (finances, time, human resources, access to information and technology, infrastructure); and physical systems and processes. From this perspective, opportunities for successful adaptation and policy development in a broader SSF context warrant an advanced understanding of how different disadvantaged communities experience climate change and the ways in which they respond to it, across scales (Ford et al., 2018b, Conway et al., 2019). Given that aquatic food dependence among coastal Indigenous peoples worldwide is much higher than it is among non-Indigenous peoples (Cisneros-Montemayor et al., 2016), a broader understanding of climate adaptations among Indigenous populations is particularly important.

Our aim in this paper is firstly to uncover broader understanding of vulnerability and resilience processes with respect to climate adaptation in SSF at a community level, which can then help better inform adaptation policy. We refer to climate adaptation policy more broadly about opportunities for building resilience in SSF and what ways make the community adaptation is a reality (i.e., successful). To do so, this paper conducts a comparative analysis of the vulnerabilities and adaptive responses of two SSF communities (Sri Lankan and Canadian Arctic case studies). Comparative studies are one of the few cornerstones of social science research yet have not been widely used in an adaptation or SSF context (Maru et al., 2014, Salas et al., 2018, Conway et al., 2019). The first two objectives of the paper are to compare and contrast the ways in which Inuit and Coastal-Vedda SSF systems experience change (objective-one) and respond to climate change (objective-two). The final objective is to examine opportunities that can nurture successful adaptation in an SSF context (objective-three). The next section will illustrate the four-step systematic methodology we used for the comparative study. The section following will compare and contrast two case studies to understand how these identified changes experienced and adaptive responses of Indigenous fishers differ (or are similar) in the Canadian Arctic and Eastern Sri Lanka. Finally, the paper discusses sources of resilience, adaptive strategies, and the definitive characteristics of a successful adaptation process aimed at SSF.

6.2 Methodology

To accomplish the comparative analysis of adaptive responses in SSF, we used a four-step systematic approach based on fieldwork conducted between 2016-2019 in the Canadian Arctic (Galappaththi et al., 2019c) and Eastern Sri Lanka (Galappaththi et al., 2020a), working closely with partner communities. In this section we describe each step and the associated methods used.

6.2.1 Step one: Conceptual framework

A place-specific resilience-based conceptual framework was developed for the case study application to assess fisheries community adaptations (Galappaththi et al., 2019b). The framework conceptualises resilience as a function of coping, adapting, and transformative capacities, and its place-based nature is designed to be applied in diverse SSFs globally. The characteristics of the framework by which community adaptation is assessed, are: place, human agency, collective action and collaboration, institutions, Indigenous and local knowledge (ILK) systems, and learning (table 6.1, figure 6.1). Moreover, throughout the study, we adopt a social-ecological systems (SES) approach to recognise the integrated human and environment subsystems as a unit of study for this paper (Berkes et al., 1998, Berkes et al., 2003). This SES analytical construct was used to capture the complex and uncertain nature of SSF systems.

Table 6.1: Definitions of characteristics of the resilience-based framework (Galappaththi et al., 2019b).

Characteristic	Definition
Place	Social and physical space that has attachments to people and social processes. Attachment to place is understood as the bonding that occurs between people and their meaningful environments (for example, livelihoods, culture, and wellbeing).
Human agency	Human (individual or collective) capacity to act independently in making their own decisions as part of the process of their way of life.
Collective action and collaboration	Action taken together (or shared) by a group of two or more people to meet a common desired objective.
Institutions	Local organizations that facilitate collective action meeting a local goal (for example, co-managed institutions).
ILK systems	Co-evolving cumulative body of knowledge (including observations, experience, lessons, and skills) belonging to a specific group of people and their resource management systems (or a place) and handed down through generations by cultural transmission; reflects the cultural identity.
Learning	Social learning, which itself refers to collective action and reflection that occurs among specific group of people as they work to improve the management of human-environment interactions.

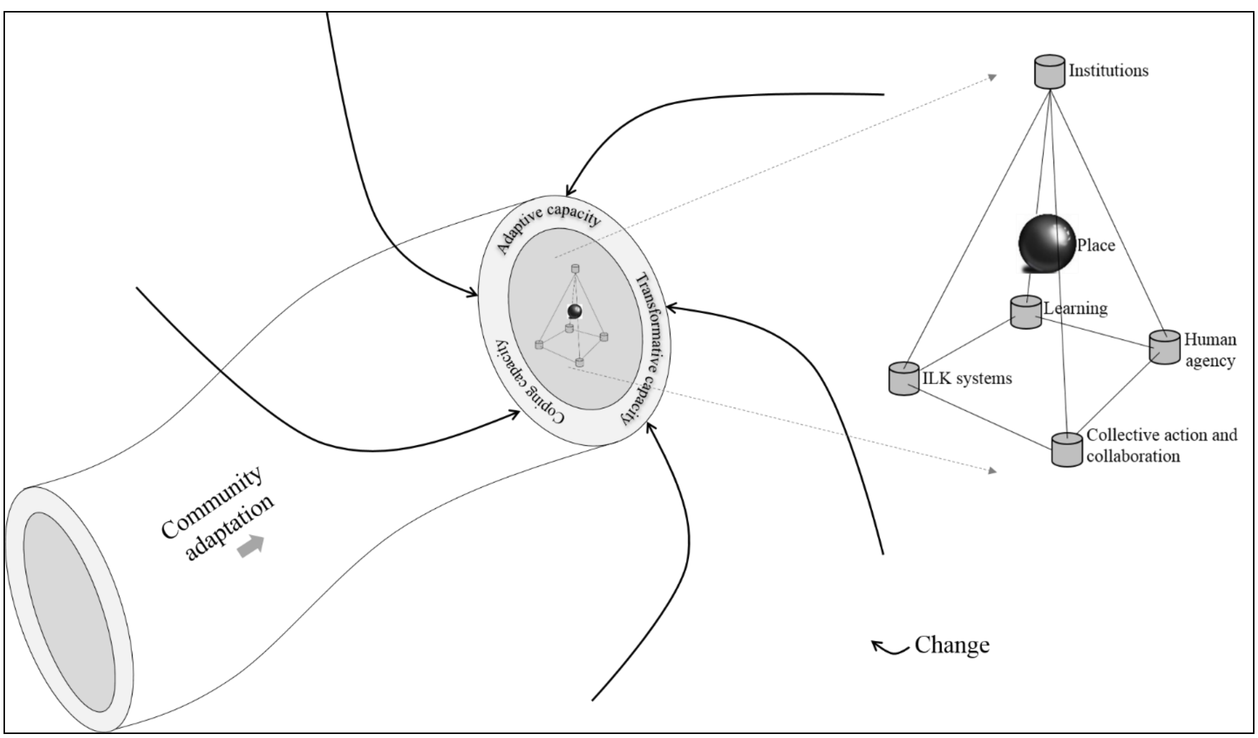


Figure 6.1: Conceptual framework for comparative analysis (building on (Galappaththi et al., 2019b)).

The white tube-shaped object represents the community adaptation process over time. The curved arrows illustrate the specific changes (internal or external) that affect the community. The outer layer of the community adaptation process represents the resilience capacities (coping, adapting, and transforming). The core of the adaptation process is a network of place-based elements (or framework characteristics).

The same conceptual and methodological framework guided both case studies. Two regions (the Arctic and tropics) were chosen to investigate how different remote SSFs experience and respond to climate change. Two Indigenous communities were strategically chosen considering the high level of fisheries activities in which they engaged and the feasibility of data collection. Fieldwork was conducted over three years in the communities of Pangnirtung (Canadian Arctic) and Kunjankalkulam (eastern Sri Lanka), using multiple data collection methods supplemented with a community-based participatory approach (Magee, 2013). First, we used participant observations (Berg, 2016) to examine the Indigenous way of life, which included spending an extensive amount of time interacting with Inuit (over 14 weeks) and Coastal Vedda (over 24 weeks) fishers (for example, attending community events, meetings with local institutions, and going on fishing trips). Second, semi-structured interviews (Longhurst, 2016) were conducted with Inuit fishers (n=62) and Coastal-Vedda fishers (n=74) to document the changes being observed in the region, and to identify and characterize the response to them. The semi-structured questioning focused on "change" in general so as not to insert bias into the interview and to keep interviews open-ended, focusing on the issues and changes that Indigenous fishers viewed as most important. All the interview questions related to 'change' referred to "about 30 years back" in fishers' lives in the geographical area of the particular region. Third, key informant interviews (Berg, 2016) were conducted with individuals related to Inuit fisheries (n=25) as well as Coastal-Vedda aquaculture (n=38), to examine areas of specific knowledge that were not accessible via fishers (for example, fisheries market information, government subsidy programs, non-government programs, fisheries co-management). Finally, focus group discussions (Carey and Asbury, 2016) were carried out in the Arctic (n=6) and in Sri Lanka (n=17) to build thematic areas related to changes that fishers experience and to the key ways in which fishers respond to such changes. The data from both case studies were analysed using 'manifest' and 'latent' content analysis (Clifford et al., 2016) supplemented with 'discourse' analysis (Wodak and Meyer, 2015) to develop themes and patterns related to the ways in which Indigenous fishers experience and respond to change.

6.2.2 Step two: Assessing Inuit adaptations in the Canadian Arctic

The proposed framework (Galappaththi et al., 2019b) was applied in the context of Inuit populations to assess the community adaptations to climate impacts of Pangnirtung, Canada. Pangnirtung is an isolated Inuit fishing community located in the Canadian territory of Nunavut, with a resident population of 1,481 (2016 census). The community is accessible only by aircraft. Residents get supplies via boat only during the summer. Residents must cope with unique challenges including high rates of food insecurity, housing shortages, and low high school graduation rates, comparable to other small Nunavut settlements. Fishing and hunting for 'country food' is an essential part of the Inuit way of life. Seal, Arctic char, and caribou are the key country food sources, though Pangnirtung caribou migration to Western lands has resulted in a higher reliance on the ocean for Inuit food security. Throughout the year, regardless of the season (or weather), going out to the land/water/ice to fish/hunt is the only way for Inuit to survive except for buying expensive processed food from the community grocery store. Inuit have access to about 20 country food sources over the year due to the seasonal availability of country food (country food diversity) (Egeland et al., 2009). The Arctic in general, and the Baffin Island region in particular, is experiencing rapid climate change and associated impacts including changing access to hunting and fishing lands due to unexpected changes in sea ice conditions (Ford et al., 2019).

Pangnirtung is one of the few communities in Nunavut territory that has significant commercial and subsistence fishing activities. The Inuit-owned fish processing plant (Pang Fisheries Ltd.) is located in the community and facilitates key fisheries, which are: an Arctic char (*Salvelinus alpinus*) fishery and a turbot (*Reinhardtius hippoglossoides*) fishery—co-existing commercial and subsistence wild capture fisheries. About 90% of turbot products are exported to eastern Asia. This market has expanded to include South Korea, Japan, Taiwan, Vietnam, and China. The market for Arctic char has drastically shrunk since about 2008 and presently is limited to small buyers in Nunavut. Yet, this fisheries system is undergoing rapid change, which Inuit fishers experience in many ways. Importantly, this process of change is integrated into their way of life. Key aspects of changes are related to: i) sea ice conditions, ii) the people themselves, iii) the landscape and seascape, iv) fish including Arctic char, turbot, and capelin (*Mallotus villosus*), v) the weather conditions, and vi) fish selling prices and markets.

Pangnirtung Inuit respond to identified changes and their implications (table 2). Most Inuit have incorporated advanced technology (such as GPS-Global Positioning Systems, VHF-Very High-Frequency radios, and advanced rifles) into their fishing and hunting activities. Fishers have limited access to loans by which to obtain new technology (fishing gear) except through the Fish Plant and Nunavut government. The livelihood diversity of Inuit is distributed among fishing, hunting, and creative work (painting, craftwork, and carving) as well as among limited job opportunities in organizations located in the community. Inuit hold (or have access to) assets required for fishing operations such as snowmobiles, boats, fishing gear, qamutiks (sleds), and trucks. Furthermore, fishers use various types of fishing gear aimed at different target species (for example, long lines, gill nets, jigging, fishing rods, clam digging tools, and spears). Inuit fishers share fishing gear and fish (Arctic char—subsistence fishery), particularly with their extended families and those who cannot fish and hunt themselves (elders). Inuit use local radio and community Facebook pages to share food as well as information related to fishing (for example, weather updates and requests for help).

Both the DFO (Department of Fisheries and Oceans) and the community HTA (Hunters and Trappers Association), along with the NWMB (Nunavut Wildlife Management Board) and other designated Inuit organizations (for example, NTI-Nunavut Tunngavik Incorporated), are co-managers of the fishery resources, as outlined in the Nunavut Agreement Article 5 (table 4). The fisheries co-management process is governed by a multi-level institution structure that consists of a mix of government, communal, and private organizations (figure 6.2), some of which are physically located in the community. This institutional structure functions mostly top-down and is characterized by flexibility; for example, Inuit select commercial fishing areas (from among eligible areas as licences permit) for turbot (Cumberland Sound) and Arctic char (lakes) based on the prevailing/changing weather and sea ice conditions. Furthermore, Inuit have a certain amount of flexibility in terms of reaching fish quotas; for instance, turbot quotas have not been fully utilized in the past couple of years (except for 2018) due to weather and sea ice conditions.

Pangnirtung Inuit possess various kinds of knowledge that are essential for harvesting and adapting to environment and climate change (Berkes and Jolly, 2001); this knowledge accumulates and evolves over the generations (Idrobo and Berkes, 2012) and is shared among friends and peer groups. It includes, for example, place-specific knowledge about Arctic char, knowledge about turbot fishing techniques, local environmental knowledge about fishing in high-risk conditions such as extreme cold, darkness, and Greenland shark (that are a turbot-long-line by-catch), and co-produced knowledge acquired by working, sharing, and learning together. However, the study identified the weakening of some aspects of knowledge systems, as many elders possess knowledge but have not practiced it themselves. For example, some young Inuit have not had to use survival skills on ice, nor have they handled dog teams, read the sky, or sewed seal skin. Moreover, Inuit fishers have various opportunities to learn about and adapt to change. Pangnirtung Inuit learn mostly from elders, parents, and extended family members. Learning-by-doing (as a way of life), learning via the internet (for example, technology and turbot food recipes), and learning via the school education system are other identified primary ways of learning.

Based on our work in Pangnirtung, we identified three primary adaptive strategies that dominate community responses to change. First, 'diversification' is a common strategy in the areas of fisheries, country food, fish export markets, and livelihood activities. Second, the use of technology for fisheries activities is a strategy employed mainly in response to safety-related vulnerabilities (Clark et al., 2016a, Clark et al., 2016b). Third, we recognise fisheries co-management as an adaptive strategy (Berkes and Armitage, 2010), mainly dealing with changing fishing seasons by achieving a shared consensus among multiple stakeholders (Berkes and Armitage, 2010, Armitage et al., 2011). Moreover, we identify four place-specific attributes (Inuit worldviews, Inuit institutions, a culture of sharing and collaboration, and ILK systems) that support the identified adaptive strategies and shape community adaptation. Each attribute has the ability to support adaptation under given circumstances.

6.2.3 Step three: Assessing Coastal-Vedda adaptation in Sri Lanka

Coastal-Vedda is a group of Indigenous people of Sri Lanka who are concentrated along the eastern coastal belt. The Kunjankalkulam Coastal-Vedda community is a rural, isolated fishing village with a resident population of 193, located in a dry climatic zone. As compared to other parts of the country, people in this region cope with unique challenges including high rates of food insecurity, a lack of drinking water and infrastructure (roads and housing), and low high school graduation rates. Moreover, this region has been directly/critically affected by the Sri Lankan civil war (1983-2009), tsunami devastation (2004), and climate extremes such as droughts, floods, and unexpected tropical storms, which have increased the complexity of the Coastal-Vedda way of life and the natural environment. Also, an increase in the number of human-elephant conflicts, an increase in the unpredictable nature of the weather, and the transformation of Coastal-Vedda due to social modernization, including the development of materialistic-centered values, are among identified changes. In the past, Coastal-Vedda used to fish in lagoons, tanks, and streams, and cultivate maize, pumpkin, and other easy-to-grow crops around their settlement area and in clearings in the surrounding jungle (slash, burn, and shifting to another area)—what has been termed 'Chena cultivation'(Seligmann and Seligmann, 1911, Dharmadasa, 1974).

Currently, Kunjankalkulam Coastal-Vedda is one of the few groups in the region that has a higher level of fisheries activities while maintaining its identity (less integrated with the majority Tamil and Muslim populations). Coastal-Vedda use a village tank (reservoir) to rear fish (i.e., reservoir aquaculture) as a primary year-round livelihood activity. With the support of the government, fisheries and aquaculture institutions, and NGOs, an annual stock of various fish fingerlings (for example, tilapia, carp, Indigenous fish species, and freshwater prawn) grows in a natural reservoir system without the need for artificial feed. This reservoir aquaculture consists of two types of fishing activities: 1). during the day, fisherwomen walk into the water to fish using fishing rods for food purposes—subsistence fishery and 2). In the early morning (2-3 am), fishermen go fishing in deep areas of the reservoir, using canoes and gill nets and selling to fish collectors every morning—commercial fishery. Key items of change that we identified in this aquaculture system are: i) continued disturbances of the Coastal-Vedda way of life during the civil war (including shooting, artillery shell attacks, and organized crime), ii) extreme weather and natural disasters (including tropical cyclones, floods, and drought conditions), iii) an increase in the number of human-elephant conflicts during the post-war period, iv) an increase in the unpredictable nature of weather patterns, and v) social pressure from modernization, the development of materialistic values, and wellbeing.

In addition to reservoir aquaculture, Coastal-Vedda are involved in a diverse range of livelihood activities such as home gardening, rice farming, beach seine, animal rearing, trapping and hunting, collecting wild honey, and collecting/selling wood from forest. In terms of adopting advanced technology (e.g., in aquaculture), Coastal-Vedda have significant room for improvement, as this Indigenous population is in the middle of a transformation from a forest-based lifestyle to a modern lifestyle. This includes adapting to a cash economy, cement housing, a non-mobile lifestyle, dress, cell phones, the practice of aquaculture, and fish selling activities. Coastal-Vedda have access to a number of assets that are required for fishing operations including canoes, cycles, pen structures, and fishing gear. Furthermore, fishers use several different types of fishing gear such as gill nets, thread nets, led nets, fishing rods, and pen structures; and often share this gear with community members. Fishers have access to loans through informal money lenders in the region.

Collective action is deeply rooted in Coastal-Vedda's way of life. In subsistence fisheries, all the fish that are harvested by the fisherwomen during the daytime are collected into one sack and later distributed equally among the families for food. This fishing operation is led and monitored by the village first-lady (spouse of the Coastal-Vedda chief). In commercial fisheries, fishermen work in small groups (2-4 persons) for security purposes when setting their nets at night. Moreover, the community uses informal networks to effectively share fisheries- and aquaculture-related information through informal gatherings. For example, women gather around the water-well to share daily updates from the community. Such information includes how the fish harvest was the previous night, who went fishing, who is planning to fish that night, and changes in fish prices. It also includes important non-fisheries-related information such as alerts about wild animals including elephants/snakes. Regular weather-related information is not a common topic of conversation, but people do use informal social networks to share information about extreme weather events, as internet use is not an option for the Coastal-Vedda community.

Kunjankalkulam reservoir aquaculture is co-managed by a multi-level institutional structure consisting of diverse stakeholder organizations that together manage stressors and changes to adapt by sharing knowledge and learning from each other (figure 6.2). The RFO (Rural Fisheries Organisation) is the key fisheries institution responsible for community-level fisheries and aquaculture management including landing-site management through the RFO treasurer. All the community fishers are members of the RFO. The Inland Fisheries Federation (IFF) is the regional-level aquaculture industry organisation that has considerable control over the inland fish market price. IFFs are represented by the leaders of RFOs. The leaders of IFFs are represented in the National Fisheries Federation (NFF) (national-level fisheries industry organization) and overlooks national-level fisheries and aquaculture development. The Batticaloa regional center of the National Aquaculture Development Authority of Sri Lanka (NAqDA) is directly involved in the co-management of reservoir aquaculture. NAqDA is the national-level government institution for inland fisheries and aquaculture management. Extension officers of NAqDA work closely with RFOs to ensure that fishers are following fisheries and aquaculture regulations and procedures. NGOs in the region (for example, World Vision, FAO, Care, and USAID) play a key role in supporting aquaculture co-management. For example, the fish fingerling stocking process in this region is funded collectively through various NGOs, the government, and the RFO.

Coastal-Vedda possess various types of knowledge systems that are essential for coping with SES change. Reservoir fishing spots, aquaculture techniques, weather predictions, wild elephants, disaster and emergency situations, climate adaptation, and collective action are common domains of knowledge. Coastal-Vedda have lost some knowledge of traditional hunting practices including making weapons (bow and arrow) partly because the war lasted over 30 years. Yet, multi-level local institutions enable knowledge sharing and have introduced new knowledge—for example, aquaculture technology (pen-culture) or climate adaptation techniques (rainwater collecting tanks)—to the system to fill such knowledge gaps. Moreover, these local institutions facilitate diverse learning opportunities for Coastal-Vedda to respond to SES change. Learning-by-doing is the most (65%) commonly practiced way of learning for Coastal-Vedda. Learning through local institutions (53%), through stakeholder institutions (32%) such as NGOs, and from parents and elders are other primary ways of learning.

We identified three commonly used adaptive strategies that are essential in responding to change in the Coastal-Vedda community. First, the adaptive multi-level institutional structure facilitates co-management while supporting knowledge sharing and co-learning. Second, aquaculture as an adaptive strategy provides a consistent supply of protein to the community. Third, we recognised diversification as an adaptive strategy which applies broadly, including livelihoods, aquacultured species, co-existing fisheries, institutions, knowledge systems, and learning opportunities. Moreover, we identified four place-specific attributes (Coastal-Vedda cultural identity and worldviews, co-management approach to aquaculture, the flexibility of locals in switching between adaptive options, and knowledge systems and learning) that support the adaptive strategies and shape community adaptation. Each attribute has the ability to support adaptation under given circumstances.

6.2.4 Step four: Comparative analysis

Comparative studies are used to test theoretical frameworks, refine concepts, and discover new relationships while contributing additional insights to individual cases studies (Lesnikowski, 2019). Individual case studies are key for developing theory and obtaining a deeper understanding of particular areas unique to individual cases. However, empirical case study comparisons are also important for examining how relationships change under different conditions, helping develop broader understanding (Dasgupta et al., 2007, Maru et al., 2014, Ford et al., 2018b). To date, in the growing local adaptation literature, most comparative studies have focused on communities within one country (e.g., (Schmitt et al., 2013, Ahmed et al., 2014, Arimi, 2014, van Putten et al., 2014, Oviedo et al., 2016, Hung et al., 2018)). In this context, the broader applicability of the findings (i.e., scaling up) is unclear/unknown, which constrains efforts to develop resilience and adaptation in communities (Conway et al., 2019, Leite et al., 2019). In this comparative analysis, we examine the broader applicability of findings by assessing what is either different from or similar to other SSFs and by bringing more insights about adaptation across spatial (the Canadian Arctic vs. Eastern Sri Lanka) and temporal (over 30 years) dimensions (Maru et al., 2014).

For the comparative analysis, we used content analysis to assess the qualitative data of both case studies (Yow, 2014, Hancock and Algozzine, 2015, Berg, 2016). The key techniques we used were 'manifest' and 'latent' content analysis (Vaismoradi et al., 2016, Krippendorff, 2018) supplemented with discourse analysis (Fairclough, 2013, Van Dijk, 2015, Wodak and Meyer, 2015) to develop themes and patterns related to the ways in which fishers experience and respond to change. We used coded data and fishers' quotes (from previous steps) to compare resulting changes (shocks and stressors) and adaptive responses in the two different SSF systems throughout three decades (Yow, 2014, George and Stratford, 2016). We also freshly coded the adaptive-strategies-related data (obtained during previous steps) to understand the most common and generalizable adaptive strategies in SSF. We compared and contrasted the coded information and themes from two case studies using various tables and institutional diagrams to identify the patterns, causes and effects, and linkages related to community adaptation that builds resilience and reduces vulnerabilities to change. The calibration of coded information was supplemented with feedback from the community representatives in the Canadian Arctic and Sri Lanka. The comparison was guided under each of the characteristics of the resilience-based framework (place, human agency, collective action and collaboration, institutions, ILK systems, and learning) to create an understanding of the relevance of such characteristics to resilience building and adaptation. The eight key sources of resilience, two adaptive strategies, and five definitive characteristics of a successful adaptation process were derived through inductive reasoning (Rihoux, 2006, Vaismoradi et al., 2016) to generate knowledge that supports successful adaptation in SSF communities and effective policy development.

Further, it is essential to understand what is adapting (in this study). We are focusing on the adaptation of Indigenous fisher populations based on their responses to changes in social-ecological systems (i.e., small-scale fisheries systems). We specifically focus on the linkages between different components of a small-scale fisheries system (e.g., collective action and collaboration, learning, resource management), which is not possible without understanding the key components of a social-ecological system (e.g., people, their livelihoods, culture, institutions, and knowledge systems related to their place) (Marshall, 2013, Galappaththi et al., 2019c, Leite et al., 2019). For example, it is important to pay attention to the characteristics that are key to co-managed fishery resources in both Inuit and Coastal-Vedda communities. Equally, it is important to understand how Indigenous peoples' worldviews and place attachments (e.g., live with change and uncertainty rather than try to migrate or quit) facilitate other processes or determinant factors that promote community adaptation. As such, the integration of all the focal areas of adaptation is essential to understanding community adaptation in rural Indigenous communities.

The way we determine how something is adaptive is essential to understand. Any action or process leading to increased community resilience *and* decreased vulnerability to adverse change was considered adaptation, consistent with (Galappaththi et al. 2019b, Galappaththi et al. 2020b, Ford et al. In Press). For example, we identified the use of advanced technology as an adaptive response in the Inuit context, as specific technology (e.g., GPS, advanced rifles) helps maintain hunting and fishing activities in-light of changing conditions.

6.3 Results: Comparative analysis

6.3.1 Changing SSF systems

The Canadian Arctic and eastern Sri Lanka are specifically different SSF systems (geographically, climatically, and socio-economically). Inuit experience climate change impacts as a way of changing biophysical (sea ice conditions, landscape, fish) and socioeconomic environments (Inuit, fish markets/price). Coastal-Vedda are affected mainly by sociopolitical changes (war and social modernization) and climate extremes (tropical storms, droughts). The Arctic capture fishery functions within the limits of climatic-seasonality (winter, spring, summer, and fall), whereas Sri Lankan aquaculture is subject to unexpected extreme events driven by monsoons and the dry conditions of the region (Bay of Bengal). Climate change is very relevant with respect to changes in Inuit SSF given the magnitude of the climate change signal in northern Canada (Ford et al., 2018b), whereas climate change is not the only key cause of changes in Coastal-Vedda SSF. For example, most of the stressors that Inuit experience are due to global warming impacts that create internal changes within Arctic SSF systems (sea ice conditions, landscape and seascape, fish species—char, weather conditions). The stressors of Coastal-Vedda are due mainly to external drivers such as civil war, natural disasters and climate extremes, wild elephant attacks, and social modernization. Yet, the nature of the implications (how stressors affect fishers' way of life) is common to both Indigenous fisher populations. For example, shorter fishing seasons, impediments to fish growth, safety concerns, damages to infrastructure, and limited access to travelling (including to fishing areas) are changing the fishing way of life (table 6.2).

Table 6.2: Comparison of implications of change affecting Indigenous fisher populations in different SSF systems.

Drivers behind change	Nature of change related to	Implications of change	
		Inuit	Coastal-Vedda
Climate-change-related impacts	Weather (temperature, winds, storms, droughts)	-Shorter fishing seasons -Safety concerns while traveling on ice -Constrained access to fishing areas -Affected fish aging process and seasonality -Damaged infrastructure including housing, trails, roads	-Shorter aquaculture season -Limited fish growth -Decrease in fishing days due to extreme weather -Constrained access (eroded gravel roads)
	Natural environment (animals, forest, snow and ice, glaciers)	-Lessening aesthetic value of the community -Inuit perceptions about reducing char fish population	-Unsafe and high-risk living environment due to wild elephants and lack of drinking water and infrastructure -Damaged infrastructure including housing
Modernisation and globalisation	People	-Weaker bonding among family members -Lessening of workdays as their health does not allow them to engage in fishing activities	-Adoption of new lifestyle (cash economy, aquaculture, cement housing); locals positioned between 'traditional' and 'modern'—middle of social transformation
Global change and modern-day colonialism	Socio-economic and political	-Shrinking Arctic char market portfolio in fish plant	-Loss of livelihoods (chena cultivation, cattle, hunting) -Loss of lives (during the war)

6.3.2 Adaptive responses of SSF systems

We compare and contrast the adaptive responses to change of Inuit and Coastal-Vedda SSF systems, using the characteristics of the resilience-based framework. These characteristics are place, human agency, collective action and collaboration, institutions, knowledge systems, and learning (table 6.3).

Table 6.3: Comparison of adaptive responses using characteristics of the framework.

Characteristics	Areas of adaptive responses	Responses to systems change	
		Inuit	Coastal-Vedda
Place	Fishery	Two co-existing (wild capture fisheries)	Reservoir aquaculture (culture-based fishery)
	Types of fisheries	Subsistence and commercial	Subsistence and commercial
	No. of fish species	Two	Eight
	Food diversity (protein supply—access to edible animals throughout the year)	n=20 (high)	n=9 (low)
Human agency	Use of advanced technology	GPS, VHF radios, advanced rifles (84%)	Not observed and couldn't measure
	Livelihood diversity (# of livelihood activities involved—occupational	n= 6 (low)	n=11 (high)

	multiplicity)		
	Access to # of assets needed for fishing activities	x= 3.8, s=1.1 (high)	x= 2.3, s=0.9 (low)
	Fishing gear diversity (access to # of different fishing gear)	x= 4.0, s=0.9 (high)	x= 3.2, s=1.8 (low)
	Access to loans	Via Fish Plant and Nunavut government	Via informal money lenders
Collective action and collaboration	Sharing fish	Observed in subsistence fishery	Observed in subsistence fishery
	Sharing fishing gear	Observed	Observed
	Sharing of weather information	Through internet and social media	Internet not available
	Sharing of information related to fishing operations	Observed in commercial fishery	Observed in commercial fishery
	Social networks	Through internet-based social media and community radio	Face-to-face small-group informal discussions
	Level of use of collective action for problem-solving	Observed	Often use (for example, local institutions)
Institutions	Fishery management approach	Co-management	Co-management
	Key local institution	HTA	RFO
	Structure	Multi-level	Multi-level
	Way of functioning	Mostly top-down	Mostly bottom-up
	Adaptive nature in functionality	Flexibility observed	Flexibility observed
ILK systems	Identified knowledge areas	Arctic char, turbot, fishing techniques, fish processing, local environment knowledge	Reservoir fishing spots, aquaculture, weather predictions, collective action, climate adaptation, disaster/ emergency situations, wild elephants
	Level of application of ILK	Some aspects of ILK identified are not used anymore	Used all ILK identified (loss of some traditional knowledge)
	Weakening of knowledge systems	Observed	Observed
	What bridges the weakening knowledge gap	Advanced technology	Knowledge of aquaculture and climate adaptation
Learning	Level of diversity of learning opportunities	Relatively less diverse opportunities	More diverse learning opportunities
	Key ways of learning (top three)	From elders/parents/extended family members (84%), learning-by-doing (13%), via internet, via school education	Learning-by-doing (65%), via local institutions (53%), via stakeholder institutions (32%), from parents and elders (28%)

6.3.2.1. Place

Inuit have co-existing wild capture fisheries of arctic char and turbot in the Arctic, whereas Coastal-Vedda engage in reservoir aquaculture (culture-based fishery). Both fisheries systems incorporate subsistence and commercial fisheries. This co-existence with commercial fisheries provides an opportunity for fishers to increase their adaptive capacity by improving their earning potential and food security to cope with the SSF systems' randomness. The process of maintaining co-existing fisheries could be considered an adaptive response to change, as it requires intentional and substantial human effort. For example, the co-existing fisheries are essential for Inuit food security—now more than ever after the caribou out-migration.

Also, in terms of food security, Inuit have access to more than 20 Arctic animal species including char and turbot, while Coastal-Vedda have access to about nine edible species including seven aquaculture species. In this context, Inuit and Coastal-Vedda have close, meaningful relationships to their 'place' or natural environment (for example, forest, mountains, coast, sea, lagoon, and reservoir); place attachment, the associated Indigenous culture, and their worldviews substantially influence ideas about adapting to change and staying within the community while dealing with challenges.

6.3.2.2. Human agency

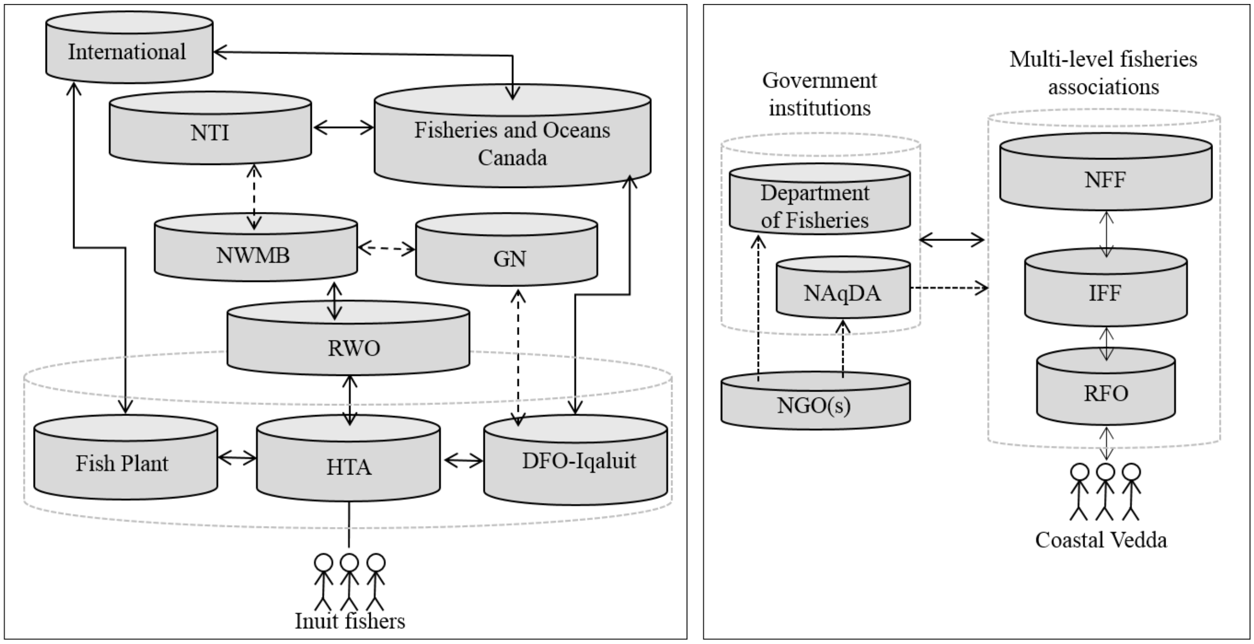
Our case studies possess different levels of human agency, yet both Indigenous populations are adapting to specific changing conditions in their SSF systems or 'place'. A key distinction we identified is the Inuit adoption of new technologies for their SSF; however, we did not observe a considerable use of technology in Coastal-Vedda aquaculture. A majority of Inuit fishers use GPSs, VHS radios, and advanced rifles in their fishing and hunting operations to overcome daily challenges such as unexpected weather and navigational challenges as well as to stay connected to the community. Based on the measure of occupational multiplicity, however, Coastal-Vedda show higher livelihood diversity (for example, home gardening, animal rearing, and collecting wild honey and fruit), which improves their food/income options for survival. In terms of fishing activities, Inuit show higher fishing gear diversity and access to assets required for fishing operations. Moreover, both fishing populations have access to loans and financing mechanisms that support their fishing activities through government programs (Inuit and Coastal-Vedda), fish plant (Inuit), NGO programs (Coastal-Vedda), and informal money lenders (Coastal-Vedda).

6.3.2.3. Collective action and collaboration

Collective action and collaboration are common phenomena among both SSF. For instance, in Indigenous subsistence fisheries, both communities widely share fish for food purposes. The sharing of fishing gear is observed at different levels within the commercial as well as subsistence fisheries in both SSF. In commercial fisheries, both Inuit and Coastal-Vedda share specific information that is required for fishing operations. The use of the internet and community radio to share weather-related information and for social networking is a distinguishing characteristic of Inuit capture fisheries. Coastal-Vedda do not have access to the internet; nonetheless, social networking and the sharing of specific fisheries information takes place through face-to-face informal gatherings in specific places within the community. These kinds of informal gatherings are also observed among Inuit. For example, just before Inuit leave for turbot fishing, they meet and do some planning and information sharing in specific places. Overall, collaboration is a common practice in both SSF systems, whereas collective action is wildly practiced by Coastal-Vedda to deal with common challenges in their Indigenous way of life.

6.3.2.4. Institutions

Inuit and Coastal-Vedda SSFs use institutions with multi-level structures for fisheries co-management (figure 6.2). Both settlements each have a key community-level institution that is the focus of attention: the HTA (Hunters and Trappers Association) for Inuit and the RFO (Regional Fisheries Organization) for Coastal-Vedda. These multi-level institution structures consist of mixed institutions; for example, the Inuit structure represents government, private, and communal institutions whereas the Coastal-Vedda structure consists of government, NGO, and communal institutions. Also, these multi-level structures have specific institutions/leadership that lead the co-management process (Gutiérrez et al., 2011)—for example, the combination of HTA, DFO, and NWMB in Arctic char fisheries and RFO, NAqDA, and NGO(s) in Sri Lankan reservoir aquaculture add on adaptive capacity to their SSFs. In terms of the nature of operations and decision-making related information flow, the Arctic institutional structure mostly works top-down while the Sri Lankan structure has a bottom-up approach. Yet, both co-management institutions show flexibility in terms of adapting to challenges and uncertainties produced by shocks and stressors, such as climate change impacts. Table 6.4 offers a detailed comparison of the two fisheries governance approaches.



(a) Co-management structure for Pangnirtung Arctic char and turbot fisheries

(b) Co-management structure for Kunjankalkulam reservoir aquaculture

Figure 6.2: Comparison of Inuit and Coastal-Vedda fisheries governance structures.

HTA (Hunters and Trappers Association); DFO (Department of Fisheries and Oceans); RWO (Regional Wildlife Organization); NWMB (Nunavut Wildlife Management Board); GN (Government of Nunavut); NTI (Nunavut Tunngavik Incorporated); RFO (Rural Fisheries Organisation); IFF (Inland Fisheries Federation); NFF (National Fisheries Federation); NAqDA (National Aquaculture Development Authority); NGO (non-governmental organisations). Solid-line arrows represent the inter-institutional links for fisheries and aquaculture management-related aspects and dotted-line arrows represent the links for financing-related aspects.

Table 6.4: Comparison of characteristics in fisheries governance context.

Area	Features of fisheries governance system	
	Inuit	Coastal-Vedda
Approach	(Adaptive) Co-management of Arctic char and turbot fisheries	(Adaptive) co-management of reservoir aquaculture
Partnerships	DFO, HTA, and NWMB directly co-manage Arctic char and turbot fisheries, while NTI, GN, and RWO are also partners in the decision-making process. An Inuit-owned private-entity fish plant informally has a large influence on the co-management process.	NAqDA and RFO directly co-manage reservoir aquaculture, while multiple NGOs and other government (Department of Fisheries) and aquaculture industry associations (IFF and NFF) are also influential in the process.
Mixed regime	Government, private, communal	Government, NGO, communal
Vertical and horizontal linkages	Both vertical and horizontal linkages are active within the mixed regime. For example, the federal government (DFO) and community organisations (HTA), with the support of	Both vertical and horizontal linkages are active within the mixed regime. For example, government institutions (NAqDA, Department of Fisheries), NGOs, and aquaculture industry

	private sector industry organisations (fish plant), horizontally connect for fisheries management while provincial government (GN/NWMB/RWO) entities vertically connect to support decision-making.	associations (RFO) connect horizontally for community aquaculture management while aquaculture industry associations connect vertically for aquaculture development.
Sharing of responsibility, authority, and power	The community organization HTA is the co-management licence holder for Arctic char and turbot fishing. For example, the HTA uses a lottery system to make decisions about issuing licences for commercial char fishing.	Government, NGOs, and the RFO together share the responsibility for funding reservoir aquaculture. Administrative power is shared among government institutions (operating license through NAqDA and canoe registration through the Department of Fisheries) and RFOs (landing-site management).
Learning-by-doing	Considering the size of fish populations and migratory patterns, the fish quota will be reviewed annually based on the best available science and Indigenous and local knowledge. Community fishers are part of the fish population monitoring program.	Particularly at the RFO level Coastal-Vedda continuously research fishing spots, the time of fingerling stocking, locations for the pen culture, and setting nets for commercial fishery, and learn from trial and error while dealing with change.

6.3.2.5. Indigenous and local knowledge systems (ILK)

Inuit and Coastal-Vedda possess diverse ILK systems. For example, Inuit hold ILK related to Arctic char, turbot, fishing techniques, fish processing, and local environment knowledge, whereas Coastal-Vedda' practice ILK related to reservoir fishing spots, aquaculture, weather predictions, collective action, climate adaptation, disaster emergency situations, and wild elephants. Both SSF systems have experienced a weakening of their ILK systems while adapting to change over the last three decades (Galappaththi et al., 2019, Galappaththi et al., 2020a). In terms of application, some aspects of Inuit ILK are no longer used but knowledge still exists among Inuit. Coastal-Vedda believe that they have already lost some traditional practices (capture fishery/hunting and equipment such as the bow and arrow). However, Coastal-Vedda are currently practicing all the components of ILK identified in the Sri Lankan study. The new knowledge of advanced technology (particularly among young Inuit) could bridge the knowledge gaps resulting from a weakening of Inuit ILK systems. Knowledge of aquaculture and climate adaptation in the Coastal-Vedda setting could bridge SSF knowledge gaps due to a loss of old hunting/fishing knowledge. A combination of different kinds of knowledge systems (that evolve over the generations) is essential to the fishing and hunting lifestyle of both Indigenous groups. We recognised both ILK systems as sources of resilience for their SSF, and as a means of measuring the understanding of adaptation as they underpin adaptive capacity to deal with change (Folke et al., 2003).

6.3.2.6. Learning

We compare the learning opportunities to foster adaptation and resilience building, which are available and currently practiced in each fisheries system, as a means of dealing with the change. Key ways of learning for Inuit fishers are through elders/parents/extended family members, learning-by-doing, the internet, and school education. Coastal-Vedda possess more diverse learning opportunities in an aquaculture setting: learning-by-doing, local and stakeholder institutions, and parents and elders. Learning from elders, parents, and extended family members is the most common means of learning among Inuit, while learning-by-doing and learning through institutions are the most popular means of learning among Coastal-Vedda. Both SSF communities building resilience to adapt to changing conditions through learning as a part of knowledge (ILK) co-production process.

6.3.3 Adaptation strategies and place specific attributes

Overall, diversification is a common strategy among Inuit and Coastal-Vedda that allows them to increase the range of options available for dealing with change and building adaptive capacity. SSF systems-specific adaptive strategies use advanced technology (Inuit) and aquaculture (Coastal-Vedda). Also, a multi-level institutional structure that facilitates collective action, co-learning, and knowledge sharing is another strategy in Sri Lanka. Co-management is a common approach practiced by Inuit and Coastal-Vedda; however, it is a particularly well-established adaptation strategy in the Inuit SSF setting for use in managing changes in capture fisheries. In addition to adaptive strategies, we compare place-specific attributes that shape the community adaptation process. Inuit and Coastal Vedda possess unique worldviews and ILK systems that support adaptation (table 6.5). Inuit's own institutions (fish plant) and culture (sharing and collaboration) are other attributes of Inuit fishers that improve their systems' resilience. The co-management approach for aquaculture and Coastal-Vedda's flexibility in switching between different adaptive responses are attributes that advance adaptation in the Sri Lankan culture-based fisheries system.

Table 6.5: Adaptation strategies and place specific attributes.

Response type	Inuit	Coastal-Vedda
Adaptation strategies	Diversification	Diversification

	Advanced technology	Aquaculture
	Co-management	Multi-level institutional structure
Place-specific attributes	Unique worldviews	Unique worldviews
	Indigenous and local knowledge systems	Indigenous and local knowledge systems
	Inuit-owned institutions	Flexibility in switching between different adaptive responses
	Culture (sharing and collaboration)	Co-management approach

6.4 Discussion

We carried out a comparative analysis of two case studies (i.e., Inuit of Canadian Arctic and Coastal-Vedda of Sri Lanka) to examine the changes (shocks and stressors) they experience, and their adaptive responses to those changes, to develop a broader understanding of opportunities for climate adaptation policy in SSFs. This idea of the comparison of case studies can be found in other climate-sensitive resource systems around the world (e.g., Maru et al. (2014) and Conway et al. (2019)). However, it is essential to deepen the understanding of the characteristic features of the ways in which people experience climate change (i.e., vulnerabilities) and possible responses (i.e., adaptations) in remote SSFs in particular. How could these responses be linked to broaden the understanding of what successful adaptation is at the community level and build resilience into the adaptation process so as to deal with the barriers to adaptation in a much broader scale?

Both the Arctic and Sri Lanka case studies show parallels in the way in which SSFs experience change. We identified four characteristics of the nature of climate change impacts in SSFs: i) SSF systems are undergoing multiple stressors simultaneously; ii) The implications of climate impacts affect people in mixed/interrelated ways combined with other non-climatic changes—intertwined nature (e.g., sea ice conditions, markets and fish price changes in the Canadian Arctic); iii) People themselves are changing (e.g., culture, economy, lifestyle) over time with the changes in SSF systems; and iv) Changes associated with rural SSF are linked to other distant systems including markets and economies (e.g., Asian fish market for Arctic turbot). These characteristics reconfirm the documented climate impacts in other resource systems in both Arctic and tropical settings (Ford et al., 2015, Arctic Council, 2016, Chen and Mueller, 2018, Ford et al., 2019, Galappaththi et al., 2019a). Also, we identified two main contextual differences associated with the nature of climate impacts in SSFs. First, climate change is one of the many other drivers of changing SSFs. Climate change creates more vulnerabilities in Arctic SSFs and it has received much attention from Inuit and researchers worldwide (Overland et al., 2014, Pearce et al., 2015, Ford et al., 2016). Meanwhile, the Coastal-Vedda, because they have been concerned with civil war and natural disasters (e.g., tsunami), have focused relatively little attention on climate change in an aquaculture context. Second, Indigenous people of SSFs regularly experience climate change impacts but locals do not always perceive climate change as a key vulnerability depending on the context. Many of the changes related to climate change are clearly noticeable in Arctic fisheries due to evident changes in a physical environment (e.g., sea ice) (Nichols et al., 2004, Ford et al., 2019). However, in some tropical SSFs, including in the Sri Lanka case study, it is not clearly visible until perhaps the fish harvesting stage. There is a risk of obscure vulnerabilities (e.g., ocean acidification) (Lam et al., 2016, Speers et al., 2016).

After examination of adaptive responses across case studies, we identified eight 'sources of resilience' that minimise vulnerability and build adaptive capacity to climate change impacts in SSFs, as table 6.6 elaborates. These are: i) use of diverse kinds of knowledge; ii) practice of different ways of learning ; iii) use of community-based institutions; iv) efforts to improve human agency; v) possession of unique worldviews; vi) holding of specific cultural attributes to keep up with adaptation; vii) effective social networks; and viii) a high level of flexibility. These eight sources of resilience can be recognised as distinct but interrelated ways of supporting adaptation to the impacts of climate change in SSFs. Yet, we are not arguing that Inuit and Coastal-Vedda SSFs are sustainable in terms of the equitable distribution of benefits among fishers/families, as power imbalances and irreducible uncertainties inherent to the SSF can affect the resilience of social-ecological systems (Berkes et al., 2003). We noticed that rural SSF systems rely on specific-distance economic and market systems to maintain local fisheries activities, which may involve uncertainty and indicate that they are not completely self-sustaining. For instance, Arctic turbot fishery relies mostly on the Asian export market, whereas Coastal-Vedda reservoir aquaculture relies partially on NGO funding support for reservoir aquaculture. However, the combined result of identified sources of resilience could greatly nurture community adaptations to climate change in SSF and Indigenous settings.

Table 6.6: Sources of resilience in changing SSFs in an Indigenous context.

Source of resilience	Description and examples	References

Use of diverse kinds of knowledge systems for daily fishing activities	Inuit use knowledge about fishing spots, turbot fishing techniques, fish processing knowledge, marketing knowledge, and local environmental knowledge. Coastal-Vedda use knowledge about reservoir aquaculture operations, weather predictions, collective action, and climate adaptation actions. Both fisher populations in a group setting work together and combine and co-produce new knowledge.	(Folke et al., 2003, Armitage et al., 2011, Galappaththi et al., 2019a)
Practice of different ways of learning opportunities to foster adaptive learning	Key ways of Inuit learning are: elders, parents, and extended family members; learning-by-doing; the internet; and school education. Coastal-Vedda learn mainly from learning-by-doing, via local/stakeholder institutions, parents, and elders. Both communities are co-learning.	(Berkes and Turner, 2006, Armitage et al., 2011, Frankenberger et al., 2013, Tschakert et al., 2014)
Use of community-based institutions to cope with common challenges and fisheries management	The purpose of local institutions is to successfully confront common challenges and resource management. Coastal-Vedda use fisheries organisations to attract resources for continuing reservoir aquaculture operation and regular aquaculture management. Inuit possess fisheries management units (Hunters and Trappers Association) as well as Inuit-owned entities (Fish Plant) to maintain their co-existing char and turbot fisheries.	(Ostrom, 1990, Berkes and Armitage, 2010, Boyd and Folke, 2012, Galappaththi and Berkes, 2014, Fidelman et al., 2017)
Efforts to improve human agency to build adaptive capacity	Building capacity through livelihood diversification (Coastal-Vedda) and the use of advanced technology for fisheries activities (Inuit) is evident. Both Indigenous groups build adaptive capacity through local institutions by collective action and collaboration.	(Brown and Westaway, 2011, Brown, 2016, Galappaththi et al., 2019b)
Unique worldviews that encourage living with the changing conditions and adapting	Both Indigenous fishers learn to live with change and uncertainty rather than try to migrate or quit. Both Inuit and Coastal-Vedda have strong attachments to place and people. These worldviews allow them to deal with change over time and to cope with, adapt to, and sometimes transform (Coastal-Vedda) certain aspects of their SSF.	(Kaján, 2014, Amundsen, 2015, Adger, 2016)
Specific cultural attributes such as sharing, collective action, and collaboration	Collaboration, sharing, and collective action are specific attributes of Indigenous people's culture. These aspects will improve social equality and cohesion through the sharing and transferring of adaptive capacity within the community. An example is the sharing of a fish harvest with Inuit/Coastal-Vedda elders who are incapable of hunting/fishing.	(Adger, 2003, Ostrom, 2014, Karlsson and Hovelsrud, 2015, Childs, 2017, Ranasinghe and Cheng, 2018, Galappaththi et al., 2019a)
Effective social networks that lubricate specific information-sharing processes that are mandatory for fishing activities	Indigenous fishers use various forms of networking that improve effective fisheries-related information sharing. For instance, Inuit use internet-based social media for weather and fishing spot updates. Further, both Inuit and Coastal-Vedda rely on informal social gatherings to share information including fish prices and warnings about animals (polar bears in the Arctic/wild elephants in Sri Lanka).	(Alexander et al., 2015, Orchard et al., 2015, Galappaththi et al., 2016)
Flexibility with which SSF systems can switch	Both Inuit and Coastal-Vedda SSF systems have the flexibility to engage in multiple adaptive responses or switch between different	(Cinner et al., 2015, Cinner

between different adaptive responses or engage in multiple responses as appropriate to adapt to changing SSF conditions	responses. For instance, most Inuit are involved in Arctic char and/or turbot fisheries. Further, most Coastal-Vedda switch between multiple income activities as livelihood options and have a range of aquaculture options (subsistence, commercial, or pen culture).	et al., 2018)

We identified two adaptation responses that are common to both SSFs. These responses are: diversification strategies and an adaptive co-management approach. First, diversification is a widely applicable strategy in the areas of livelihoods, fisheries, knowledge systems, learning opportunities, and institutions. In the broader resilience literature, diversification has been identified as a source of resilience (Folke et al., 2003) and a means of adaptation, particularly in the context of climate change (Cline et al., 2017, Asfaw et al., 2018, Galappaththi et al., 2019a, Leu, 2019). Nurturing diversity in changing social-ecological systems can increase creativity and adaptive capacity as well as set the system for reorganization and renewal (Folke, 2016, Nayak and Armitage, 2018). Second, the adaptive co-management approach is widely used in natural resource management setting including SSF in both developed and developing regions (Dale and Armitage, 2011, Fidelman et al., 2017). The identified characteristics of Inuit and Coastal-Vedda governance regimes in table 4 (e.g., partnerships, mixed regimes, vertical/horizontal linkages, learning-by-doing, and the sharing of power, responsibility, and authority) are well-documented and recognised in the co-management literature in various resource systems (Armitage et al., 2007, Armitage et al., 2008, Berkes, 2009, Berkes and Armitage, 2010, Armitage et al., 2011, Dale and Armitage, 2011, Alexander et al., 2015, Galappaththi and Berkes, 2015, Kocho-Schellenberg and Berkes, 2015, Nunan et al., 2015, Fidelman et al., 2017). Adaptive co-management in SSF and Indigenous contexts draws on their collective capacity to use accessible resources at the right time and in the right way to harness resources and human capital together. Brown (2016) identified and termed this attribute 'resourcefulness.' It reflects human agency and capabilities, innovation, and opportunities.

What does successful adaptation look like in the context of SSF (Adger et al., 2005, Osbahr et al., 2010, Piggott-McKellar et al., 2019)? We argue that successful adaptation must bring equity benefits and opportunities to marginalised vulnerable communities (e.g., rural Indigenous SSFs), ensuring nutrition, food security, and sustainable livelihoods through a bottom-up participatory resilience-building approach (Leite et al., 2019). Building on recognized sources of resilience (table 6.6), we identified five definitive characteristics of a successful adaptation process in SSF. They are: i) Continuous learning through knowledge co-production (learning new knowledge and updating existing knowledge) (Armitage et al., 2011, Dale and Armitage, 2011); ii) Capacity-building to improve human agency (transferring existing capacities and building new capacities) (Cinner et al., 2018); iii) Place-specific nature (rootedness), which recognizes the situated nature of resilience and the importance of culture and place, including the focus on identity, worldviews, and attachment (Brown, 2016); iv) Collective action and partnerships through community-based institutions to effectively co-manage (fisheries) resources (Schipper et al., 2014, Conway et al., 2019); and v) Flexibility in terms of switching between adaptive responses (Cinner et al., 2018). These characteristics are important in judging success, but the relative weight allocated to each criterion is not given; rather, it emerges from a societal process of consent and action (Adger et al., 2005, Osbahr et al., 2010). Cultivation of these characteristics has the potential to address some of the barriers to effective community-based adaptation as identified by Piggott-McKellar et al. (2019).

We have identified a wide range of elements that represent adaptation in an Indigenous fisheries context (e.g., adaptive strategies, sources of resilience). Additionally, the adaptability of a community also implies that it could *not* be adaptive, as it is determined by various factors (i.e., characteristics of the successful adaptation). In the presence of definitive characteristics, these elements could act as adaptation. Yet, in the absence of the same characteristics, these elements could also not be adaptive. For example, Coastal-Vedda's community-based institutions could not perform well without the continuous learning of new aquaculture techniques, such as pen culture systems (continuous learning through knowledge co-production). It is difficult to imagine how Inuit communities continue their turbot fishery without paying attention to the sea ice condition of the Cumberland Sound fishing area (a place-specific nature). Thus, we identified what constitutes (successful) adaptation in an Indigenous fisheries context, which are the five definitive characteristics.

6.5 Conclusions

In this paper, we have compared two empirical studies (i.e., from the Canadian Arctic and Sri Lanka) to articulate an understanding of how SSF communities can build resilience and minimise vulnerability in the face of climate change and other identified multiple stressors. Also in this paper, we have identified what successful adaptation looks like in the context of remote marginalized Indigenous populations. We argue that successful adaptation, particularly in a disadvantaged community setting, should focus on bottom-up resilience-building approaches that offer equity benefits and opportunities in the areas of nutrition, food security, and livelihoods. The community adaptation process could offer support through commonly used adaptive strategies (e.g., diversification and adaptive co-management) and various community resilience-building approaches. We proposed eight sources of resilience, which are: i) the use of diverse kinds of knowledge; ii) the practice of different ways of learning; iii) the use of community-based institutions; iv) efforts to improve human agency; v) the possession of unique worldviews; vi) the holding of specific cultural attributes to keep up with adaptation; vii) effective social networks; and viii) a high level of flexibility. These sources of resilience could guide the adaptation process with identified definitive characteristics (continuous learning; capacity building; rootedness; collective action; and flexibility). These opportunities could be used to guide and formulate the community adaptation process and help with policy development, particularly in the domains of climate change adaptation and sustainable SSF. Also, this study provides policy insights to broaden the understanding of what successful adaptation looks like in remote disadvantaged communities.

6.6 References

ADGER, W. N. 2003. Social capital, collective action, and adaptation to climate change. *Economic Geography,* 79**,** 387-404.

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

ADGER, W. N., ARNELL, N. W. & TOMPKINS, E. L. 2005. Successful adaptation to climate change across scales. *Global environmental change,* 15**,** 77-86.

AHMED, N., BUNTING, S. W., RAHMAN, S. & GARFORTH, C. J. 2014. Community-based climate change adaptation strategies for integrated prawn–fish–rice farming in B angladesh to promote social–ecological resilience. *Reviews in Aquaculture,* 6**,** 20-35.

ALEXANDER, S. M., ARMITAGE, D. & CHARLES, A. 2015. Social networks and transitions to co-management in Jamaican marine reserves and small-scale fisheries. *Global Environmental Change,* 35**,** 213-225.

AMUNDSEN, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment,* 20**,** 257-276.

ARCTIC COUNCIL 2016. Arctic Resilience Report, Arctic Council. *In:* CARSON, M. & PETERSON, G. (eds.). Stockholm: Stockholm Environment Institute and Stockholm Resilience Centre.

ARIMI, K. S. 2014. Determinants of climate change adaptation strategies used by fish farmers in Epe Local Government Area of Lagos State, Nigeria. *Journal of the Science of Food and Agriculture,* 94**,** 1470-1476.

ARMITAGE, D., BERKES, F., DALE, A., KOCHO-SCHELLENBERG, E. & PATTON, E. 2011. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change,* 21**,** 995-1004.

ARMITAGE, D., BERKES, F. & DOUBLEDAY, N. (eds.) 2007. *Adaptive co-management: collaboration, learning, and multi-level governance,* Vancouver: UBC Press.

ARMITAGE, D., MARSCHKE, M. & PLUMMER, R. 2008. Adaptive co-management and the paradox of learning. *Global environmental change,* 18**,** 86-98.

ASFAW, S., PALLANTE, G. & PALMA, A. 2018. Diversification strategies and adaptation deficit: Evidence from rural communities in Niger. *World Development,* 101**,** 219-234.

BERG, B. L. 2016. *Qualitative research methods for the social sciences,* Boston, Pearson Education.

BERKES, F. 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of environmental management,* 90**,** 1692-1702.

BERKES, F. & ARMITAGE, D. 2010. Co-management institutions, knowledge, and learning: Adapting to change in the Arctic. *Etudes/Inuit/Studies***,** 109-131.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F., FOLKE, C. & COLDING, J. (eds.) 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience,* Cambridge, UK: Cambridge University Press.

BERKES, F. & JOLLY, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology,* 5**,** 18.

BERKES, F. & TURNER, N. J. 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology,* 34**,** 479.

BOYD, E. & FOLKE, C. (eds.) 2012. *Adapting institutions: Governance, complexity and social-ecological resilience,* New York: Cambridge University Press.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

BROWN, K. & WESTAWAY, E. 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual review of environment and resources,* 36**,** 321-342.

CAREY, M. A. & ASBURY, J.-E. 2016. *Focus group research,* London, Routledge.

CHEN, J. & MUELLER, V. 2018. Coastal climate change, soil salinity and human migration in Bangladesh. *Nature Climate Change,* 8**,** 981-985.

CHILDS, K. 2017. Culture and life: The last Veddas of Sri Lanka. *Guardian (Sydney)***,** 10.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8**,** 117-123.

CINNER, J. E., HUCHERY, C., HICKS, C. C., DAW, T. M., MARSHALL, N., WAMUKOTA, A. & ALLISON, E. H. 2015. Changes in adaptive capacity of Kenyan fishing communities. *Nature Climate Change,* 5**,** 872-876.

CISNEROS-MONTEMAYOR, A. M., PAULY, D., WEATHERDON, L. V. & OTA, Y. 2016. A global estimate of seafood consumption by coastal Indigenous peoples. *PLoS One,* 11**,** e0166681.

CLARK, D. G., FORD, J. D., BERRANG-FORD, L., PEARCE, T., KOWAL, S. & GOUGH, W. 2016a. The role of environmental factors in search and rescue incidents in Nunavut, Canada. *Public health,* 137**,** 44-49.

CLARK, D. G., FORD, J. D., PEARCE, T. & BERRANG-FORD, L. 2016b. Vulnerability to unintentional injuries associated with land-use activities and search and rescue in Nunavut, Canada. *Social Science & Medicine,* 169**,** 18-26.

CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. 2016. *Key methods in geography,* London, Sage.

CLINE, T. J., SCHINDLER, D. E. & HILBORN, R. 2017. Fisheries portfolio diversification and turnover buffer Alaskan fishing communities from abrupt resource and market changes. *Nature communications,* 8**,** 14042.

CONWAY, D., NICHOLLS, R. J., BROWN, S., TEBBOTH, M. G., ADGER, W. N., AHMAD, B., BIEMANS, H., CRICK, F., LUTZ, A. F. & DE CAMPOS, R. S. 2019. The need for bottom-up assessments of climate risks and adaptation in climate-sensitive regions. *Nature Climate Change,* 9**,** 503-511.

CUNSOLO-WILLOX, A. & ELLIS, N. R. 2018. Ecological grief as a mental health response to climate change-related loss. *Nature Climate Change,* 8**,** 275-281.

D'ARMENGOL, L., CASTILLO, M. P., RUIZ-MALLÉN, I. & CORBERA, E. 2018. A systematic review of co-managed small-scale fisheries: Social diversity and adaptive management improve outcomes. *Global environmental change,* 52**,** 212-225.

DALE, A. & ARMITAGE, D. 2011. Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *Marine Policy,* 35**,** 440-449.

DASGUPTA, S., LAPLANTE, B., MEISNER, C. M., WHEELER, D. & JIANPING YAN, D. 2007. The impact of sea level rise on developing countries: a comparative analysis. *World Bank policy research working paper*.

DHARMADASA, K. 1974. The creolization of an aboriginal language: The case of Vedda in Sri Lanka (Ceylon). *Anthropological Linguistics,* 16**,** 79-106.

EGELAND, G. M., CHARBONNEAU-ROBERTS, G., KULUGUQTUQ, J., KILABUK, J., OKALIK, L., SOUEIDA, R. & KUHNLEIN, H. V. 2009. Back to the future: using traditional food and knowledge to promote a healthy future among Inuit. *Indigenous Peoples' Food Systems.* Food and Agriculture Organization of the United Nations, Centre for Indigenous Peoples' Nutrition and Environment, Rome 2009.

FAIRCLOUGH, N. 2013a. *Critical discourse analysis: The critical study of language,* NY, Routledge.

FIDELMAN, P., VAN TUYEN, T., NONG, K. & NURSEY-BRAY, M. 2017. The institutions-adaptive capacity nexus: Insights from coastal resources co-management in Cambodia and Vietnam. *Environmental Science & Policy,* 76**,** 103-112.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FORD, J., MCDOWELL, G. & PEARCE, T. 2015. The adaptation challenge in the Arctic. *Nature Clim. Change,* 5**,** 1046-1053.

FORD, J. D., CLARK, D., PEARCE, T., BERRANG-FORD, L., COPLAND, L., DAWSON, J., NEW, M. & HARPER, S. L. 2019. Changing access to ice, land and water in Arctic communities. *Nature Climate Change,* 9**,** 335-339.

FORD, J. D., COUTURE, N., BELL, T. & CLARK, D. G. 2018a. Climate change and Canada's north coast: research trends, progress, and future directions. *Environmental Reviews,* 26**,** 82-92.

FORD, J. D., KING, N., GALAPPATHTHI, E. K., PEARCE, T., MCDOWELL, G. & HARPER, S. In Press. Resilience of Indigenous peoples to environmental change *One Earth***,** (10.1016/j.oneear.2020.05.014).

FORD, J. D., SHERMAN, M., BERRANG-FORD, L., LLANOS, A., CARCAMO, C., HARPER, S., LWASA, S., NAMANYA, D., MARCELLO, T. & MAILLET, M. 2018b. Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. *Global environmental change,* 49**,** 129-139.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2016. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-195.

FRANKENBERGER, T., MUELLER, M., SPANGLER, T. & ALEXANDER, S. 2013. Community resilience: conceptual framework and measurement feed the future learning Agenda. *Rockville, MD: Westat,* 1.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2019a. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C. (eds.) *Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, Bangkok, 8–10 August, 2016. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO. 240 pp. Licence: CC BY-NC-SA 3.0 IGO.*

GALAPPATHTHI, E. K. & BERKES, F. 2014. Institutions for managing common-pool resources: the case of community-based shrimp aquaculture in northwestern Sri Lanka. *Maritime Studies,* 13**,** 1-16.

GALAPPATHTHI, E. K. & BERKES, F. 2015. Can co-management emerge spontaneously? Collaborative management in Sri Lankan shrimp aquaculture. *Marine Policy,* 60**,** 1-8.

GALAPPATHTHI, E. K., FORD, J. & BENNETT, E. 2020a. Climate change and adaptation to social-ecological change: The case of Indigenous people and reservoir aquaculture in Sri Lanka. *Climatic Change***,** 18.

GALAPPATHTHI, E. K., FORD, D.J., BENNETT, E.M., BERKES, F. 2019c. "Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada." *Journal of environmental management* **250**(109534): 11.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019b. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GALAPPATHTHI, E. K., KODITHUWAKKU, S. S. & GALAPPATHTHI, I. M. 2016. Can environment management integrate into supply chain management? Information sharing via shrimp aquaculture cooperatives in northwestern Sri Lanka. *Marine Policy,* 68**,** 187-194.

GALAPPATHTHI, E. K., ICHIEN, S. T., HYMAN, A. A., AUBRAC, C. J. & FORD, J. D. 2020b. Climate change adaptation in aquaculture. *Reviews in Aquaculture* (Published online: 17 April 2020, https://doi.org/10.1111/raq.12427).

GEORGE, K. & STRATFORD, E. 2016. Oral history and human Geography. *In:* HAY, I. (ed.) *Qualitative research methods in human geography.* Melbourne: Oxford University Press.

GUTIÉRREZ, N. L., HILBORN, R. & DEFEO, O. 2011. Leadership, social capital and incentives promote successful fisheries. *Nature,* 470**,** 386.

HANCOCK, D. R. & ALGOZZINE, B. 2015. *Doing case study research: A practical guide for beginning researchers,* London, Teachers College Press.

HUNG, H.-C., LU, Y.-T. & HUNG, C.-H. 2018. The determinants of integrating policy-based and community-based adaptation into coastal hazard risk management: a resilience approach. *Journal of Risk Research***,** 1-19.

IDROBO, C. J. & BERKES, F. 2012. Pangnirtung inuit and the Greenland shark: co-producing knowledge of a little discussed species. *Human Ecology,* 40**,** 405-414.

IPCC 2018. de Coninck, H., A. Revi, M. Babiker, P. Bertoldi, M. Buckeridge, A. Cartwright, W. Dong, J. Ford, S. Fuss, J.-C. Hourcade, D. Ley, R. Mechler, P. Newman, A. Revokatova, S. Schultz, L. Steg, and T. Sugiyama, 2018: Strengthening and Implementing the Global Response. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [MassonDelmotte,V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

KAJÁN, E. 2014. Community perceptions to place attachment and tourism development in Finnish Lapland. *Tourism Geographies,* 16**,** 490-511.

KARLSSON, M. & HOVELSRUD, G. K. 2015. Local collective action: Adaptation to coastal erosion in the Monkey River Village, Belize. *Global Environmental Change,* 32**,** 96-107.

KEYS, P. W., GALAZ, V., DYER, M., MATTHEWS, N., FOLKE, C., NYSTRÖM, M. & CORNELL, S. E. 2019. Anthropocene risk. *Nature Sustainability*.

KOCHO-SCHELLENBERG, J.-E. & BERKES, F. 2015. Tracking the development of co-management: using network analysis in a case from the Canadian Arctic. *Polar Record,* 51**,** 422-431.

KRIPPENDORFF, K. 2018. *Content analysis: An introduction to its methodology,* London, Sage publications.

LAM, V. W., CHEUNG, W. W. & SUMAILA, U. R. 2016. Marine capture fisheries in the Arctic: winners or losers under climate change and ocean acidification? *Fish and Fisheries,* 17**,** 335-357.

LEITE, M., ROSS, H. & BERKES, F. 2019. Interactions between individual, household, and fishing community resilience in southeast Brazil. *Ecology and Society,* 24.

LESNIKOWSKI, A. 2019. *Climate change adaptation policy formulation among local governments: A policy instruments approach.* PhD, McGill University.

LEU, T. C. 2019. Tourism as a livelihood diversification strategy among Sámi Indigenous people in northern Sweden. *Acta Borealia,* 36**,** 75-92.

LONGHURST, R. 2016. Semi-structured Interviews and Focus Group. *In:* CLIFFORD, N., COPE, M., GILLESPIE, T. & FRENCH, S. (eds.) *Key Methods in Geography.* 3 ed. London: Sage.

MAGEE, T. 2013. *A field guide to community based adaptation,* London, Routledge.

MARSHALL, G. R. 2013. Transaction costs, collective action and adaptation in managing complex social–ecological systems. *Ecological Economics,* 88**,** 185-194.

MARU, Y. T., SMITH, M. S., SPARROW, A., PINHO, P. F. & DUBE, O. P. 2014. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Global Environmental Change,* 28**,** 337-350.

NAYAK, P. K. & ARMITAGE, D. 2018. Social-ecological regime shifts (SERS) in coastal systems. *Ocean & Coastal Management,* 161**,** 84-95.

NICHOLS, T., BERKES, F., JOLLY, D., SNOW, N. B. & HARBOUR, C. O. S. 2004. Climate change and sea ice: local observations from the Canadian Western Arctic. *Arctic***,** 68-79.

NUNAN, F., HARA, M. & ONYANGO, P. 2015. Institutions and co-management in East African Inland and Malawi fisheries: a critical perspective. *World Development,* 70**,** 203-214.

ORCHARD, S. E., STRINGER, L. C. & QUINN, C. H. 2015. Impacts of aquaculture on social networks in the mangrove systems of northern Vietnam. *Ocean & Coastal Management,* 114**,** 1-10.

OSBAHR, H., TWYMAN, C., ADGER, W. & THOMAS, D. 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society,* 15.

OSTROM, E. 1990. *Governing the commons: The evolution of institutions for collective action,* New York, Cambridge University Press.

OSTROM, E. 2014. Collective action and the evolution of social norms. *Journal of Natural Resources Policy Research,* 6**,** 235-252.

OVERLAND, J. E., WANG, M., WALSH, J. E. & STROEVE, J. C. 2014. Future Arctic climate changes: Adaptation and mitigation time scales. *Earth's Future,* 2**,** 68-74.

OVIEDO, A. F., MITRAUD, S., MCGRATH, D. G. & BURSZTYN, M. 2016. Implementing climate variability adaptation at the community level in the Amazon floodplain. *Environmental Science & Policy,* 63**,** 151-160.

PEARCE, T., FORD, J., WILLOX, A. C. & SMIT, B. 2015. Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic,* 68**,** 233.

PIGGOTT-MCKELLAR, A. E., MCNAMARA, K. E., NUNN, P. D. & WATSON, J. E. 2019. What are the barriers to successful community-based climate change adaptation? A review of grey literature. *Local Environment,* 24**,** 374-390.

RANASINGHE, R. & CHENG, L. 2018. Tourism-induced mobilities and transformation of Indigenous cultures: where is the Vedda community in Sri Lanka heading to? *Journal of Tourism and Cultural Change,* 16**,** 521-538.

RIHOUX, B. 2006. Qualitative comparative analysis (QCA) and related systematic comparative methods recent advances and remaining challenges for social science research. *International Sociology,* 21**,** 679-706.

SALAS, S., BARRAGÁN-PALADINES, M. J. & CHUENPAGDEE, R. 2018. *Viability and Sustainability of Small-Scale Fisheries in Latin America and The Caribbean,* London, Springer.

SCHIPPER, E. L. F., AYERS, J., REID, H., HUQ, S. & RAHMAN, A. (eds.) 2014. *Community-based adaptation to climate change: scaling it up,* London: Routledge.

SCHMITT, K., ALBERS, T., PHAM, T. & DINH, S. 2013. Site-specific and integrated adaptation to climate change in the coastal mangrove zone of Soc Trang Province, Viet Nam. *Journal of Coastal Conservation,* 17**,** 545-558.

SELIGMANN, C. G. & SELIGMANN, B. (eds.) 1911. *The veddas,* Cambridge: Cambridge University Press.

SPEERS, A. E., BESEDIN, E. Y., PALARDY, J. E. & MOORE, C. 2016. Impacts of climate change and ocean acidification on coral reef fisheries: An integrated ecological–economic model. *Ecological Economics,* 128**,** 33-43.

TSCHAKERT, P., DIETRICH, K., TAMMINGA, K., PRINS, E., SHAFFER, J., LIWENGA, E. & ASIEDU, A. 2014. Learning and envisioning under climatic uncertainty: an African experience. *Environment and Planning A,* 46**,** 1049-1068.

TSCHAKERT, P., ELLIS, N., ANDERSON, C., KELLY, A. & OBENG, J. 2019. One thousand ways to experience loss: A systematic analysis of climate-related intangible harm from around the world. *Global Environmental Change,* 55**,** 58-72.

VAISMORADI, M., JONES, J., TURUNEN, H. & SNELGROVE, S. 2016. Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice,* 6**,** 100-110.

VAN DIJK, T. A. 2015. Critical discourse analysis. *In:* TANNEN, D., HAMILTON, H. E. & SCHIFFRIN, D. (eds.) *The handbook of discourse analysis.* New Delhi, India: John Wiley & Sons, Inc.

VAN PUTTEN, I., METCALF, S., FRUSHER, S., MARSHALL, N. & TULL, M. 2014. Fishing for the impacts of climate change in the marine sector: a case study. *International Journal of Climate Change Strategies and Management,* 6**,** 421-441.

WODAK, R. & MEYER, M. 2015. *Methods of critical discourse studies,* London, Sage.

YOW, V. R. 2014. *Recording oral history: A guide for the humanities and social sciences,* New York, Rowman & Littlefield.

Chapter 7. Conclusion

7.1 Summary and discussion of thesis

The aim of this thesis is to identify, examine, and evaluate opportunities for social-ecological systems resilience building and vulnerability reduction (i.e., adaptation) through developing an in-depth understanding of how remote Indigenous SSFs experience and respond to change. This research addresses four research objectives:

1) To develop a conceptual framework to help assess community adaptations to climate change in SSF systems,

2) To assess community adaptations to climate change among Inuit fisher communities, using a case study from Pangnirtung, Baffin Island, Nunavut,

3) To assess community adaptations to climate change among Coastal-Vedda fisher communities, using a case study from Kunjankalkulam in eastern Sri Lanka, and

4) To carry out a comparative analysis of two case studies (i.e., Inuit of Canadian Arctic and Coastal-Vedda of Sri Lanka) to examine the changes (shocks and stressors) they experience and their adaptive responses to those changes, to develop a broader understanding of opportunities for climate adaptation policy in SSFs.

The research is guided by a conceptual, empirical, and comparative (three-tier) methodological approach designed specifically for the thesis. This methodology is a combination of diverse qualitative research approaches to best serve the comparative analysis of empirical case studies (Glaser, 1965, Hewitt-Taylor, 2001, Rihoux, 2006, Fram, 2013). With regard to objective one, chapter 3 developed a conceptual framework to assess community adaptations to climate change in a fisheries context based on an extensive literature review (n=128 publications). This conceptual framework is used throughout the study to assess community adaptations. Objectives two and three are addressed in chapter 4 (Inuit) and chapter 5 (Coastal-Vedda), respectively. Chapters 4 and 5 are case studies based on primary field data that was collected using mixed methods (participant observations, semi-structured interviews [n= 136], focus groups [n= 23], and key informants [n= 63]). In these empirical chapters, this research examines how Indigenous populations experience climate change impacts and how they respond to it. Regarding research objective four, chapter 6 conducts a comparative analysis of Inuit and Coastal-Vedda case studies to deepen the understanding of adaptation to climate change in SSFs, which brings together insights from communities in the global north and south. Finally, chapter 7 summarizes the overall findings from these chapters and describes the contributions of this thesis with respect to theoretical, methodological, and empirical development in adaptation research. Table 7.1 highlights the major findings of the study by research objective.

My primary argument is that different Indigenous fisher populations live in different environmental conditions (e.g., Canadian Arctic, Eastern Sri Lanka) and respond to uniquely different climate change impacts in a similar way. This understanding creates opportunities for adaptation research, such as insights into adaptive strategies, sources of community resilience, and the identification of definitive characteristics of successful climate adaptation. Given that aquatic food dependence among coastal Indigenous peoples worldwide is much higher than it is among non-Indigenous peoples (Cisneros-Montemayor et al., 2016), this research is particularly important. In this context, the previous four chapters produced conceptual, methodological, and empirical advancements in the understanding of climate adaptations employed by Indigenous community members, including knowledge contributions and policy implications that uncover insights for future research directions.

Chapter 3 of the thesis proposed a conceptual framework to assess community adaptation to climate change impacts in a fisheries context based on a textual content analysis (Galappaththi et al., 2019b). This framework stems from an integration of conceptual elements from the theoretical areas of social-ecological resilience and development resilience. As illustrated in table 7.1, this framework provides the key characteristics and associated indicators necessary to assess community adaptations, and is already being used to guide research in other areas (Pellowe and Leslie, 2019, Amin et al., 2020, Nguyen et al., 2020). Three of these characteristics (agency, learning, and social organization) conceptually overlap with the characteristics proposed by Cinner et al. (2018b) for building an adaptive capacity for climate change in tropical coastal communities. However, the uniqueness of the proposed framework relies on: a) definition of resilience as a function of coping, adapting, and transformative capacities, b) the fact that the proposed framework does not have limitations in terms of tropical applications, as it includes place-specific attributes such as ‘place’ and Indigenous/local knowledge, and c) the fact that it has been specifically designed and tested for Indigenous fisher populations. Also, this chapter suggests that the proposed conceptual framework could apply broadly (i.e., not be limited to Indigenous fisheries) to assess community adaptations, as it addresses most of the prevailing critiques of the notion of resilience.

Chapter 4 presents empirical findings from the case study involving Inuit of the Canadian Arctic, using qualitative mixed methods. Inuit community adaptations are assessed using the characteristics of the resilience-based conceptual framework, as proposed in chapter 3. In the literature, most of the assessment of community-level climate adaptation is limited to tropical coastal communities (exceptions being (Berkes and Jolly, 2001, Pearce et al., 2015)); therefore, this chapter brings more significance to the empirical research area of climate change adaptation as well as SSFs. Here, I draw on the ways in which Inuit fishers experience change, including climate change impacts, and the various ways they respond to it. As Table 7.1 indicates, the most prominent changes that Inuit experience are related to climate change impacts (e.g., changes in sea-ice conditions, the landscape and seascape, and weather conditions). The chapter identified three community-level adaptive strategies and four place-specific attributes that can shape community adaptations.

Chapter 5 presents the empirical findings from Coastal-Vedda of Eastern Sri Lanka, using the same resilience-based conceptual framework. To my knowledge, there is (as far as I know) no documented evidence of changes that Coastal-Vedda face (Gaasbeek, 2013, Ranaweera, 2015); this chapter draws attention to the ways in which Coastal-Vedda experience diverse changes, including climate change and the diverse ways they respond to it. The most prominent changes that Coastal-Vedda fishers experience are not directly associated with climate change impacts (e.g., disturbance from the Sri Lankan civil war, increased frequency of human-elephant conflicts). This chapter also identified three community-level adaptive strategies and four place-specific attributes that shape community adaptations. Further, this chapter reveals insights into some drivers of social change that are not associated with climate change impacts in the context of Indigenous SSF communities.

Chapter 6 is a comparative analysis of the community adaptation of Inuit and Coastal-Vedda. The chapter co-produces broader insights into adaptation to climate change in SSFs by combining the individual case studies from Indigenous communities from the global north and south. This is not possible without moving beyond individual case studies. Comparative analysis of empirical case studies is an apparent knowledge gap in the climate change adaptation, small-scale fisheries, and Indigenous studies literature (Maru et al., 2014, Conway et al., 2019); this limits the ability to more deeply understand the types of opportunities available for successful adaptation (Adger et al., 2005, Osbahr et al., 2010, Piggott-McKellar et al., 2019) to climate change impacts. Using a three-tier methodological approach, and guided by the resilience-based conceptual framework, the chapter produces eight sources of resilience, two common adaptive strategies in SSFs. Further, this chapter recognizes five definitive characteristics of successful adaptation to climate change in fisheries.

Table 7.1: Major findings of the study by research objective.

Research objective	Major findings
To develop a conceptual framework to assess community adaptations to climate change in SSF systems.	-Propose a place-specific framework to assess community adaptation in a fisheries context. -Propose conceptual tools for assessing adaptation, which are: key characteristics (place, human agency, collective action and collaboration, institutions, knowledge systems, learning) and associated indicators (e.g., fishing gear diversity, level of fishery resources available, level, vulnerabilities for fishing operations such as climate uncertainties).
To assess community adaptations to climate change among Inuit fisher communities, using a case study from Pangnirtung, Baffin Island, Nunavut.	- Stressors associated with climate change impacts are major changes for Inuit populations in the Arctic. -Most of the changes that Inuit experience are changes in: sea-ice conditions, Inuit people themselves, the landscape and the seascape, fish, weather conditions, markets, and fish selling prices. -Three community-level adaptive strategies are: diversification, technology use, and fisheries governance that employs a co-management approach. -Four place-specific attributes are: Inuit-owned institutions, Inuit worldviews, a culture of sharing and collaborating, and Indigenous and local knowledge systems.
To assess community adaptations to climate change among Coastal-Vedda fisher communities, using a case study from Kunjankalkulam in eastern Sri Lanka.	- Stressors associated with climate change impacts are not the major changes that Coastal-Vedda populations experience. There are other sources of stressors in the developing context. -The most-highlighted changes in the Coastal-Vedda reservoir aquaculture context are: disturbance from the Sri Lankan civil war, changes in climate and the frequency and severity of natural disasters, an increased frequency of human-elephant conflicts, increasingly unpredictable weather patterns, and transformation of Coastal-Vedda due to social modernisation. -Three community-level adaptive strategies are: adaptive institutions with a multi-level institutional structure that facilitates collective action and collaboration, the use of aquaculture, and the diversification of livelihoods. -Four place-specific attributes are: cultural identity and worldviews, co-management of aquaculture, flexibility in choosing adaptive options, and Indigenous and local knowledge systems and learning.

To carry out a comparative analysis of two case studies (i.e., Inuit of the Canadian Arctic and Coastal-Vedda of Sri Lanka) to examine the changes (shocks and stressors) they experience, and their adaptive responses to those changes, to develop a broader understanding of opportunities for climate adaptation policy in SSFs.	-Subsistence and commercial fisheries may be able to co-exist in small Indigenous fisheries communities. -Climate change has mixed impacts on fishing communities (e.g., Inuit capture fisheries). -Some Indigenous fisher populations experience climate change with other major changes that are not associated with climate change (e.g., Coastal-Vedda). -Two common adaptive strategies are: diversification and adaptive co-management. -Eight sources of resilience are: i) use of diverse kinds of knowledge; ii) practice of different ways of learning; iii) use of community-based institutions; iv) efforts to improve human agency; v) unique worldviews; vi) specific cultural attributes that keep up with adaptation; vii) effective social networks; and viii) a high level of flexibility. -Five definitive characteristics of successful adaptation are: i) continuous learning through knowledge co-production; ii) capacity-building to improve human agency; iii) a place-specific nature (rootedness); iv) collective action and partnerships through community-based institutions; and v) flexibility.

7.2 Original knowledge contributions

There is a substantial amount of literature that focuses on the individual areas of climate change adaptation, SSFs, and Indigenous populations. However, to my knowledge, no documented evidence is thus far available regarding the climate change adaptations of Indigenous populations in an SSF context (except for publications coming out of the present study). This thesis creates a foundation upon which to address the unusual and alarming combination of a) Indigenous food insecurity, b) Indigenous people's high dependence on fisheries, and c) the vulnerability of SSF to climate change. The proposed conceptual framework and methodology with comparative cases allowed me to connect the dots from Cisneros-Montemayor et al. (2016) to Kuhnlein et al. (2013) in a broader climate adaptation setting. Given the limited attention paid to climate adaptation among Indigenous fishing communities, this thesis contributes to the conceptual, empirical, and methodological advancement of the respective research areas.

Conceptual: As highlighted in the IPCC fifth assessment report (IPCC, 2014: 390), community-based adaptation demands further advancements for the development of climate adaptation research, and this has become even more important in sectors such as SSFs, and Indigenous SSFs in particular (Cisneros-Montemayor et al., 2016). Recently, there has been growing interest in producing frameworks aimed at evaluating climate change adaptations in fisheries-related sectors (Cinner et al., 2018a, Cinner and Barnes, 2019, Freduah et al., 2019, Galappaththi et al., 2019b). However, the conceptual framework (chapter 3) for assessing climate adaptations of Indigenous fisher communities substantially contributes novel insights to the area of community-based adaptation.

This framework is the result of the integration of conceptual elements from the domains of human development and resilience thinking. Recognizing resilience as a combination of coping, adapting, and transformative capacities and as a process (not as an outcome), this framework conceptualizes beyond Walker et al.'s (2006) most commonly cited definition of resilience. This understanding of resilience was combined with the concepts of resistance, rootedness, and resourcefulness to bring additional insights to the framework's characteristics, as described in chapter 3. Further, this framework explicitly addresses most of the prevailing criticisms of resilience thinking, allowing for broader application.

Given the fact that climate change affects the communities in an integrated manner, the 'place' dimension of the proposed framework seeks to capture heterogeneity and complexities that are specific to particular SSFs. Characteristics of the conceptual framework (place, agency, collective action, institutions, knowledge systems, learning) are applicable in broader and diverse contexts and are not limited to a specific geographical setting. So far, the proposed frameworks (by other authors) for assessment of climate adaptations in fisheries are limited to tropical coastal areas (Marshall et al., 2010, Cinner, 2013, Cinner et al., 2018a). In this thesis, I used this framework to assess community climate adaptations in both global north and south SSFs.

Empirical: Adaptation to climate change impacts are taking place at the community level, specifically among vulnerable populations that are sensitive to climate impacts (Schipper et al., 2014, Ford et al., 2015, Ford et al., 2016b, Galappaththi et al., 2019b, Piggott-McKellar et al., 2019). From this perspective, a better understanding of the ways in which such communities experience climate impacts, and the ways they respond to changes, is essential for the development of the notion of climate change adaptation (Galappaththi et al., 2019a, Galappaththi et al., 2019b). To my knowledge, this is the first study aimed explicitly at climate change adaptations in Indigenous fisher communities after the Western Arctic study of Berkes and Jolly (2001). Further, the thesis involves comparative analysis with an Indigenous fisher community from a very different geographic area, based on a common framework.

The thesis uncovers a broader understanding of community adaptations, bringing insights from different SSFs in the Eastern Arctic and Sri Lanka. Chapters 4 and 5 contribute with a deeper understanding of adaptation in Inuit and Coastal-Vedda SSF communities. It unfolds how Indigenous fishers experience climate change in an integrated way (with other socio-economic, political, and financial and market-related aspects) and reveals the implications. Further, the chapters examine how these Indigenous populations adapt to various changes in the context of climate change. Each empirical chapter identifies adaptive strategies and place-specific attributes that shape the community adaptation process. This highlights the importance of considering place-specific characteristics of Indigenous SSF for climate change adaptation research. Regarding 'place' as a central element of adaptation research is a quite new approach that deserves further attention (Amundsen, 2015, Adger, 2016).

Methodological: This thesis has an advanced, three-tier methodological approach that includes conceptual, empirical, and comparative phases throughout the study. Combining the case study approach with comparative analysis using a novel conceptual framework is a unique way to examine opportunities for climate adaptation. Indigenous community representatives from the Canadian Arctic and Sri Lanka actively participated in this knowledge co-production process as part of a community-based participatory research approach (Minkler et al., 2003, O'toole et al., 2003, Pain, 2004, Hacker, 2013). Comparative case studies from the global north and south make the findings more broadly applicable (i.e., scaling up), and provide ways to develop resilience and adaptation in communities (Conway et al., 2019, Leite et al., 2019). My thesis contributes to adaptation research with much broader insights including common adaptive strategies applicable in the Indigenous SSF context and sources of resilience to build adaptation to climate change. Moreover, my thesis provides insights into what successful adaptation looks like in an Indigenous community setting, which deepens the understanding of climate change adaptation in Indigenous SSFs.

7.3 Policy implications

7.3.1 Always, the 'place'

This thesis highlights the importance of examining the characteristics of place in climate change adaptation research in an Indigenous SSF context. One of the reasons for studying two different SSFs is to understand the heterogeneous nature of different systems that affect the process of climate adaptation. The findings of chapter 6 inform policy development, as they provide a deeper understanding of what successful adaptation looks like in a broader Indigenous context. Successful adaptation can be distinctive to the community, but definitive characteristics of such an adaptation process are similar (e.g., Coastal-Vedda reservoir aquaculture vs. Inuit co-existing capture fisheries). Further, sources of resilience identified in this study have policy implications, as they can be adapted for use in different community settings to overcome common barriers (Piggott-McKellar et al., 2019) in the adaptation process with respect to sustainable SSF. Most government policies end up reducing resilience (inadvertently) instead of building it (Adger et al., 2011). However, building resilience is important because resilience is an essential component of policies that can reduce vulnerability (Nayak and Berkes, 2019). Given the importance of the changes taking place at the community level in terms of the adaptation process, I suggest keeping the 'place' aspects at the center of policy development related to climate change adaptation in Indigenous SSFs.

7.3.2 Community-based adaptation has significant potential for reducing vulnerability

Instead of developing adaptation policy based on a normative vision of what policy-makers think effective adaptation policy looks like, establishing an understanding of how particular Indigenous populations experience—and are already adapting to—change is effective in terms of achieving successful adaptation. Building on this empirical foundation, 'community-based adaptation' has a promising potential for successful adaptation than other top-down adaptation approaches (Conway et al., 2019) in Indigenous SSFs. Adaptation policy development should support the community-based adaptation process, as it fits well with the community strengths, weaknesses, and desires that are relevant for community adaptation. Policy development should focus on identifying investable strengths (e.g., Inuit knowledge systems and Coastal-Vedda's local institutions) and capacity building needs (e.g., Inuit local institutions and Coastal Vedda's use of technology) to speed up the community adaptation process. Chapter 3 provides conceptual tools for policy development including framework characteristics and respective local indicators of community adaptations.

7.3.3 It's not always climate change

Other kinds of change are also taking place in SSF communities. For example, natural disasters (tsunami) and the civil war lasted for 30 years in Sri Lankan Coastal-Vedda communities. These are non-climatic drivers that can have a great influence on the community adaptation process. Thus, adaptation policy should capture a broad range of changes (both climatic and non-climatic) that could be relevant for adaptation. The neglecting of certain non-climatic aspects could create barriers preventing successful community adaptation. Further, understanding the inter-linked nature (Berkes et al., 2003, Nayak and Armitage, 2018) of various drivers of change is equally important for climate change policy development. For example, Inuit turbot fisheries rely on environmental (sea ice conditions), social (local knowledge), and economic (international markets) factors (Galappaththi et al., 2019a).

7.4 Limitations and further reflections on the conceptual framework

All conceptual frameworks are limited; no individual framework can explain everything. This section describes the identified limitations of the proposed conceptual framework, as well as the limitations in explaining empirical data.

7.4.1 Place-centered versus livelihood-centered

The introduction and some other chapters of the thesis have references to the livelihood literature (Scoones, 1998, Marschke and Berkes, 2006, Osbahr et al., 2010, Reed et al., 2013, Islam et al., 2014, Leu, 2019). This leaves the reader wondering why this literature does not play a role in the conceptual framework. Livelihood is not identified as a characteristic of the framework, which focuses on place, human agency, collective action, institutions, knowledge systems, and learning. In this study, livelihood emerged as one of the key themes, and I use livelihood framework terminology (e.g., diversification) throughout the thesis. Livelihood is captured under 'place' along with other dimensions, such as place attachment and specific fisheries. In doing this, we draw upon concepts from the livelihoods literature, but not a formal livelihoods approach, because we use resilience as our framing to capture the dynamic and evolving nature of social-ecological systems.

Different Indigenous fisher populations live in different environmental conditions and respond to uniquely different climate change impacts in a similar (or different) way. This understanding creates opportunities for adaptation research, which is the primary aim of the study. This research looks at how populations involved in the same livelihood activities (i.e., fisheries) respond to change in different places (i.e., Arctic Canada and Eastern Sri Lanka). Climate change impacts are specific to different areas (or communities) in a rural fisheries context. Yet, the implications of such climate impacts can be complicated and specific to livelihood activity. A community has multiple livelihood activities, and they are all undergoing the same climate change impacts (e.g., Pangnirtung and Kunjankalkulam communities). Examination of both climate change impacts (on places) and its implications (for livelihoods) is essential to understanding people's responses from a climate adaptation policy perspective.

The livelihood-centered framework could also work for this study (to assess community adaptation to climate change in an Indigenous fisheries context). Livelihood-centered framing would be different from the place-centered approach and might lead to different results. In the Coastal-Vedda context, livelihood-centered framing could lead to a deeper analysis of diverse livelihood activities, as this Vedda group is transforming from a traditional lifestyle. However, in the Inuit context, livelihood-centered framing might not be able to capture some of the key elements of the Indigenous way of life (e.g., place attachments, place-specific vulnerabilities, culture, belief systems, and perceptions linked to the place).

7.4.2 Diversification definition

The study draws upon concepts from the livelihoods literature (use of the term ‘diversification’), but not a formal livelihoods approach. In this study, ‘diversification’ refers to increased opportunities and/or the reduced risk and vulnerability of various adverse changes by engaging in a broader range of information/income sources or interactions. Diversification applies across multiple scales of activities, such as food/nutritional sources, numerous fisheries, livelihoods, institutions for managing fisheries, knowledge systems, and ways of learning (Appendix: Table C8).

For instance, during the focus group discussions, Coastal-Vedda described how diversification of their livelihoods is linked to the adverse conditions. Coastal-Vedda are not involved in the same activities they practiced historically, in the same way. For example, historically, they collected wild honey/fruits/wood for *subsistence* purposes, while now, mostly, they collect such resources for *selling* purposes. The recent conditions (e.g., shocks, stressors) experienced by Coastal-Vedda are very different from historical conditions. Therefore, it is not a *continuation* of the same livelihood activities over time. At a community level, Coastal-Vedda diversification is a part of on-going semi-subsistence livelihoods. However, at the individual level (and household level), I observed people shifting in between different livelihood activities based on the changing conditions (e.g., weather, natural disasters). I noticed changes in their portfolio of activities. For example, when the stormy season comes, some Coastal-Vedda move from portfolio 1 (aquaculture, rice farming, selling wood) to portfolio 2 (aquaculture, beach seine, selling honey). The weightage on each livelihood activity depends on several factors, such as a person's agency, knowledge, and skills. These kinds of different livelihood portfolios help Coastal-Vedda build resilience in facing adverse changes.

7.4.3 Overlapping definitions

Based on the given definitions as in table 3.2, it is sometimes challenging to distinguish collective action and institutions (characteristics of the conceptual framework). In chapter 3, ‘institutions’ refers to “local organizations formed by the society to facilitate collective action that meets a local goal (for example, community cooperatives and associations),” and ‘collective action’ refers to “action taken together by a group of two or more people to meet a common desired objective” (Galappaththi et al., 2019b: 20). Though chapter 3 indicates the overlapping nature of the characteristics (i.e., network of place-based elements), one can argue that collective action is a part of institutions or *vice versa*, understanding institutions as a set of norms and rules. However, this dispute around overlapping definitions had a limited impact on this study, as both institutions and collective action helped me capture community adaptations to meet the research objectives.

7.4.4 3Rs and 3D

The concepts of the 3Rs (resistance, rootedness, and resourcefulness) and the 3 dimensions of resilience—3D (coping, adaptation, and transformation) receive significant space in the framework chapter, but one might criticize the fact that they are barely acknowledged in the rest of the thesis. As explained in the section 2.1 of this chapter 2, I used 3D and 3Rs to develop the conceptual framework's characteristics. The rest of the study relies highly on the framework characteristics (i.e., place, agency, collective action, institutions, knowledge systems, and learning) rather than on the concepts used to derive the characteristics. The framework characteristics are more useful in developed indicators to capture adaptations. For instance, 3Rs and 3D are much broader concepts that are applicable at the community level—breaking them down into place-based elements helped in employing empirical assessments relatively effectively. Yet, I acknowledge the scope of the framework in explaining empirical data limits to the framework characteristics.

7.4.5 Rarely asks about resilience of what to what (or whom)

This study's conceptual framework builds on the theoretical elements of resilience thinking. Resilience thinking is criticized for rarely asking about the resilience of what to what (or whom), as discussed in section 2.1.2 (chapter 2). The application of resilience thinking with the social-ecological systems approach allows me to better examine the nonlinear relationships that exist within a complex Indigenous fishery. Thus, this study does not focus on examining specific causes and effects (i.e., linear relationships); rather, it focuses on nonlinear relationships (e.g., linkages) between social and ecological subsystems. The outcome of this holistic approach could be perceived as a limitation. For example, it is challenging to say with certainty which causes (e.g., climate impacts) lead to which effects (e.g., implications for fisheries), though such relationships are part of the output of the resilience and vulnerability of Indigenous fisheries systems. Additionally, this conceptual approach is limited to asking about the adaptation of what to what (or whom). For instance, it is difficult to specify which causes (e.g., adaptive responses) lead to which effects (e.g., resilience-building outcomes in fisheries) because of the complex and integrated nature of climate change impacts and adaptation. One of the key findings of this study is the highlighting of this complex and non-linear nature of climate change adaptation in Indigenous fisheries systems.

7.5 Future research directions

7.5.1 Frameworks aimed at climate change adaptation

This thesis presents a framework that assesses climate change adaptation in Indigenous fisher communities, and leaves many questions open for future research. Climate change adaptation research moving with well-developing thinking about assessments based on the theoretical areas of adaptive capacity (Cinner et al., 2018a, Freduah et al., 2019), resilience (Nelson et al., 2007, Lyon, 2014), and vulnerability (Ford and Smit, 2004, Füssel, 2007). There is growing interest in integrated conceptual approaches to climate adaptation research (Reed et al., 2013, Maru et al., 2014). However, the assessment tools for climate adaptation in an SSF context have significant potential in terms of future research (Freduah et al., 2019, Galappaththi et al., 2019b); this potential is even more important in an Indigenous context, due to the importance of fish to food security (Cisneros-Montemayor et al., 2016). Conceptualizing adaptation within the context of Indigenous communities requires further research attention with a strong, integrated theoretical foundation that can understand changing processes and the place-specific aspects that capture specific attributes of the Indigenous way of life (Cochran et al., 2013, Ford et al., 2016a). Thus, further development of the conceptual framework proposed in chapter 3 will be useful for future adaptation research.

Based on the Inuit and Coastal-Vedda case studies, the proposed framework worked effectively to assess the community adaptation to climate change in a fisheries context. The framework was able to capture place-specific attributes (e.g., Indigenous worldviews, knowledge systems) and adaptive strategies of the small-scale fisheries systems (e.g., diversification, co-management). Further, this framework facilitates the study with empirical data analysis, organization of results, and comparative analysis. The study insights can be used to further strengthen the framework. Livelihood emerged as a significant component of community adaptation and could be included as a framework characteristic (as part of the network of place-based elements) to further strengthen the framework for future applications. Maintaining both a place and a livelihood focus in this framework is vital for future applications.

7.5.2 Comparative analysis studies for climate adaptation research

In rapidly changing areas, including the Arctic, it is very difficult to design effective adaptation policy options relying only on predicting models that project future climate change impacts (Ford et al., 2018). In such a context, comparative analysis of case studies will provide supplementation in the form of more broad, timely and detailed non-linear understandings of community adaptations based on primary data. Currently, most prominent comparative studies are based primarily on secondary data (Mees, 2017, Biesbroek et al., 2018). Further, comparative studies are major research gaps in the areas of SSF policy development, particularly in the Indigenous context. Chapter 6 brings broader insights to climate change adaptation research, building on a comparative analysis of Indigenous case studies from the global north and south. Given appropriate data about how fishers experience and respond to climate change, a comparative analysis of multiple Coastal-Vedda communities in Sri Lanka could be a useful avenue for further research. The Arctic and Sri Lankan case studies are comparable with other, similar SSF systems around the world as well.

7.5.3 Governance of climate change adaptation

Any social system involving resources must be monitored and must navigate towards sustainability (Leach et al., 2013, Keys et al., 2019). This includes climate adaptation processes. Indigenous SSF communities must be governed through social-ecological systems change (Nayak and Armitage, 2018). One possible way of moving forward with my thesis is through the integration of commons (Petrescu et al., 2016, Armitage et al., 2017) and governance (Bisaro and Hinkel, 2016, Termeer et al., 2016) conceptual elements into the proposed framework in chapter 3, to expand into the governance of community adaptations to climate change. A place-specific approach/attributes will be equally (or even more) important in the governance context. The governance of climate adaptation in communities is developing thinking and documented cases are mostly records of non-Indigenous and non-fisheries contexts. Thus, the development of management tools, the identification of innovative methods of managing climate adaptations, and the development of policy options for governance are useful avenues for future research.

7.6 References

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

ADGER, W. N., ARNELL, N. W. & TOMPKINS, E. L. 2005. Successful adaptation to climate change across scales. *Global environmental change,* 15**,** 77-86.

ADGER, W. N., BROWN, K., NELSON, D. R., BERKES, F., EAKIN, H., FOLKE, C., GALVIN, K., GUNDERSON, L., GOULDEN, M. & O'BRIEN, K. 2011. Resilience implications of policy responses to climate change. *Wiley Interdisciplinary Reviews: Climate Change,* 2**,** 757-766.

AMIN, M. N., HOSSAIN, M. S., DE BRUYN, L. L. & WILSON, B. 2020. A systematic review of soil carbon management in Australia and the need for a social-ecological systems framework. *Science of the total environment,* 719**,** 135182.

AMUNDSEN, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment,* 20**,** 257-276.

ARMITAGE, D., CHARLES, A. & BERKES, F. 2017. *Governing the coastal commons: communities, resilience and transformation,* Oxford, UK, Earthscan, Routledge / Taylor & Francis.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F. & JOLLY, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology,* 5**,** 18.

BIESBROEK, R., BERRANG-FORD, L., FORD, J. D., TANABE, A., AUSTIN, S. E. & LESNIKOWSKI, A. 2018. Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review. *Wiley Interdisciplinary Reviews: Climate Change,* 9**,** e548.

BISARO, A. & HINKEL, J. 2016. Governance of social dilemmas in climate change adaptation. *Nature Climate Change,* 6**,** 354.

CINNER, J. 2013. Evaluating social and ecological vulnerability of coral reef fisheries to climate change. *PLoS ONE,* 8**,** e74321.

CINNER, J. & BARNES, M. L. 2019. Social Dimensions of Resilience in Social-Ecological Systems. *One Earth,* 1**,** 51-56.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018a. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8**,** 117.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018b. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8**,** 117-123.

CISNEROS-MONTEMAYOR, A. M., PAULY, D., WEATHERDON, L. V. & OTA, Y. 2016. A global estimate of seafood consumption by coastal indigenous peoples. *PLoS One,* 11**,** e0166681.

COCHRAN, P., HUNTINGTON, O. H., PUNGOWIYI, C., TOM, S., CHAPIN, F. S., HUNTINGTON, H. P., MAYNARD, N. G. & TRAINOR, S. F. 2013. Indigenous frameworks for observing and responding to climate change in Alaska. *In:* MALDONADO, J. K., COLOMBI, B. & PANDYA, R. (eds.) *Climate Change and Indigenous Peoples in the United States.* New York: Springer.

CONWAY, D., NICHOLLS, R. J., BROWN, S., TEBBOTH, M. G., ADGER, W. N., AHMAD, B., BIEMANS, H., CRICK, F., LUTZ, A. F. & DE CAMPOS, R. S. 2019. The need for bottom-up assessments of climate risks and adaptation in climate-sensitive regions. *Nature Climate Change,* 9**,** 503-511.

FORD, J., FALK, K. & TESAR, C. 2018. Adaptation and Resilience. In: Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. pp. [307-328]. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

FORD, J., MAILLET, M., POULIOT, V., MEREDITH, T., CAVANAUGH, A. & TEAM, I. R. 2016a. Adaptation and Indigenous peoples in the United Nations Framework Convention on Climate Change. *Climatic Change,* 139**,** 429-443.

FORD, J. D. & SMIT, B. 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic***,** 389-400.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2015. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-191.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2016b. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-195.

FRAM, S. M. 2013. The constant comparative analysis method outside of grounded theory. *The qualitative report,* 18**,** 1-25.

FREDUAH, G., FIDELMAN, P. & SMITH, T. F. 2019. A framework for assessing adaptive capacity to multiple climatic and non-climatic stressors in small-scale fisheries. *Environmental Science & Policy,* 101**,** 87-93.

FÜSSEL, H.-M. 2007. Vulnerability: a generally applicable conceptual framework for climate change research. *Global Environmental Change,* 17**,** 155-167.

GAASBEEK, T. 2013. Flying below the Radar. *In:* DOROTHEA, H. (ed.) *Disaster, Conflict and Society in Crises: Everyday Politics of Crisis Response.* NY: Routledge.

GALAPPATHTHI, E. K., FORD, J., BENNETT, E. & BERKES, F. 2019a. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada *Journal of Environmental management,* 250**,** 11.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019b. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GLASER, B. G. 1965. The constant comparative method of qualitative analysis. *Social problems,* 12**,** 436-445.

HACKER, K. 2013. *Community-based participatory research,* London, Sage.

HEWITT-TAYLOR, J. 2001. Use of constant comparative analysis in qualitative research. *Nursing Standard,* 15**,** 39-42.

IPCC 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy,

S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

ISLAM, M. M., SALLU, S., HUBACEK, K. & PAAVOLA, J. 2014. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change,* 14**,** 281-294.

KEYS, P. W., GALAZ, V., DYER, M., MATTHEWS, N., FOLKE, C., NYSTRÖM, M. & CORNELL, S. E. 2019. Anthropocene risk. *Nature Sustainability*.

KUHNLEIN, H. V., ERASMUS, B., SPIGELSKI, D. & BURLINGAME, B. E. 2013. *Indigenous peoples' food systems and well-being: Interventions & policies for healthy communities,* Rome, FAO/CINE.

LEACH, M., RAWORTH, K. & ROCKSTRÖM, J. 2013. Between social and planetary boundaries: Navigating pathways in the safe and just space for humanity. *ISSC and UNESCO editors, World social science report 2013, changing global environments.* Paris, France: OECD Publishing and UNESCO Publishing.

LEITE, M., ROSS, H. & BERKES, F. 2019. Interactions between individual, household, and fishing community resilience in southeast Brazil. *Ecology and Society,* 24.

LEU, T. C. 2019. Tourism as a livelihood diversification strategy among Sámi indigenous people in northern Sweden. *Acta Borealia,* 36**,** 75-92.

LYON, C. 2014. Place systems and social resilience: A framework for understanding place in social adaptation, resilience, and transformation. *Society & Natural Resources,* 27**,** 1009-1023.

MARSCHKE, M. J. & BERKES, F. 2006. Exploring strategies that build livelihood resilience: a case from Cambodia. *Ecology and Society,* 11**,** 1-16.

MARSHALL, N. A., MARSHALL, N., MARSHALL, P., TAMELANDER, J., OBURA, D., MALLERET-KING, D. & CINNER, J. 2010. *A framework for social adaptation to climate change: sustaining tropical coastal communitites [sic] and industries,* Gland, Switzerland, IUCN.

MARU, Y. T., SMITH, M. S., SPARROW, A., PINHO, P. F. & DUBE, O. P. 2014. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Global Environmental Change,* 28**,** 337-350.

MEES, H. 2017. Local governments in the driving seat? A comparative analysis of public and private responsibilities for adaptation to climate change in European and North-American cities. *Journal of Environmental Policy & Planning,* 19**,** 374-390.

MINKLER, M., BLACKWELL, A. G., THOMPSON, M. & TAMIR, H. 2003. Community-based participatory research: implications for public health funding. *American journal of public health,* 93**,** 1210-1213.

NAYAK, P. K. & ARMITAGE, D. 2018. Social-ecological regime shifts (SERS) in coastal systems. *Ocean & Coastal Management,* 161**,** 84-95.

NAYAK, P. K. & BERKES, F. (eds.) 2019. *Interplay between local and global: Change processes and small-scale fisheries (chapter 11),* Cham: Springer.

NELSON, D. R., ADGER, W. N. & BROWN, K. 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual review of Environment and Resources,* 32**,** 395.

NGUYEN, H., TRAN, D., LUAN, P., HO, L., LOAN, V., ANH NGOC, P., QUANG, N., WYATT, A. & SEA, W. 2020. Socio-ecological resilience of mangrove-shrimp models under various threats exacerbated from salinity intrusion in coastal area of the Vietnamese Mekong Delta. *International Journal of Sustainable Development & World Ecology***,** 1-14, DOI: 10.1080/13504509.2020.1731859.

O'TOOLE, T. P., AARON, K. F., CHIN, M. H., HOROWITZ, C. & TYSON, F. 2003. Community-based Participatory Research. *Journal of general internal medicine,* 18**,** 592-594.

OSBAHR, H., TWYMAN, C., ADGER, W. & THOMAS, D. 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society,* 15.

PAIN, R. 2004. Social geography: participatory research. *Progress in human geography,* 28**,** 652.

PEARCE, T., FORD, J., WILLOX, A. C. & SMIT, B. 2015. Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic,* 68**,** 233.

PELLOWE, K. & LESLIE, H. 2019. Heterogeneity among clam harvesters in northwest Mexico shapes individual adaptive capacity. *Ecology and Society,* 24.

PETRESCU, D., PETCOU, C. & BAIBARAC, C. 2016. Co-producing commons-based resilience: lessons from R-Urban. *Building Research & Information,* 44**,** 717-736.

PIGGOTT-MCKELLAR, A. E., MCNAMARA, K. E., NUNN, P. D. & WATSON, J. E. 2019. What are the barriers to successful community-based climate change adaptation? A review of grey literature. *Local Environment,* 24**,** 374-390.

RANAWEERA, L. 2015. A Case Report: the Coastal Vedda Community Trapped in the Civil War in Sri Lanka, Heritage as Prime Mover in History, Culture and Religion of South and Southeast Asia, Sixth International Conference of the South and Southeast Asian Association for the Study of Culture and Religion (SSEASR), Center for Asian studies of the University of Kelaniya, Sri Lanka. p.50.

REED, M., PODESTA, G., FAZEY, I., GEESON, N., HESSEL, R., HUBACEK, K., LETSON, D., NAINGGOLAN, D., PRELL, C. & RICKENBACH, M. 2013. Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. *Ecological Economics,* 94**,** 66-77.

RIHOUX, B. 2006. Qualitative comparative analysis (QCA) and related systematic comparative methods recent advances and remaining challenges for social science research. *International Sociology,* 21**,** 679-706.

SCHIPPER, E. L. F., AYERS, J., REID, H., HUQ, S. & RAHMAN, A. (eds.) 2014. *Community-based adaptation to climate change: scaling it up,* London: Routledge.

SCOONES, I. 1998. Sustainable rural livelihoods: a framework for analysis. *IDS Working Paper 72.* Sussex, UK: Institute of Development Studies.

TERMEER, C. J., DEWULF, A. & BIESBROEK, G. R. 2016. Transformational change: governance interventions for climate change adaptation from a continuous change perspective. *Journal of Environmental Planning and Management***,** 1-19.

WALKER, B., GUNDERSON, L., KINZIG, A., FOLKE, C., CARPENTER, S. & SCHULTZ, L. 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and society,* 11**,** 13.

Reference list for the thesis

AAAS. 2016. *American Association of the Advancement of Science* [Online]. Available: https://www.aaas.org/page/srhrl-ethics-law-activities [Accessed 30 Oct. 2016].

AARONSON, S. A. 2016. Repression, Civil Conflict, and Leadership Tenure:The Sri Lanka Case Study, Institute for International Economic Policy Working Paper Series, Elliott School of International Affairs, The George Washington University. Washington, D.C.

ADGER, W. N. 2000. Social and ecological resilience: are they related? *Progress in human geography,* 24**,** 347-364.

ADGER, W. N. 2003. Social capital, collective action, and adaptation to climate change. *Economic Geography,* 79**,** 387-404.

ADGER, W. N. 2016. Place, well-being, and fairness shape priorities for adaptation to climate change. *Global Environmental Change,* 38**,** A1-A3.

ADGER, W. N., ARNELL, N. W. & TOMPKINS, E. L. 2005a. Successful adaptation to climate change across scales. *Global environmental change,* 15**,** 77-86.

ADGER, W. N., BARNETT, J., BROWN, K., MARSHALL, N. & O'BRIEN, K. 2012. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change,* 3**,** 112-117.

ADGER, W. N., BROWN, K., NELSON, D. R., BERKES, F., EAKIN, H., FOLKE, C., GALVIN, K., GUNDERSON, L., GOULDEN, M. & O'BRIEN, K. 2011. Resilience implications of policy responses to climate change. *Wiley Interdisciplinary Reviews: Climate Change,* 2**,** 757-766.

ADGER, W. N., BUTLER, C. & WALKER-SPRINGETT, K. 2017. Moral reasoning in adaptation to climate change. *Environmental Politics***,** 1-20.

ADGER, W. N., HUGHES, T. P., FOLKE, C., CARPENTER, S. R. & ROCKSTRÖM, J. 2005b. Social-ecological resilience to coastal disasters. *Science,* 309**,** 1036-1039.

ADHIKARI, S., KESHAV, C. A., BARLAYA, G., RATHOD, R., MANDAL, R., IKMAIL, S., SAHA, G., DE, H., SIVARAMAN, I. & MAHAPATRA, A. 2018. Adaptation and Mitigation Strategies of Climate Change Impact in Freshwater Aquaculture in some states of India. *Journal of FisheriesSciences. com,* 12**,** 16-21.

AGRAWAL, A. 1995. Dismantling the divide between indigenous and scientific knowledge. *Development and change,* 26**,** 413-439.

AGRAWAL, A. & LEMOS, M. C. 2015. Adaptive development. *Nature Climate Change,* 5**,** 185.

AHMED, N., BUNTING, S. W., RAHMAN, S. & GARFORTH, C. J. 2014. Community-based climate change adaptation strategies for integrated prawn–fish–rice farming in B angladesh to promote social–ecological resilience. *Reviews in Aquaculture,* 6**,** 20-35.

ALDRICH, D. P. & MEYER, M. A. 2015. Social capital and community resilience. *American Behavioral Scientist,* 59**,** 254-269.

ALEXANDER, S. M., ARMITAGE, D. & CHARLES, A. 2015. Social networks and transitions to co-management in Jamaican marine reserves and small-scale fisheries. *Global Environmental Change,* 35**,** 213-225.

ALLISON, E. H. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish Fish.,* 10**,** 173-196.

AMAP 2018. Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xvi-354pp.

AMARASINGHE, U., CHANDRASEKARA, W. & KITHSIRI, H. 1997. Traditional practices for resource sharing in an artisanal fishery of a Sri Lankan estuary. *Asian Fisheries Science,* 9**,** 311-324.

AMARASINGHE, U. S. & NGUYEN, T. T. T. 2009. Enhancing rural farmer income through fish production: Secondary use of water resources in Sri Lanka and elsewhere. *In:* DE SILVA, S. S. & DAVY, F. B. (eds.) *Success Stories in Asian Aquaculture.* Netherlands: Springer Science.

AMARASINGHE, U. S. & WIJENAYAKE, W. M. H. K. 2015. Results of a decade of R & D efforts on culture-based fisheries in Sri Lanka. *In:* DE SILVA, S. S., INGRAM, B. A. & WILKINSON, S. (eds.) *Perspectives on culture-based fisheries development in Asia. Proceedings of the Regional Consultation on Culture-Based Fisheries Developments in Asia, 21st to 23rd October 2014, Siem Reap, Cambodia. NACA, Bangkok and ACIAR, Canberra. .*

AMIN, A. 2013. Surviving the turbulent future. *Environment and Planning D: Society and Space,* 31**,** 140-156.

AMIN, M. N., HOSSAIN, M. S., DE BRUYN, L. L. & WILSON, B. 2020. A systematic review of soil carbon management in Australia and the need for a social-ecological systems framework. *Science of the total environment,* 719**,** 135182.

AMUNDSEN, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment,* 20**,** 257-276.

ANDREOTTI, V. 2014. Critical literacy: Theories and practices in development education. *Policy & Practice-A Development Education Review*.

ARAOS, M., FORD, J., BERRANG-FORD, L., BIESBROEK, R. & MOSER, S. 2017. Climate change adaptation planning for Global South megacities: the case of Dhaka. *Journal of Environmental Policy & Planning,* 19**,** 682-696.

ARCHER, D., ALMANSI, F., DIGREGORIO, M., ROBERTS, D., SHARMA, D. & SYAM, D. 2014. Moving towards inclusive urban adaptation: approaches to integrating community-based adaptation to climate change at city and national scale. *Climate and Development,* 6**,** 345-356.

ARCTIC-COUNCIL 2013. Arctic Resilience Interim Report 2013. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm.

ARCTIC COUNCIL 2016. Arctic Resilience Report, Arctic Council. *In:* CARSON, M. & PETERSON, G. (eds.). Stockholm: Stockholm Environment Institute and Stockholm Resilience Centre.

ARIMI, K. S. 2014. Determinants of climate change adaptation strategies used by fish farmers in Epe Local Government Area of Lagos State, Nigeria. *Journal of the Science of Food and Agriculture,* 94**,** 1470-1476.

ARKEMA, K. K., GUANNEL, G., VERUTES, G., WOOD, S. A., GUERRY, A., RUCKELSHAUS, M., KAREIVA, P., LACAYO, M. & SILVER, J. M. 2013. Coastal habitats shield people and property from sea-level rise and storms. *Nature Climate Change,* 3**,** 913-918.

ARLINGHAUS, R., ALÓS, J., BEARDMORE, B., DAEDLOW, K., DOROW, M., FUJITANI, M., HÜHN, D., HAIDER, W., HUNT, L. & JOHNSON, B. 2017. Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. *Reviews in Fisheries Science & Aquaculture,* 25**,** 1-41.

ARMITAGE, D. 2005. Adaptive capacity and community-based natural resource management. *Environmental management,* 35**,** 703-715.

ARMITAGE, D., BERKES, F., DALE, A., KOCHO-SCHELLENBERG, E. & PATTON, E. 2011. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change,* 21**,** 995-1004.

ARMITAGE, D., BERKES, F. & DOUBLEDAY, N. (eds.) 2007. *Adaptive co-management: collaboration, learning, and multi-level governance,* Vancouver: UBC Press.

ARMITAGE, D., CHARLES, A. & BERKES, F. 2017. *Governing the coastal commons: communities, resilience and transformation,* Oxford, UK, Earthscan, Routledge / Taylor & Francis.

ARMITAGE, D., MARSCHKE, M. & PLUMMER, R. 2008a. Adaptive co-management and the paradox of learning. *Global environmental change,* 18**,** 86-98.

ARMITAGE, D. R., PLUMMER, R., BERKES, F., ARTHUR, R. I., CHARLES, A. T., DAVIDSON-HUNT, I. J., DIDUCK, A. P., DOUBLEDAY, N. C., JOHNSON, D. S. & MARSCHKE, M. 2008b. Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment,* 7**,** 95-102.

ARMITAGE, D. R., PLUMMER, R., BERKES, F., ARTHUR, R. I., CHARLES, A. T., DAVIDSON-HUNT, I. J., DIDUCK, A. P., DOUBLEDAY, N. C., JOHNSON, D. S. & MARSCHKE, M. 2009. Adaptive co-management for social–ecological complexity. *Frontiers in Ecology and the Environment,* 7**,** 95-102.

ASFAW, S., PALLANTE, G. & PALMA, A. 2018. Diversification strategies and adaptation deficit: Evidence from rural communities in Niger. *World Development,* 101**,** 219-234.

ASSEMBLY, G. 2014. Sustainable Development goals, Improving human and planetary wellbeing. *Global change biology,* 82**,** 20-23.

ATKINSON, R. & FLINT, J. 2001. Accessing hidden and hard-to-reach populations: Snowball research strategies. *Social research update,* 33**,** 1-4.

ATTANAPOLA, C. T. & LUND, R. 2013. Contested identities of indigenous people: Indigenization or integration of the Veddas in Sri Lanka. *Singapore Journal of Tropical Geography,* 34**,** 172-187.

AYERS, J. & FORSYTH, T. 2009. Community-based adaptation to climate change. *Environment: science and policy for sustainable development,* 51**,** 22-31.

AYERS, J. M., HUQ, S., FAISAL, A. M. & HUSSAIN, S. T. 2014. Mainstreaming climate change adaptation into development: a case study of Bangladesh. *Wiley Interdisciplinary Reviews: Climate Change,* 5**,** 37-51.

BABBIE, E. R. 2015. *The practice of social research,* Bostern, Nelson Education.

BAGGIO, J., BROWN, K. & HELLEBRANDT, D. 2015. Boundary object or bridging concept? A citation network analysis of resilience. *Ecology and Society,* 20**,** 2.

BAHADUR, A., LOVELL, E. & PICHON, F. 2016. Effectiveness in Building Resilience: Synthesis report for Oxfam's Resilience Outcome Area. Oxfarm International.

BAHADUR, A. V., PETERS, K., WILKINSON, E., PICHON, F., GRAY, K. & TANNER, T. 2015. The 3As: Tracking resilience across BRACED. *Working and Discussion Papers. London: Overseas Development Institute* 57.

BARANGE, M., BAHRI, T., BEVERIDGE, M. C., COCHRANE, K. L., FUNGE-SMITH, S. & POULAIN, F. 2018. Impacts of climate change on fisheries and aquaculture, Synthesis of current knowledge, adaptation and mitigation options. Rome: Food and Agriculture Organization of the United Nations, FAO Fisheries and Aquaculture Technical Paper No. 627, Rome. 628pp. Rome: FAO.

BARRETT, C. B. & CONSTAS, M. A. 2014. Toward a theory of resilience for international development applications. *Proceedings of the National Academy of Sciences,* 111**,** 14625-14630.

BAVINCK, M. 2001. *Marine resource management: conflict and regulation in the fisheries of the Coromandel Coast, Livelihood and Environment Series 5,* New Delhi, Sage Publications.

BAXTER, J. & EYLES, J. 1997. Evaluating qualitative research in social geography: establishing ‘rigour’in interview analysis. *Transactions of the Institute of British Geographers,* 22**,** 505-525.

BENE, C. 2009. Are fishers poor or vulnerable? Assessing economic vulnerability in small-scale fishing communities. *J. Dev. Stud.,* 45**,** 911-933.

BÉNÉ, C., AL-HASSAN, R. M., AMARASINGHE, O., FONG, P., OCRAN, J., ONUMAH, E., RATUNIATA, R., VAN TUYEN, T., MCGREGOR, J. A. & MILLS, D. J. 2016a. Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and Vietnam. *Global Environmental Change,* 38**,** 153-170.

BÉNÉ, C., ARTHUR, R., NORBURY, H., ALLISON, E. H., BEVERIDGE, M., BUSH, S., CAMPLING, L., LESCHEN, W., LITTLE, D. & SQUIRES, D. 2016b. Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Development,* 79**,** 177-196.

BÉNÉ, C., BARANGE, M., SUBASINGHE, R., PINSTRUP-ANDERSEN, P., MERINO, G., HEMRE, G.-I. & WILLIAMS, M. 2015. Feeding 9 billion by 2050–Putting fish back on the menu. *Food Security,* 7**,** 261-274.

BÉNÉ, C., HEADEY, D., HADDAD, L. & VON GREBMER, K. 2016c. Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. *Food Security,* 8**,** 123-138.

BÉNÉ, C., NEWSHAM, A., DAVIES, M., ULRICHS, M. & GODFREY-WOOD, R. 2014. Review article: resilience, poverty and development. *Journal of International Development,* 26**,** 598-623.

BÉNÉ, C., WOOD, R. G., NEWSHAM, A. & DAVIES, M. 2012. Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. *IDS Working Papers,* 2012**,** 1-61.

BENNETT, E. 2005. Gender, fisheries and development. *Marine policy,* 29**,** 451-459.

BERG, B. 2007. *Qualitative research methods for the social sciences,* Boston, California State University: Allyn and Bacon.

BERG, B. L. 2016. *Qualitative research methods for the social sciences,* Boston, Pearson Education.

BERKES, F. 2003. Alternatives to conventional management: Lessons from small-scale fisheries. *Environments,* 31**,** 5.

BERKES, F. 2006. From community-based resource management to complex systems: the scale issue and marine commons. *Ecology and Society,* 11.

BERKES, F. 2007. Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural hazards,* 41**,** 283-295.

BERKES, F. 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of environmental management,* 90**,** 1692-1702.

BERKES, F. 2011. Restoring unity: The concept of marine social-ecological systems. *In:* OMMER, R., PERRY, R., COCHRANE, K. & CURY, P. (eds.) *World fisheries: A social-ecological analysis.* Sussex, UK: Wiley-Blackwell.

BERKES, F. 2012. *Sacred ecology,* New York, Routledge.

BERKES, F. & ARMITAGE, D. 2010. Co-management institutions, knowledge, and learning: Adapting to change in the Arctic. *Etudes/Inuit/Studies***,** 109-131.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F., COLDING, J. & FOLKE, C. 2008. *Navigating social-ecological systems: building resilience for complexity and change*, Cambridge University Press.

BERKES, F. & DAVIDSON-HUNT, I. J. 2007. Communities and social enterprises in the age of globalization. *Journal of Enterprising Communities: People and Places in the Global Economy,* 1**,** 209-221.

BERKES, F., FOLKE, C. & COLDING, J. (eds.) 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience,* Cambridge, UK: Cambridge University Press.

BERKES, F., FOLKE, C. & COLDING, J. 2000. *Linking social and ecological systems: management practices and social mechanisms for building resilience*, Cambridge University Press.

BERKES, F. & JOLLY, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology,* 5**,** 18.

BERKES, F. & ROSS, H. 2013. Community resilience: toward an integrated approach. *Society & Natural Resources,* 26**,** 5-20.

BERKES, F. & ROSS, H. 2016. Panarchy and community resilience: Sustainability science and policy implications. *Environmental Science & Policy,* 61**,** 185-193.

BERKES, F. & SEIXAS, C. S. 2005. Building resilience in lagoon social–ecological systems: a local-level perspective. *Ecosystems,* 8**,** 967-974.

BERKES, F. & TURNER, N. J. 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology,* 34**,** 479.

BERMAN, R., QUINN, C. & PAAVOLA, J. 2012. The role of institutions in the transformation of coping capacity to sustainable adaptive capacity. *Environmental Development,* 2**,** 86-100.

BERRANG-FORD, L., DINGLE, K., FORD, J. D., LEE, C., LWASA, S., NAMANYA, D. B., HENDERSON, J., LLANOS, A., CARCAMO, C. & EDGE, V. 2012. Vulnerability of indigenous health to climate change: A case study of Uganda's Batwa Pygmies. *Social science & medicine,* 75**,** 1067-1077.

BEYMER-FARRIS, B. A., BASSETT, T. J. & BRYCESON, I. 2012. Promises and pitfalls of adaptive management in resilience thinking: the lens of political ecology. *In:* PLIENINGER, T. & BIELING, C. (eds.) *Resilience and the cultural landscape.* Cambridge: Cambridge University Press.

BIESBROEK, R., BERRANG-FORD, L., FORD, J. D., TANABE, A., AUSTIN, S. E. & LESNIKOWSKI, A. 2018. Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review. *Wiley Interdisciplinary Reviews: Climate Change,* 9**,** e548.

BIRT, L., SCOTT, S., CAVERS, D., CAMPBELL, C. & WALTER, F. 2016. Member checking: a tool to enhance trustworthiness or merely a nod to validation? *Qualitative health research,* 26**,** 1802-1811.

BISARO, A. & HINKEL, J. 2016. Governance of social dilemmas in climate change adaptation. *Nature Climate Change,* 6**,** 354.

BLANCHARD, J. L., WATSON, R. A., FULTON, E. A., COTTRELL, R. S., NASH, K. L., BRYNDUM-BUCHHOLZ, A., BÜCHNER, M., CAROZZA, D. A., CHEUNG, W. W. & ELLIOTT, J. 2017. Linked sustainability challenges and trade-offs among fisheries, aquaculture and agriculture. *Nature ecology & evolution,* 1**,** 1240.

BOHLE, H.-G., ETZOLD, B. & KECK, M. 2009. Resilience as agency. *IHDP Update,* 2**,** 8-13.

BOILLAT, S. & BERKES, F. 2013. Perception and interpretation of climate change among Quechua farmers of Bolivia: indigenous knowledge as a resource for adaptive capacity. *Ecology and Society,* 18.

BOSMA, R. H., NHAN, D. K., UDO, H. M. & KAYMAK, U. 2012. Factors affecting farmers' adoption of integrated rice–fish farming systems in the Mekong delta, Vietnam. *Reviews in Aquaculture,* 4**,** 178-190.

BOUSQUET, F., BOTTA, A., ALINOVI, L., BARRETEAU, O., BOSSIO, D., BROWN, K., CARON, P., D'ERRICO, M., DECLERCK, F. & DESSARD, H. 2016. Resilience and development: mobilizing for transformation. *Ecology and Society,* 21.

BOWEN, G. A. 2008. Naturalistic inquiry and the saturation concept: a research note. *Qualitative research,* 8**,** 137-152.

BOYD, E. & FOLKE, C. (eds.) 2012. *Adapting institutions: Governance, complexity and social-ecological resilience,* New York: Cambridge University Press.

BRAND, F. S. & JAX, K. 2007. Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and society,* 12**,** 23.

BREEN, R. L. 2006. A practical guide to focus-group research. *Journal of Geography in Higher Education,* 30**,** 463-475.

BROAD, R. & CAVANAGH, J. 2011. Reframing Development in the Age of Vulnerability: from case studies of the Philippines and Trinidad to new measures of rootedness. *Third World Quarterly,* 32**,** 1127-1145.

BROOKS, N. 2003. Vulnerability, risk and adaptation: A conceptual framework. *Tyndall Centre for Climate Change Research Working Paper,* 38**,** 1-16.

BROW, J. 1978. *Veddha Villages of Anuradhapura: The Anthropological History of a Community in Sri Lanka. ,* Seattle, WA, University of Washington Press.

BROWN, K. 2012. 3 Policy discourses of resilience. *Climate Change and the Crisis of Capitalism: A Chance to Reclaim, Self, Society and Nature***,** 37.

BROWN, K. 2014. Global environmental change IA social turn for resilience? *Progress in Human Geography,* 38**,** 107-117.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

BROWN, K. & WESTAWAY, E. 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual review of environment and resources,* 36**,** 321-342.

BRZOSKA, M. & FRÖHLICH, C. 2016. Climate change, migration and violent conflict: vulnerabilities, pathways and adaptation strategies. *Migration and Development,* 5**,** 190-210.

BUNCE, A. & FORD, J. 2015. How is adaptation, resilience, and vulnerability research engaging with gender? *Environmental Research Letters,* 10**,** 123003.

CAMERON, J. 2010. Focusing on the Focus Group. *In:* HAY, I. (ed.) *Qualitative Research Methods in Human Geography.* New York: Oxford University Press.

CAMPBELL, D. & BERGERON, J. 2012. Natural revegetation of winter roads on peatlands in the Hudson Bay lowland, Canada. *Arctic, Antarctic, and Alpine Research,* 44**,** 155-163.

CAREY, M. A. & ASBURY, J.-E. 2016. *Focus group research,* London, Routledge.

CARLSSON, L. & BERKES, F. 2005. Co-management: concepts and methodological implications. *Journal of environmental management,* 75**,** 65-76.

CARPENTER, S., WALKER, B., ANDERIES, J. M. & ABEL, N. 2001. From metaphor to measurement: resilience of what to what? *Ecosystems,* 4**,** 765-781.

CASH, D., ADGER, W. N., BERKES, F., GARDEN, P., LEBEL, L., OLSSON, P., PRITCHARD, L. & YOUNG, O. 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. *Ecology and society,* 11.

CASTLEDEN, H., MORGAN, V. S. & LAMB, C. 2012. "I spent the first year drinking tea": Exploring Canadian university researchers' perspectives on community-based participatory research involving Indigenous peoples. *The Canadian Geographer/Le Géographe canadien,* 56**,** 160-179.

CHAMLEE-WRIGHT, E. & STORR, V. H. 2009. "There's no place like New Orleans": Sense of place and community recovery in the Ninth Ward after Hurricane Katrina. *Journal of Urban Affairs,* 31**,** 615-634.

CHANDRASOMA, J. & PUSHPALATHA, K. B. C. 2018. Fisheries enhancements in inland waters in Sri Lanka with special reference to culture based fisheries: current status and impacts. *Sri Lanka Journal of Aquatic Sciences* 23**,** 49-65.

CHAPIN, F. S., CARPENTER, S. R., KOFINAS, G. P., FOLKE, C., ABEL, N., CLARK, W. C., OLSSON, P., SMITH, D. M. S., WALKER, B. & YOUNG, O. R. 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology & Evolution,* 25**,** 241-249.

CHARBONNEAU-ROBERTS, G., YOUNG, K. & EGELAND, G. M. 2007. Inuit anthropometry and insulin resistance. *International journal of circumpolar health,* 66**,** 129-134.

CHEN, J. & MUELLER, V. 2018. Coastal climate change, soil salinity and human migration in Bangladesh. *Nature Climate Change,* 8**,** 981-985.

CHILDS, K. 2017. Culture and life: The last Veddas of Sri Lanka. *Guardian (Sydney)*, 10.

CHRISTENSEN, J. 2011. *Homeless in a homeland: housing (in)security and homelessness in Inuvik and Yellowknife, Northwest Territories, Canada.* Doctor of Philosophy, McGill University.

CHRISTOPLOS, I. 2010. Understanding climate change adaptation: lessons from community-based approaches. *imate and Development,* 2, 73-74.

CINNER, J. 2013. Evaluating social and ecological vulnerability of coral reef fisheries to climate change. *PLoS ONE,* 8, e74321.

CINNER, J. & BARNES, M. L. 2019. Social Dimensions of Resilience in Social-Ecological Systems. *One Earth,* 1, 51-56.

CINNER, J. E. 2012. Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Glob. Environ. Change,* 22, 12-20.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018a. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8, 117.

CINNER, J. E., ADGER, W. N., ALLISON, E. H., BARNES, M. L., BROWN, K., COHEN, P. J., GELCICH, S., HICKS, C. C., HUGHES, T. P. & LAU, J. 2018b. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change,* 8, 117-123.

CINNER, J. E., HUCHERY, C., HICKS, C. C., DAW, T. M., MARSHALL, N., WAMUKOTA, A. & ALLISON, E. H. 2015. Changes in adaptive capacity of Kenyan fishing communities. *Nature Climate Change,* 5, 872-876.

CISNEROS-MONTEMAYOR, A. M., PAULY, D., WEATHERDON, L. V. & OTA, Y. 2016. A global estimate of seafood consumption by coastal indigenous peoples. *PLoS One,* 11, e0166681.

CLARK, D. G., FORD, J. D., BERRANG-FORD, L., PEARCE, T., KOWAL, S. & GOUGH, W. 2016a. The role of environmental factors in search and rescue incidents in Nunavut, Canada. *Public health,* 137, 44-49.

CLARK, D. G., FORD, J. D., PEARCE, T. & BERRANG-FORD, L. 2016b. Vulnerability to unintentional injuries associated with land-use activities and search and rescue in Nunavut, Canada. *Social Science & Medicine,* 169**,** 18-26.

CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. 2016. *Key methods in geography,* London, Sage.

CLINE, T. J., SCHINDLER, D. E. & HILBORN, R. 2017. Fisheries portfolio diversification and turnover buffer Alaskan fishing communities from abrupt resource and market changes. *Nature communications,* 8**,** 14042.

CLOKE, P., COOKE, P., CURSONS, J., MILBOURNE. P., AND WIDDOWFIELD, R. 2000. Ethics, reflexivity and research: encounters with homeless people, *Ethics, Place & Environment,* 3, 133–54.

COCHRAN, P., HUNTINGTON, O. H., PUNGOWIYI, C., TOM, S., CHAPIN, F. S., HUNTINGTON, H. P., MAYNARD, N. G. & TRAINOR, S. F. 2013. Indigenous frameworks for observing and responding to climate change in Alaska. *In:* MALDONADO, J. K., COLOMBI, B. & PANDYA, R. (eds.) *Climate Change and Indigenous Peoples in the United States.* New York: Springer.

COLLINGS, P. 2009. Participant observation and phased assertion as research strategies in the Canadian Arctic. *Field Methods,* 21**,** 133-153.

COLLINGS, P., MARTEN, M. G., PEARCE, T. & YOUNG, A. G. 2016. Country food sharing networks, household structure, and implications for understanding food insecurity in Arctic Canada. *Ecology of food and nutrition,* 55**,** 30-49.

CONDON, R. G. 1990. The rise of adolescence: Social change and life stage dilemmas in the Central Canadian Arctic. *Human Organization***,** 266-279.

CONWAY, D., NICHOLLS, R. J., BROWN, S., TEBBOTH, M. G., ADGER, W. N., AHMAD, B., BIEMANS, H., CRICK, F., LUTZ, A. F. & DE CAMPOS, R. S. 2019. The need for bottom-up assessments of climate risks and adaptation in climate-sensitive regions. *Nature Climate Change,* 9**,** 503-511.

COPE, M. 2010. Coding Transcripts and Diaries. *In:* CLIFFORD, N., FRENCH, S. & VALENTINE, G. (eds.) *Key Methods in Geography.* London: SAGE.

COTE, M. & NIGHTINGALE, A. J. 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Progress in Human Geography,* 36**,** 475-489.

COULTHARD, S. 2008. Adapting to environmental change in artisanal fisheries—Insights from a South Indian Lagoon. *Global Environmental Change,* 18**,** 479-489.

COULTHARD, S. 2012. Can we be both resilient and well, and what choices do people have? Incorporating agency into the resilience debate from a fisheries perspective. *Ecology and Society,* 17**,** 4.

COX, M., ARNOLD, G. & TOMÁS, S. V. 2010. A review of design principles for community-based natural resource management. *Ecology and Society,* 15**,** 38.

CRANG, M. & COOK, I. 2007. *Doing ethnographies,* Thousand Oaks, CA, Sage Publications.

CRESWELL, J. W. 2013a. *Qualitative inquiry and research design: Choosing among five approaches,* Thousand Oaks, Sage.

CRESWELL, J. W. 2013b. *Research design: Qualitative, quantitative, and mixed methods approaches,* New York, Sage publications.

CUNSOLO-WILLOX, A. & ELLIS, N. R. 2018. Ecological grief as a mental health response to climate change-related loss. *Nature Climate Change,* 8**,** 275-281.

CUTCLIFFE, J. R. & MCKENNA, H. P. 1999. Establishing the credibility of qualitative research findings: the plot thickens. *Journal of advanced nursing,* 30**,** 374-380.

CUTTER, S. L., BARNES, L., BERRY, M., BURTON, C., EVANS, E., TATE, E. & WEBB, J. 2008. A place-based model for understanding community resilience to natural disasters. *Global environmental change,* 18**,** 598-606.

D'ARMENGOL, L., CASTILLO, M. P., RUIZ-MALLÉN, I. & CORBERA, E. 2018. A systematic review of co-managed small-scale fisheries: Social diversity and adaptive management improve outcomes. *Global environmental change,* 52**,** 212-225.

DABNEY, D. A., HOLLINGER, R. C. & DUGAN, L. 2004. Who actually steals? A study of covertly observed shoplifters. *Justice Quarterly,* 21**,** 693-728.

DALE, A. & ARMITAGE, D. 2011. Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *Marine Policy,* 35**,** 440-449.

DANIELSEN, F., TOPP-JØRGENSEN, E., LEVERMANN, N., LØVSTRØM, P., SCHIØTZ, M., ENGHOFF, M. & JAKOBSEN, P. 2014. Counting what counts: Using local knowledge to improve Arctic resource management. *Polar Geography,* 37**,** 69-91.

DASGUPTA, S., LAPLANTE, B., MEISNER, C. M., WHEELER, D. & JIANPING YAN, D. 2007. The impact of sea level rise on developing countries: a comparative analysis. *World Bank policy research working paper*.

DAVIDSON-HUNT, I. J. & BERKES, F. 2003. Nature and society through the lens of resilience: toward a human-in-ecosystem perspective. *Navigating social-ecological systems: Building resilience for complexity and change***,** 53-82.

DE JONG, K., MULHERN, M., FORD, N., SIMPSON, I., SWAN, A. & VAN DER KAM, S. 2002. Psychological trauma of the civil war in Sri Lanka. *Lancet,* 359**,** 1517-1518.

DE SILVA, C., WEATHERHEAD, E., KNOX, J. W. & RODRIGUEZ-DIAZ, J. 2007. Predicting the impacts of climate change—A case study of paddy irrigation water requirements in Sri Lanka. *Agricultural Water Management,* 93**,** 19-29.

DE SILVA, S. S., AMARASINGHE, U. S. & NGUYEN, T. T. 2006. Better-practice approaches for culture-based fisheries development in Asia. *ACIAR Monograph.* Canberra.

DENIS, M. & MOSER, S. C. 2015. IPCC: calling social scientists of all kinds. *Nature,* 521**,** 161-161.

DEPPISCH, S. & HASIBOVIC, S. 2013. Social-ecological resilience thinking as a bridging concept in transdisciplinary research on climate-change adaptation. *Natural hazards,* 67**,** 117-127.

DEVINE-WRIGHT, P. 2013. Think global, act local? The relevance of place attachments and place identities in a climate changed world. *Global Environmental Change,* 23**,** 61-69.

DEWALT, K. M. & DEWALT, B. R. 2010. *Participant observation: A guide for fieldworkers,* Lanham, Rowman Altamira Press.

DEY, M. M., GOSH, K., VALMONTE-SANTOS, R., ROSEGRANT, M. W. & CHEN, O. L. 2016a. Economic impact of climate change and climate change adaptation strategies for fisheries sector in Fiji. *Marine Policy,* 67**,** 164-170.

DEY, M. M., GOSH, K., VALMONTE-SANTOS, R., ROSEGRANT, M. W. & CHEN, O. L. 2016b. Economic impact of climate change and climate change adaptation strategies for fisheries sector in Solomon Islands: Implication for food security. *Marine Policy,* 67**,** 171-178.

DHARMADASA, K. 1974. The creolization of an aboriginal language: The case of Vedda in Sri Lanka (Ceylon). *Anthropological Linguistics,* 16**,** 79-106.

DHARMADASA, K. N. O. 1993. Vedda: the 'Adivasi' of Sri Lanka. SOBA 4:3, 7–11. Ministry of Environment and Parliamentary Affairs, Sri Lanka.

DIEMER, K. M., CONROY, M. J., FERGUSON, S. H., HAUSER, D. D., GRGICAK-MANNION, A. & FISK, A. T. 2011. Marine mammal and seabird summer distribution and abundance in the fjords of northeast Cumberland Sound of Baffin Island, Nunavut, Canada. *Polar biology,* 34**,** 41-48.

DILLMAN, C. 1977. Ethical problems in social science research peculiar to participant observation. *Human organization,* 36**,** 405-407.

DONEY, S. C., FABRY, V. J., FEELY, R. A. & KLEYPAS, J. A. 2016. Ocean Acidification: The Other CO2 Problem. *Annual Review of Marine Science* 1**,** 169-192.

DOWLING, R. 2016. Power, Subjectivity, and Ethics in Qualitative Research. *In:* HAY, I. (ed.) *Qualitataive Research Methods in Human Geography.* 4th ed. New York: Oxford University Press.

DOWSLEY, M. 2015. Identity and the evolving relationship between Inuit women and the land in the eastern Canadian Arctic. *Polar Record,* 51**,** 536-549.

DUERDEN, F. 2004. Translating climate change impacts at the community level. *Arctic,* 57**,** 204-212.

DUNN, K. 2003. Interviewing. *In:* HAY, I. (ed.) *Qualitative research methods in human geography.* Melbourne: Oxford University Press.

DUPUIS, J. & BIESBROEK, R. 2013. Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. *Global Environmental Change,* 23**,** 1476-1487.

EGELAND, G. M., CHARBONNEAU-ROBERTS, G., KULUGUQTUQ, J., KILABUK, J., OKALIK, L., SOUEIDA, R. & KUHNLEIN, H. V. 2009. Back to the future: using traditional food and knowledge to promote a healthy future among Inuit. *Indigenous Peoples' Food Systems.* Food and Agriculture Organization of the United Nations, Centre for Indigenous Peoples' Nutrition and Environment, Rome 2009.

ENGLAND, K. V. L. 1994. Getting personal: Reflexivity, positionality, and feminist research. *Professional Geographer,* 46**,** 80-89.

ENSOR, J. E., ABERNETHY, K. E., HODDY, E. T., ASWANI, S., ALBERT, S., VACCARO, I., BENEDICT, J. J. & BEARE, D. J. 2018. Variation in perception of environmental change in nine Solomon Islands communities: implications for securing fairness in community-based adaptation. *Regional Environmental Change,* 18**,** 1131-1143.

ERIKSEN, S., ALDUNCE, P., BAHINIPATI, C. S., MARTINS, R. D. A., MOLEFE, J. I., NHEMACHENA, C., O'BRIEN, K., OLORUNFEMI, F., PARK, J. & SYGNA, L. 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate and Development,* 3**,** 7-20.

ESCOBAR, A. 2008. *Territories of difference: place, movements, life, redes,* Durham and London, Duke University Press.

ESHAM, M. & GARFORTH, C. 2013. Climate change and agricultural adaptation in Sri Lanka: a review. *Climate and Development,* 5**,** 66-76.

EYSENBACH, G. & TILL, J. E. 2001. Ethical issues in qualitative research on internet communities. *Bmj,* 323**,** 1103-1105.

FAIRCLOUGH, N. 2013a. *Critical discourse analysis: The critical study of language,* NY, Routledge.

FAIRCLOUGH, N. 2013b. Critical Discourse Analysis: The Critical Study of Language.

FAO 2015. Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector, by Cecile Brugère and Cassandra De Young. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, Italy.

FAO 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome: Food and Agriculture Organization of the United Nations.

FERNÁNDEZ-LLAMAZARES, Á., GARCIA, R. A., DÍAZ-REVIRIEGO, I., CABEZA, M., PYHÄLÄ, A. & REYES-GARCÍA, V. 2017. An empirically tested overlap between indigenous and scientific knowledge of a changing climate in Bolivian Amazonia. *Regional Environmental Change***,** 1-13.

FERNANDO, P., WIKRAMANAYAKE, E., WEERAKOON, D., JAYASINGHE, L., GUNAWARDENE, M. & JANAKA, H. 2005. Perceptions and patterns of human–

elephant conflict in old and new settlements in Sri Lanka: insights for mitigation and management. *Biodiversity & Conservation,* 14**,** 2465-2481.

FIDELMAN, P., VAN TUYEN, T., NONG, K. & NURSEY-BRAY, M. 2017. The institutions-adaptive capacity nexus: Insights from coastal resources co-management in Cambodia and Vietnam. *Environmental Science & Policy,* 76**,** 103-112.

FISCHER, J., GARDNER, T. A., BENNETT, E. M., BALVANERA, P., BIGGS, R., CARPENTER, S., DAW, T., FOLKE, C., HILL, R. & HUGHES, T. P. 2015. Advancing sustainability through mainstreaming a social–ecological systems perspective. *Current Opinion in Environmental Sustainability,* 14**,** 144-149.

FLOWERDEW, R. & MARTIN, D. 2005. *Methods in Human Geography: A guide for students doing a research project,* London, Pearson Prentice Hall.

FOLKE, C. 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change,* 16**,** 253-267.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

FOLKE, C., BIGGS, R., NORSTRÖM, A., REYERS, B. & ROCKSTRÖM, J. 2016. Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society,* 21.

FOLKE, C., CARPENTER, S., WALKER, B., SCHEFFER, M., ELMQVIST, T., GUNDERSON, L. & HOLLING, C. S. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. *Annu. Rev. Ecol. Evol. Syst.,* 35**,** 557-581.

FOLKE, C., CARPENTER, S. R., WALKER, B., SCHEFFER, M., CHAPIN, T. & ROCKSTROM, J. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society,* 15**,** 20.

FOLKE, C., CHAPIN III, F. S. & OLSSON, P. 2009. Transformations in ecosystem stewardship. *In:* SF, C. I., GP, K. & C, F. (eds.) *Principles of Ecosystem Stewardship.* New York: Springer.

FOLKE, C., COLDING, J. & BERKES, F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. *In:* BERKES, F., COLDING, J. & FOLKE, C. (eds.) *Navigating social-ecological systems: Building resilience for complexity and change.* New York: Cambridge University Press.

FORD, J., BERRANG-FORD, L., BIESBROEK, R., ARAOS, M., AUSTIN, S. & LESNIKOWSKI, A. 2015a. Adaptation tracking for a post-2015 climate agreement. *Nature Climate Change,* 5**,** 967.

FORD, J., FALK, K. & TESAR, C. 2018a. Adaptation and Resilience. In: Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. pp. [307-328]. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

FORD, J., FALK, K. & TESAR, C. 2018b. Adaptation and resilince (Chapter 11). *In:* AMAP (ed.) *Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region.* Oslo, Norway: Arctic Monitoring and Assessment Programme (AMAP).

FORD, J. D., KING, N., GALAPPATHTHI, E. K., PEARCE, T., MCDOWELL, G. & HARPER, S. In Press. Resilience of Indigenous peoples to environmental change *One Earth***,** (10.1016/j.oneear.2020.05.014).

FORD, J., MAILLET, M., POULIOT, V., MEREDITH, T., CAVANAUGH, A. & TEAM, I. R. 2016a. Adaptation and Indigenous peoples in the United Nations Framework Convention on Climate Change. *Climatic Change,* 139**,** 429-443.

FORD, J., MCDOWELL, G. & PEARCE, T. 2015b. The adaptation challenge in the Arctic. *Nature Clim. Change,* 5**,** 1046-1053.

FORD, J., PEARCE, T., MCDOWELL, G., BERRANG-FORD, L., SAYLES, J. & BELFER, E. In Press. Vulnerability and its discontents: The past, present, and future of climate change vulnerability research. *Climatic Change*.

FORD, J. D. 2009a. Sea ice, climate change, and community vulnerability in northern Foxe Basin, Canada. *Clim. Res.,* 38**,** 137-154.

FORD, J. D. 2009b. Vulnerability of Inuit food systems to food insecurity as a consequence of climate change: a case study from Igloolik, Nunavut. *Regional Environmental Change,* 9**,** 83-100.

FORD, J. D. 2012. Indigenous Health and Climate Change. *American Journal of Public Health,* 102**,** 1260-1266.

FORD, J. D. 2014. Adapting to the effects of climate change on Inuit health. *Am. J. Public Health,* 104**,** e9-e17.

FORD, J. D. & BEAUMIER, M. 2011. Feeding the family during times of stress: experience and determinants of food insecurity in an Inuit community. *The Geographical Journal,* 177**,** 44-61.

FORD, J. D., BELL, T. & ST-HILAIRE-GRAVEL, D. 2010a. Vulnerability of community infrastructure to climate change in Nunavut: a case study from Arctic Bay. *Community adaptation and vulnerability in arctic regions.* Springer.

FORD, J. D., BERRANG-FORD, L., KING, M. & FURGAL, C. 2010b. Vulnerability of Aboriginal health systems in Canada to climate change. *Global Environmental Change,* 20**,** 668-680.

FORD, J. D., CAMERON, L., RUBIS, J., MAILLET, M., NAKASHIMA, D., WILLOX, A. C. & PEARCE, T. 2016b. Including indigenous knowledge and experience in IPCC assessment reports. *Nature Clim. Change,* 6**,** 349-353.

FORD, J. D., CAMERON, L., RUBIS, J., MAILLET, M., NAKASHIMA, D., WILLOX, A. C. & PEARCE, T. 2016c. Including indigenous knowledge and experience in IPCC assessment reports. *Nature Climate Change,* 6**,** 349-353.

FORD, J. D., CLARK, D., PEARCE, T., BERRANG-FORD, L., COPLAND, L., DAWSON, J., NEW, M. & HARPER, S. L. 2019. Changing access to ice, land and water in Arctic communities. *Nature Climate Change,* 9**,** 335-339.

FORD, J. D., COUTURE, N., BELL, T. & CLARK, D. G. 2018c. Climate change and Canada's north coast: research trends, progress, and future directions. *Environmental Reviews,* 26**,** 82-92.

FORD, J. D. & KING, D. 2015. A framework for examining adaptation readiness. *Mitigation and Adaptation Strategies for Global Change,* 20**,** 505-526.

FORD, J. D., MCDOWELL, G. & PEARCE, T. 2015c. The adaptation challenge in the Arctic. *Nature Climate Change,* 5**,** 1046-1053.

FORD, J. D., MCDOWELL, G., SHIRLEY, J., PITRE, M., SIEWIERSKI, R., GOUGH, W., DUERDEN, F., PEARCE, T., ADAMS, P. & STATHAM, S. 2013. The dynamic multiscale nature of climate change vulnerability: an Inuit harvesting example. *Annals of the Association of American Geographers,* 103**,** 1193-1211.

FORD, J. D., SHERMAN, M., BERRANG-FORD, L., LLANOS, A., CARCAMO, C., HARPER, S., LWASA, S., NAMANYA, D., MARCELLO, T. & MAILLET, M. 2018d.

Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. *Global environmental change,* 49**,** 129-139.

FORD, J. D. & SMIT, B. 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic***,** 389-400.

FORD, J. D., SMIT, B. & WANDEL, J. 2006. Vulnerability to climate change in the Arctic: a case study from Arctic Bay, Canada. *Global Environmental Change,* 16**,** 145-160.

FORD, J. D., SMIT, B., WANDEL, J., ALLURUT, M., SHAPPA, K., ITTUSARJUAT, H. & QRUNNUT, K. 2008. Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *The Geographical Journal,* 174**,** 45-62.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2015d. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-191.

FORD, J. D., STEPHENSON, E., CUNSOLO WILLOX, A., EDGE, V., FARAHBAKHSH, K., FURGAL, C., HARPER, S., CHATWOOD, S., MAURO, I. & PEARCE, T. 2016d. Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 175-195.

FORD, J. D., VANDERBILT, W. & BERRANG-FORD, L. 2012. Authorship in IPCC AR5 and its implications for content: climate change and Indigenous populations in WGII. *Climatic change,* 113**,** 201-213.

FORSYTH, T. 2017. Community based adaptation. *In:* VON STORCH, H. (ed.) *Oxford Research Encyclopedia of Climate Science.* Oxford, UK: Oxford University Press.

FOWLER, R. 1997. Norman Fairclough, Critical discourse analyisis The critical study of languageLondonLongman, 1995 Pp XIII, 265. *Language in Society,* 26**,** 421-423.

FRAM, S. M. 2013. The constant comparative analysis method outside of grounded theory. *The qualitative report,* 18**,** 1-25.

FRANKENBERGER, T., MUELLER, M., SPANGLER, T. & ALEXANDER, S. 2013. Community resilience: conceptual framework and measurement feed the future learning Agenda. *Rockville, MD: Westat,* 1.

FREDUAH, G., FIDELMAN, P. & SMITH, T. F. 2019. A framework for assessing adaptive capacity to multiple climatic and non-climatic stressors in small-scale fisheries. *Environmental Science & Policy,* 101**,** 87-93.

FREIRE, P. 2000. *Pedagogy of the oppressed,* London, Bloomsbury Publishing.

FRESHWATER, D. & ROLFE, G. 2001. Critical reflexivity: a politically and ethically engaged research method for nursing. *Nursing Times Research,* 6**,** 526-537.

FRIEDRICH, T. L., GRIFFITH, J. A. & MUMFORD, M. D. 2016. Collective leadership behaviors: Evaluating the leader, team network, and problem situation characteristics that influence their use. *The Leadership Quarterly,* 27**,** 312-333.

FRISCH, L., MATHIS, J., KETTLE, N. & TRAINOR, S. 2015. Gauging perceptions of ocean acidification in Alaska. *Marine Policy,* 53**,** 101-110.

FÜSSEL, H.-M. 2007. Vulnerability: a generally applicable conceptual framework for climate change research. *Global Environmental Change,* 17**,** 155-167.

GAASBEEK, T. 2013. Flying below the Radar. *In:* DOROTHEA, H. (ed.) *Disaster, Conflict and Society in Crises: Everyday Politics of Crisis Response.* NY: Routledge.

GALAPPATHTHI, E. 2013. *Community-based Shrimp Aquaculture in Northwestern Sri Lanka.* Master of Natural Resources Management , Winnipeg, University of Manitoba.

GALAPPATHTHI, E. & BERKES, F. 2015a. Drama of the commons in small-scale shrimp aquaculture in northwestern, Sri Lanka. *International Journal of the Commons,* 9**,** 347-368.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2018. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C., eds. FishAdapt: The Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, 2018 Bangkok. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO.

GALAPPATHTHI, E., BERKES, F. & FORD, J. 2019a. Climate change adaptation efforts in coastal shrimp aquaculture: A case from northwestern Sri Lanka. *In:* JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C. (eds.) *Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture, Bangkok, 8–10 August, 2016. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO. 240 pp. Licence: CC BY-NC-SA 3.0 IGO.*

GALAPPATHTHI, E. K. & BERKES, F. 2014. Institutions for managing common-pool resources: the case of community-based shrimp aquaculture in northwestern Sri Lanka. *Maritime Studies,* 13**,** 1-16.

GALAPPATHTHI, E. K. & BERKES, F. 2015b. Can co-management emerge spontaneously? Collaborative management in Sri Lankan shrimp aquaculture. *Marine Policy,* 60**,** 1-8.

GALAPPATHTHI, E. K., FORD, J., BENNETT, E. & BERKES, F. 2019b. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada *Journal of Environmental management,* 250**,** 11.

GALAPPATHTHI, E. K., FORD, J., BENNETT, E. & BERKES, F. 2019c. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada. *Journal of Environmental management,* 250**,** 109534.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2019d. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92**,** 17-26.

GALAPPATHTHI, E. K., FORD, J. D. & BENNETT, E. M. 2020a. Climate change and adaptation to social-ecological change: the case of indigenous people and culture-based fisheries in Sri Lanka. *Climatic Change* (Published online: 27 April 2020, 2010.1007/s10584-10020-02716-10583).

GALAPPATHTHI, E. K., ICHIEN, S. T., HYMAN, A. A., AUBRAC, C. J. & FORD, J. D. 2020b. Climate change adaptation in aquaculture. *Reviews in Aquaculture* (Published online: 17 April 2020, https://doi.org/10.1111/raq.12427).

GALAPPATHTHI, E. K., KODITHUWAKKU, S. S. & GALAPPATHTHI, I. M. 2016. Can environment management integrate into supply chain management? Information sharing via shrimp aquaculture cooperatives in northwestern Sri Lanka. *Marine Policy,* 68**,** 187-194.

GARMESTANI, A., ALLEN, C. & GUNDERSON, L. 2009. Panarchy: discontinuities reveal similarities in the dynamic system structure of ecological and social systems. *Ecology and Society,* 14.

GEORGE, K. & STRATFORD, E. 2016. Oral history and human Geography. *In:* HAY, I. (ed.) *Qualitative research methods in human geography.* Melbourne: Oxford University Press.

GILES, A. R., LYNCH, M., STADIG, G. S., DOUCETTE ISSALUK, M., DARROCH, F. & STRACHAN, S. 2014. Using a public health approach to understand "skipping" snowmobiles in Pangnirtung, Nunavut, Canada. *International Journal of Aquatic Research and Education,* 8**,** 6.

GIULIANI, M. V. 2003. Theory of attachment and place attachment. *In:* M. BONNES & T. LEE, M. B. (eds.) *Psychological theories for environmental issues* Aldershot: Ashgate.

GLASER, B. G. 1965. The constant comparative method of qualitative analysis. *Social problems,* 12**,** 436-445.

GOLAFSHANI, N. 2003. Understanding reliability and validity in qualitative research. *The qualitative report,* 8**,** 597-606.

GÓMEZ-BAGGETHUN, E., CORBERA, E. & REYES-GARCÍA, V. 2013. Traditional ecological knowledge and global environmental change: research findings and policy implications. *Ecology and society,* 18**,** 8.

GRANEHEIM, U.H. AND LUNDMAN, B. 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness, *Nurse Education Today* 24: 105-112

GREBMEIER, J. M., OVERLAND, J. E., MOORE, S. E., FARLEY, E. V., CARMACK, E. C., COOPER, L. W., FREY, K. E., HELLE, J. H., MCLAUGHLIN, F. A. & MCNUTT, S. L. 2006. A major ecosystem shift in the northern Bering Sea. *Science,* 311**,** 1461-1464.

GRIGGS, D., STAFFORD-SMITH, M., GAFFNEY, O., ROCKSTRÖM, J., ÖHMAN, M. C., SHYAMSUNDAR, P., STEFFEN, W., GLASER, G., KANIE, N. & NOBLE, I. 2013. Policy: Sustainable development goals for people and planet. *Nature,* 495**,** 305.

GUNATILAKA, A. 2017. Water security and related issues in Sri Lanka: the need for integrated water resource management (IWRM). *Journal of the National Science Foundation of Sri Lanka,* 36.

GUNAWARDENA, A. & STEELE, P. 2008. The stake-net fishery association of Negombo lagoon, Sri Lanka: Why has it survived over 250 years and will it survive another 100 years. *In:* GHATE, R., JODHA, N. S. & MUKHOPADHYAY, P. (eds.) *Promise, trust and evolution: managing the commons of South Asia.* New York: Oxford University Press.

GUNDERSON, L. H. & HOLLING, C. S. (eds.) 2002. *Panarchy: understanding transformations in human and natural systems,* Washington: Island press.

GUTIÉRREZ, N. L., HILBORN, R. & DEFEO, O. 2011. Leadership, social capital and incentives promote successful fisheries. *Nature,* 470**,** 386.

HACKER, K. 2013. *Community-based participatory research,* London, Sage.

HANCOCK, B., OCKLEFORD, E. & WINDRIDGE, K. 1998. *An introduction to qualitative research*, Trent focus group Nottingham.

HANCOCK, D. R. & ALGOZZINE, B. 2015. *Doing case study research: A practical guide for beginning researchers,* London, Teachers College Press.

HARVEY, B., CARLILE, L., ENSOR, J., GARSIDE, B. & PATTERSON, Z. 2012. Understanding Context in Learning-centred Approaches to Climate Change Communication. *IDS Bulletin,* 43**,** 31-37.

HARVEY, D. 2006. *Spaces of global capitalism,* London, Verso.

HARWOOD, L., SMITH, T., GEORGE, J., SANDSTROM, S., WALKUSZ, W. & DIVOKY, G. 2015. Change in the Beaufort Sea ecosystem: diverging trends in body condition and/or production in five marine vertebrate species. *Progress in Oceanography,* 136**,** 263-273.

HATT, K. 2013. Social attractors: a proposal to enhance "resilience thinking" about the social. *Society & Natural Resources,* 26**,** 30-43.

HAY, I. 2003. Ethical Practice in Geographycal Research. *In:* CLIFFORD, N. & VALENTINE, G. (eds.) *Key Methods in Geography.* London: Sage.

HAY, I. 2016. *Qualitative research methods in human geography,* Melbourne, Oxford University Press.

HEGNEY, D. G., BUIKSTRA, E., BAKER, P., ROGERS-CLARK, C., PEARCE, S., ROSS, H., KING, C. & WATSON-LUKE, A. 2007. Individual resilience in rural people: a Queensland study, Australia. *Rural and remote health,* 7**,** 1-13.

HELLER, E., CHRISTENSEN, J., LONG, L., MACKENZIE, C. A., OSANO, P. M., RICKER, B., KAGAN, E. & TURNER, S. 2011. Dear diary: Early career geographers collectively reflect on their qualitative field research experiences. *Journal of Geography in Higher Education,* 35**,** 67-83.

HENDRIX, C. S. & SALEHYAN, I. 2012. Climate change, rainfall, and social conflict in Africa. *Journal of peace research,* 49**,** 35-50.

HERATH, T. & JOSEPH, J. 2016. Prevalence of Risk Factors of Under-Nutrition Among Children 1 to 5 Years in Eastern, Sri Lanka. *Journal of Food and Nutrition Sciences,* 4**,** 103-107.

HERTEL, T. W. & ROSCH, S. D. 2010. Climate change, agriculture, and poverty. *Applied Economic Perspectives and Policy,* 32**,** 355-385.

HEWITT-TAYLOR, J. 2001. Use of constant comparative analysis in qualitative research. *Nursing Standard,* 15**,** 39-42.

HICKS, C. C., LEVINE, A., AGRAWAL, A., BASURTO, X., BRESLOW, S. J., CAROTHERS, C., CHARNLEY, S., COULTHARD, S., DOLSAK, N. & DONATUTO, J. 2016. Engage key social concepts for sustainability. *Science,* 352**,** 38-40.

HIGH, S. 2016. *Centre for Oral History and Digital Storytelling* [Online]. Montreal, QC: Concordia University. Available: http://storytelling.concordia.ca/toolbox/ethics [Accessed 29 October 2016].

HIWASAKI, L., LUNA, E. & SHAW, R. 2014. Process for integrating local and indigenous knowledge with science for hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities. *International journal of disaster risk reduction,* 10**,** 15-27.

HOGGART, K., LEES, L., DAVIES, A. & MOULD, A. 2002. *Researching human geography,* London, Routledge.

HOLLING, C. S. 1973. Resilience and stability of ecological systems. *Annual review of ecology and systematics***,** 1-23.

HOMER-DIXON, T. 2002. *The ingenuity gap: can we solve the problems of the future?,* Toronto, Vintage Canada.

HOMER-DIXON, T., WALKER, B., BIGGS, R., CRÉPIN, A.-S., FOLKE, C., LAMBIN, E., PETERSON, G., ROCKSTRÖM, J., SCHEFFER, M. & STEFFEN, W. 2015. Synchronous failure: the emerging causal architecture of global crisis. *Ecology and Society,* 20.

HOOVER, D. L., KNAPP, A. K. & SMITH, M. D. 2014. Resistance and resilience of a grassland ecosystem to climate extremes. *Ecology,* 95**,** 2646-2656.

HOPKINS, P. E. 2007. Positionalities and knowledge: Negotiating ethics in practice. *ACME: An International E-Journal for Critical Geographies,* 6**,** 386-394.

HUET, C., FORD, J. D., EDGE, V. L., SHIRLEY, J., KING, N. & HARPER, S. L. 2017. Food insecurity and food consumption by season in households with children in an Arctic city: a cross-sectional study. *BMC public health,* 17**,** 578.

HUNG, H.-C., LU, Y.-T. & HUNG, C.-H. 2018. The determinants of integrating policy-based and community-based adaptation into coastal hazard risk management: a resilience approach. *Journal of Risk Research***,** 1-19.

HUNTINGTON, H. P., BEGOSSI, A., GEARHEARD, S. F., KERSEY, B., LORING, P. A., MUSTONEN, T., PAUDEL, P. K., SILVANO, R. A. & VAVE, R. 2017. How small communities respond to environmental change: patterns from tropical to polar ecosystems. *Ecology and Society,* 22.

IDROBO, C. J. & BERKES, F. 2012. Pangnirtung inuit and the Greenland shark: co-producing knowledge of a little discussed species. *Human Ecology,* 40**,** 405-414.

INGOLD, T. 2006. Rethinking the animate, re-animating thought. *Ethnos,* 71**,** 9-20.

INGOLD, T. 2015. *The life of lines,* New York, Routledge.

IPCC 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. In C.B., Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgley, eds. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014a. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014b. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White, eds. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and NY, Cambridge University Press.

IPCC 2014c. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.). Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland.

IPCC 2018a. de Coninck, H., A. Revi, M. Babiker, P. Bertoldi, M. Buckeridge, A. Cartwright, W. Dong, J. Ford, S. Fuss, J.-C. Hourcade, D. Ley, R. Mechler, P. Newman, A. Revokatova, S. Schultz, L. Steg, and T. Sugiyama, 2018: Strengthening and Implementing the Global Response. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [MassonDelmotte,V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

IPCC 2018b. Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/.

IPCC 2019a. Barioni, L.G., T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu, 2019: Food Security (Chapter 5). In: Climate change and land. An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [Contreras, E.M., and A.A. Diouf (eds.)]. In Press.

IPCC 2019b. Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M.

Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.

ISLAM, M. M., SALLU, S., HUBACEK, K. & PAAVOLA, J. 2014. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change,* 14**,** 281-294.

ISRAEL, B. A., SCHULZ, A. J., PARKER, E. A., BECKER, A. B., ALLEN, A. J. & GUZMAN, J. R. 2003. Critical issues in developing and following community based participatory research principles. *Community-based participatory research for health,* 1**,** 53-76.

JACKSON, P. 2001. Making sense of qualitative data. *In:* LIMB, M. & DWYER, C. (eds.) *Qualitative methodologies for geographers: Issues and debates.* London, UK: Arnold.

JANSSEN, M. A. 2007. An update on the scholarly networks on resilience, vulnerability, and adaptation within the human dimensions of global environmental change. *Ecology and Society,* 12**,** 9.

JANSSEN, M. A. & OSTROM, E. 2006. Resilience, vulnerability, and adaptation: A cross-cutting theme of the International Human Dimensions Programme on Global Environmental Change. *Global Environmental Change,* 16**,** 237-239.

JANSSON, A. 1994. *Investing in natural capital: the ecological economics approach to sustainability*, Island Press.

JAYANTHI, M., THIRUMURTHY, S., SAMYNATHAN, M., DURAISAMY, M., MURALIDHAR, M., ASHOKKUMAR, J. & VIJAYAN, K. K. 2018. Shoreline change and potential sea level rise impacts in a climate hazardous location in southeast coast of India. *Environmental Monitoring and Assesment,* 190**,** 50-64.

JEANS, H., CASTILLO, G. E. & THOMAS, S. 2017. Absorb, Adapt, Transform: Resilience capacities. Oxford, UK: Oxfam International.

JENNINGS, S., PASCOE, S., HALL-ASPLAND, S., LE BOUHELLEC, B., NORMAN-LOPEZ, A., SULLIVAN, A. & PECL, G. 2016. Setting objectives for evaluating management adaptation actions to address climate change impacts in south-eastern Australian fisheries. *Fisheries Oceanography,* 25**,** 29-44.

JOHNSON, J., DE YOUNG, C., BAHRI, T., SOTO, D. & VIRAPAT, C. 2019. Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and

Aquaculture, Bangkok, 8–10 August, 2016. FAO Fisheries and Aquaculture Proceedings No. 61. Rome, FAO. 240 pp. Licence: CC BY-NC-SA 3.0 IGO.

JOHNSON, M. 1992. A silent conspiracy?: Some ethical issues of participant observation in nursing research. *International Journal of Nursing Studies,* 29**,** 213-223.

KAISER, K. 2009. Protecting respondent confidentiality in qualitative research. *Qualitative Health Research,* 19**,** 1632-1641.

KAJÁN, E. 2014. Community perceptions to place attachment and tourism development in Finnish Lapland. *Tourism Geographies,* 16**,** 490-511.

KALLBEKKEN, S. & AASEN, M. 2010. The demand for earmarking: Results from a focus group study. *Ecological economics,* 69**,** 2183-2190.

KARLSSON, M. & HOVELSRUD, G. K. 2015. Local collective action: Adaptation to coastal erosion in the Monkey River Village, Belize. *Global Environmental Change,* 32**,** 96-107.

KASPERSON, R. E. & ARCHER, E. R. 2005. Vulnerable Peoples and Places. *Ecosystems and Human Well-Being: Current State and Trends: Findings of the Condition and Trends Working Group,* 1**,** 143.

KAWULICH, B. B. Participant observation as a data collection method. Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 2005.

KEARNS, R. A. 2003. Seeing with Clarity: Understanding Observational Research. *In:* HAY, I. (ed.) *Qualitative research methods in human geography.* Melbourne: Oxford University Press.

KEEN, M., BROWN, V. A. & DYBALL, R. 2005. Social Learning: A New Approach to Environmental Management. *In:* DYBALL, R., BROWN, V. A. & KEEN, M. (eds.) *Social Learning in Environmental Management.* London: Earthscan.

KELMAN, I., GAILLARD, J., LEWIS, J. & MERCER, J. 2016. Learning from the history of disaster vulnerability and resilience research and practice for climate change. *Natural Hazards,* 82**,** 129-143.

KENCH, P., THOMPSON, D., FORD, M., OGAWA, H. & MCLEAN, R. 2015. Coral islands defy sea-level rise over the past century: Records from a central Pacific atoll. *Geology,* 43**,** 515-518.

KESKITALO, E. C. H., DANNEVIG, H., HOVELSRUD, G. K., WEST, J. J. & SWARTLING, Å. G. 2011. Adaptive capacity determinants in developed states: examples from the Nordic countries and Russia. *Regional Environmental Change,* 11**,** 579-592.

KEYS, P. W., GALAZ, V., DYER, M., MATTHEWS, N., FOLKE, C., NYSTRÖM, M. & CORNELL, S. E. 2019. Anthropocene risk. *Nature Sustainability*.

KHAN, F. N., COLLINS, A. M., NAYAK, P. K. & ARMITAGE, D. 2018. Women's perspectives of small-scale fisheries and environmental change in Chilika lagoon, India. *Maritime Studies,* 17**,** 145-154.

KNAPP, C. N. & TRAINOR, S. F. 2013. Adapting science to a warming world. *Global environmental change,* 23**,** 1296-1306.

KOCHO-SCHELLENBERG, J.-E. & BERKES, F. 2015. Tracking the development of co-management: using network analysis in a case from the Canadian Arctic. *Polar Record,* 51**,** 422-431.

KOFINAS, G., CLARK, D., HOVELSRUD, G., ALESSA, L., AMUNDSEN, H., BERMAN, M., BERKES, F., CHAPIN III, F., FORBES, B. & FORD, J. 2013. Adaptive and transformative capacity. *Arctic Council. Arctic Resilience Interim Report. Stockholm Environment Institute and Stockholm Resilience Centre. Stockholm***,** 71-91.

KÖNIG, U. 2018. Climate change and snow tourism in Australia. *Geographica Helvetica,* 54**,** 147-157.

KORALAGAMA, D., GUPTA, J. & POUW, N. 2017. Inclusive development from a gender perspective in small scale fisheries. *Current Opinion in Environmental Sustainability,* 24**,** 1-6.

KRAL, M. J. 2012. Postcolonial suicide among Inuit in arctic Canada. *Culture, medicine, and psychiatry,* 36**,** 306-325.

KRIPPENDORFF, K. 2018. *Content analysis: An introduction to its methodology,* London, Sage publications.

KRUEGER, R. A. & CASEY, M. A. 2014. *Focus groups: A practical guide for applied research,* Singapore, Sage publications.

KRUPNIK, I. & JOLLY, D. (eds.) 2010. *The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change,* Fairbanks, AK: Arctic Research Consortium of the United States.

KUHNLEIN, H. V., ERASMUS, B., SPIGELSKI, D. & BURLINGAME, B. E. 2013. *Indigenous peoples' food systems and well-being: Interventions & policies for healthy communities,* Rome, FAO/CINE.

KULARATNE, M. G., AMARASINGHE, U. S., WATTAGE, P. & DE SILVA, S. S. 2009. Evaluation of community participation for the development of culture-based fisheries in village reservoirs of Sri Lanka. *Aquaculture Economics and Management,* 13**,** 22-38.

KULATILAKE, M., LIYANAGE, H. S. W. A., FERNANDO, W. M. J. R., CHANDRASOMA, J. & DER KNAPP, M. V. 2010. Development of co-management in inland fisheries in Sri Lanka: case studies of Senanayake Samudra and Mahavilachchiya reservoirs. *Aquatic Ecosystem Health & Management,* 13**,** 281-287.

KUMAR, K. 1989. Conducting key informant interviews in developing countries. Agency for International Development Washington DC.

LAIDLER, G. J., DIALLA, A. & JOAMIE, E. 2008. Human geographies of sea ice: freeze/thaw processes around Pangnirtung, Nunavut, Canada. *Polar Record,* 44**,** 335-361.

LAIDLER, G. J., ELEE, P., IKUMMAQ, T., JOAMIE, E. & APORTA, C. 2010. Mapping Inuit sea ice knowledge, use, and change in Nunavut, Canada (Cape Dorset, Igloolik, Pangnirtung). *In:* KRUPNIK I., APORTA C., GEARHEARD S., LAIDLER G. & L., K. H. (eds.) *SIKU: Knowing our ice.* Dordrecht: Springer.

LAIDLER, G. J., FORD, J. D., GOUGH, W. A., IKUMMAQ, T., GAGNON, A. S., KOWAL, S., QRUNNUT, K. & IRNGAUT, C. 2009. Travelling and hunting in a changing Arctic: assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. *Climatic change,* 94**,** 363-397.

LAIDLER, G. J., HIROSE, T., KAPFER, M., IKUMMAQ, T., JOAMIE, E. & ELEE, P. 2011. Evaluating the Floe Edge Service: how well can SAR imagery address Inuit community concerns around sea ice change and travel safety? *The Canadian Geographer/Le Géographe canadien,* 55**,** 91-107.

LAM, V. W., CHEUNG, W. W. & SUMAILA, U. R. 2016. Marine capture fisheries in the Arctic: winners or losers under climate change and ocean acidification? *Fish and Fisheries,* 17**,** 335-357.

LANGE, M. & CONSORTIUM, B. 2003. The Barents Sea impact study (BASIS): methodology and first results. *Continental shelf research,* 23**,** 1673-1694.

LARSEN, J. N. & FONDAHL, G. 2015. Arctic human development report: Regional processes and global linkages. Rosendahls-Schultz Grafisk, Denmark: Nordic Council of Ministers.

LATOUR, B. 2012. *We have never been modern,* Cambridge, Massachusetts, Harvard University Press.

LATOUR, B. 2014. Agency at the Time of the Anthropocene. *New Literary History,* 45**,** 1-18.

LAURIER, E. 2016. Participant and Non-participant Observation. *In:* CLIFFORD, N., COPE, M., FRENCH, S. & GILLESPIE, T. (eds.) *Key methods in Geography.* London: Sage.

LAZARUS, R. S. 1966. *Psychological stress and the coping process,* New York, NY, US, McGraw-Hill.

LE CORRE, M., DUSSAULT, C. & CÔTÉ, S. D. 2017. Weather conditions and variation in timing of spring and fall migrations of migratory caribou. *Journal of Mammalogy,* 98**,** 260-271.

LEACH, M., RAWORTH, K. & ROCKSTRÖM, J. 2013. Between social and planetary boundaries: Navigating pathways in the safe and just space for humanity. *ISSC and UNESCO editors, World social science report 2013, changing global environments.* Paris, France: OECD Publishing and UNESCO Publishing.

LEACH, M., SCOONES, I. & STIRLING, A. 2010. *Dynamic sustainabilities: technology, environment, social justice,* London, UK, Routlsdge.

LEBEL, L. 2013. Local knowledge and adaptation to climate change in natural resource-based societies of the Asia-Pacific. *Mitig. Adapt. Strateg. Glob. Change,* 18**,** 1057-1076.

LEBEL, L., ANDERIES, J. M., CAMPBELL, B., FOLKE, C., HATFIELD-DODDS, S., HUGHES, T. P. & WILSON, J. 2006. Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society,* 11**,** 19.

LEHMAN, J. 2014. Expecting the sea: The nature of uncertainty on Sri Lanka's East coast. *Geoforum,* 52**,** 245-256.

LEHTI, V., NIEMELÄ, S., HOVEN, C., MANDELL, D. & SOURANDER, A. 2009. Mental health, substance use and suicidal behaviour among young indigenous people in the Arctic: a systematic review. *Social Science & Medicine,* 69**,** 1194-1203.

LEI, Y., YUE, Y., ZHOU, H. & YIN, W. 2014. Rethinking the relationships of vulnerability, resilience, and adaptation from a disaster risk perspective. *Natural hazards,* 70**,** 609-627.

LEITE, M., ROSS, H. & BERKES, F. 2019. Interactions between individual, household, and fishing community resilience in southeast Brazil. *Ecology and Society,* 24.

LESNIKOWSKI, A. 2019. *Climate change adaptation policy formulation among local governments: A policy instruments approach.* PhD, McGill University.

LESNIKOWSKI, A., FORD, J., BIESBROEK, R., BERRANG-FORD, L., MAILLET, M., ARAOS, M. & AUSTIN, S. E. 2017. What does the Paris Agreement mean for adaptation? *Climate Policy,* 17**,** 825-831.

LEU, T. C. 2019. Tourism as a livelihood diversification strategy among Sámi indigenous people in northern Sweden. *Acta Borealia,* 36**,** 75-92.

LEVINE, S., LUDI, E. & JONES, L. 2011. Rethinking support for adaptive capacity to climate change. *Oxfam Policy and Practice: Climate Change and Resilience,* 7**,** 49-97.

LICHTENSTEIN, B. B. & PLOWMAN, D. A. 2009. The leadership of emergence: A complex systems leadership theory of emergence at successive organizational levels. *The Leadership Quarterly,* 20**,** 617-630.

LINCOLN, Y. S. & GUBA, E. G. 1985. *Naturalistic inquiry* Thousand Oaks, CA, Sage Publications.

LINDA, S. 2007. Legal and Ethical Issues in Oral History. *In:* CHARLTON, T. L., MYERS, L. E. & SHARPLESS, R. (eds.) *History of Oral History.* New York: Altamira Press.

LIU, J., et al. (2007). "Complexity of coupled human and natural systems." *Science* **317**(5844): 1513-1516.

LOBE, K. & BERKES, F. 2004. The padu system of community-based fisheries management: change and local institutional innovation in south India. *Marine Policy,* 28**,** 271-281.

LONGHURST, R. 2016. Semi-structured Interviews and Focus Group. *In:* CLIFFORD, N., COPE, M., GILLESPIE, T. & FRENCH, S. (eds.) *Key Methods in Geography.* 3 ed. London: Sage.

LORENZEN, K., AINSWORTH, C. H., BAKER, S. M., BARBIERI, L. R., CAMP, E. V., DOTSON, J. R. & LESTER, S. E. 2017. Climate Change Impacts on Florida's Fisheries and Aquaculture Sectors and Options for Adaptation. *Florida's Climate: Changes, Variations, & Impacts*.

LUND, R. 2000. Geographies of eviction, expulsion and marginalization: stories and coping capacities of the Veddhas, Sri Lanka. *Norsk Geografisk Tidsskrift,* 54**,** 102-109.

LYON, C. 2014. Place systems and social resilience: A framework for understanding place in social adaptation, resilience, and transformation. *Society & Natural Resources,* 27**,** 1009-1023.

MACK, N., WOODSONG, C., MACQUEEN, K. M., GUEST, G. & NAMEY, E. 2005. Qualitative research methods: A data collector's field guide. Family Health International.

MAGEE, T. 2013. *A field guide to community based adaptation,* London, Routledge.

MAHON, R., MCCONNEY, P. & ROY, R. N. 2008. Governing fisheries as complex adaptive systems. *Marine Policy,* 32**,** 104-112.

MANOGARAN, C. & PFAFFENBERGER, B. 1996. The Sri Lankan Tamils: Ethnicity and Identity. *Geographical Review,* 86**,** 150-152.

MANSEAU, M., PARLEE, B. & AYLES, B. 2005. A place for traditional ecological knowledge in resource management. *In:* BERKES, F., HUEBERT, R., HELEN, F. & MANSEAU, M., DIDUCK, ALAN (eds.) *Breaking Ice: Renewable resource and ocean management in the Canadian North.* Calgary, Alberta, Canada: Calgary University Press.

MARSCHKE, M. J. & BERKES, F. 2006a. Exploring strategies that build livelihood resilience: a case from Cambodia. *Ecology and Society,* 11**,** 42.

MARSCHKE, M. J. & BERKES, F. 2006b. Exploring strategies that build livelihood resilience: a case from Cambodia. *Ecology and Society,* 11**,** 1-16.

MARSHALL, G. R. 2013. Transaction costs, collective action and adaptation in managing complex social–ecological systems. *Ecological Economics,* 88**,** 185-194.

MARSHALL, N. A., MARSHALL, N., MARSHALL, P., TAMELANDER, J., OBURA, D., MALLERET-KING, D. & CINNER, J. 2010. *A framework for social adaptation to climate change: sustaining tropical coastal communitites [sic] and industries,* Gland, Switzerland, IUCN.

MARTIN-BREEN, P. & ANDERIES, J. M. 2011. Resilience: A literature review.

MARU, Y. T., SMITH, M. S., SPARROW, A., PINHO, P. F. & DUBE, O. P. 2014a. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Global Environmental Change,* 28**,** 337-350.

MARU, Y. T., STAFFORD-SMITH, M., SPARROW, A. & PINHO, P. F. 2014b. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Glob. Environ. Change,* 28**,** 337-350.

MATYAS, D. & PELLING, M. 2015. Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. *Disasters,* 39.

MAYUNGA, J. S. 2007. Understanding and applying the concept of community disaster resilience: a capital-based approach. *Summer academy for social vulnerability and resilience building, Munich, Germany,* 1**,** 16.

MCCLANAHAN, T., ALLISON, E. H. & CINNER, J. E. 2015. Managing fisheries for human and food security. *Fish and Fisheries,* 16**,** 78-103.

MCCUBBIN, S., SMIT, B. & PEARCE, T. 2015. Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu. *Global Environmental Change,* 30**,** 43-55.

MCLAUGHLIN, A. A., DOANE, L. S., COSTIUC, A. L. & FEENY, N. C. 2009. Stress and resilience. *Determinants of minority mental health and wellness.* Springer.

MCLAUGHLIN, P. & DIETZ, T. 2008. Structure, agency and environment: Toward an integrated perspective on vulnerability. *Global Environmental Change,* 18**,** 99-111.

MCPHERSON, J. M., SAMMY, J., SHEPPARD, D. J., MASON, J. J., BRICHIERI-COLOMBI, T. A. & MOEHRENSCHLAGER, A. 2016. Integrating traditional knowledge when it appears to conflict with conservation: lessons from the discovery and protection of sitatunga in Ghana. *Ecology and Society,* 21.

MEES, H. 2017. Local governments in the driving seat? A comparative analysis of public and private responsibilities for adaptation to climate change in European and North-American cities. *Journal of Environmental Policy & Planning,* 19**,** 374-390.

MILLS, J., HARRISON, H., FRANKLIN, R. & BIRKS, M. Case study research: Foundations and methodological orientations. Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 2017. DEU, 17.

MINKLER, M., BLACKWELL, A. G., THOMPSON, M. & TAMIR, H. 2003. Community-based participatory research: implications for public health funding. *American journal of public health,* 93**,** 1210-1213.

MIRZA, M. M. Q. 2003. Climate change and extreme weather events: can developing countries adapt? *Climate policy,* 3**,** 233-248.

MISTRY, J. & BERARDI, A. 2016. Bridging indigenous and scientific knowledge. *Science,* 352**,** 1274-1275.

MONTELLO, D. & SUTTON, P. 2006. *An introduction to scientific research methods in geography,* London, Sage Publications.

MOORE, J. S., LOEWEN, T., HARRIS, L. & TALLMAN, R. 2014. Genetic analysis of sympatric migratory ecotypes of Arctic charr Salvelinus alpinus: alternative mating tactics or reproductively isolated strategies? *Journal of fish biology,* 84**,** 145-162.

MORGAN, D. L. 1996. Focus groups. *Annual review of sociology***,** 129-152.

MOSER, S. 2008. Personality: a new positionality? *Area,* 40**,** 383-392.

MOSS, R. H., MEEHL, G., LEMOS, M. C., SMITH, J., ARNOLD, J., ARNOTT, J., BEHAR, D., BRASSEUR, G. P., BROOMELL, S. & BUSALACCHI, A. 2013. Hell and high water: practice-relevant adaptation science. *Science,* 342**,** 696-698.

MUNOZ, S.-A., STEINER, A. & FARMER, J. 2015. Processes of community-led social enterprise development: learning from the rural context. *Community Development Journal,* 50**,** 478-493.

MUSANTE, K. & DEWALT, B. R. 2010. *Participant observation: A guide for fieldworkers*, Rowman Altamira.

NAKASHIMA, D., GALLOWAY MCLEAN, K. G., THULSTRUP, H., RAMOS CASTILLO, A. & RUBIS, J. T. 2012a. Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation.

NAKASHIMA, D. J., MCLEAN, K. G., THULSTRUP, H., CASTILLO, A. R. & RUBIS, J. 2012b. Weathering uncertainty: traditional knowledge for climate change assessment and adaptation. UNESCO Paris.

NAYAK, P. K. & ARMITAGE, D. 2018. Social-ecological regime shifts (SERS) in coastal systems. *Ocean & Coastal Management,* 161**,** 84-95.

NAYAK, P. K. & BERKES, F. (eds.) 2019. *Interplay between local and global: Change processes and small-scale fisheries (chapter 11),* Cham: Springer.

NELSON, D. R. 2011. Adaptation and resilience: responding to a changing climate. *Wiley Interdisciplinary Reviews: Climate Change,* 2**,** 113-120.

NELSON, D. R., ADGER, W. N. & BROWN, K. 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual review of Environment and Resources,* 32**,** 395.

NELSON, F. E., ANISIMOV, O. A. & SHIKLOMANOV, N. I. 2002. Climate change and hazard zonation in the circum-Arctic permafrost regions. *Natural Hazards,* 26**,** 203-225.

NEW, M., LIVERMAN, D., SCHRODER, H. & ANDERSON, K. 2011. Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences,* 369**,** 6-19.

NGUYEN, K. V. & JAMES, H. 2013. Measuring household resilience to floods: a case study in the Vietnamese Mekong River Delta. *Ecology and Society,* 18.

NGUYEN, H., TRAN, D., LUAN, P., HO, L., LOAN, V., ANH NGOC, P., QUANG, N., WYATT, A. & SEA, W. 2020. Socio-ecological resilience of mangrove-shrimp models under various threats exacerbated from salinity intrusion in coastal area of the Vietnamese Mekong Delta. *International Journal of Sustainable Development & World Ecology***,** 1-14, DOI: 10.1080/13504509.2020.1731859.

NICHOLS, T., BERKES, F., JOLLY, D., SNOW, N. B. & HARBOUR, C. O. S. 2004. Climate change and sea ice: local observations from the Canadian Western Arctic. *Arctic***,** 68-79.

NILSSON, M., GRIGGS, D. & VISBECK, M. 2016. Policy: map the interactions between Sustainable Development Goals. *Nature News,* 534**,** 320.

NUNAN, F., HARA, M. & ONYANGO, P. 2015. Institutions and co-management in East African Inland and Malawi fisheries: a critical perspective. *World Development,* 70**,** 203-214.

O'REILLY, C. M., ALIN, S. R., PLISNIER, P.-D., COHEN, A. S. & MCKEE, B. A. 2003. Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa. *Nature,* 424**,** 766.

O'TOOLE, T. P., AARON, K. F., CHIN, M. H., HOROWITZ, C. & TYSON, F. 2003. Community-based Participatory Research. *Journal of general internal medicine,* 18**,** 592-594.

O'BRIEN, K. 2012. Global environmental change II From adaptation to deliberate transformation. *Progress in Human Geography,* 36**,** 667-676.

O'BRIEN, K., LEICHENKO, R., KELKAR, U., VENEMA, H., AANDAHL, G., TOMPKINS, H., JAVED, A., BHADWAL, S., BARG, S. & NYGAARD, L. 2004. Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global environmental change,* 14**,** 303-313.

OMMER, R. E., PERRY, R. I., MURRAY, G. & NEIS, B. 2012. Social–ecological dynamism, knowledge, and sustainable coastal marine fisheries. *Current Opinion in Environmental Sustainability,* 4**,** 316-322.

ORCHARD, S. E., STRINGER, L. C. & QUINN, C. H. 2015. Impacts of aquaculture on social networks in the mangrove systems of northern Vietnam. *Ocean & Coastal Management,* 114**,** 1-10.

OSBAHR, H., TWYMAN, C., ADGER, W. & THOMAS, D. 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. *Ecology and Society,* 15.

ÖSTERBLOM, H., JOUFFRAY, J.-B., FOLKE, C., CRONA, B., TROELL, M., MERRIE, A. & ROCKSTRÖM, J. 2015. Transnational corporations as 'keystone actors' in marine ecosystems. *PloS one,* 10.

ÖSTERBLOM, H., SISSENWINE, M., SYMES, D., KADIN, M., DAW, T. & FOLKE, C. 2011. Incentives, social–ecological feedbacks and European fisheries. *Marine Policy,* 35**,** 568-574.

OSTROM, E. 1990. *Governing the commons: The evolution of institutions for collective action,* New York, Cambridge University Press.

OSTROM, E. 2014. Collective action and the evolution of social norms. *Journal of Natural Resources Policy Research,* 6**,** 235-252.

OSTROM, O. 2005. Understanding institutional diversity. *Princeton: Princeton University Press,* 17**,** 8.

OVERLAND, J. E., WANG, M., WALSH, J. E. & STROEVE, J. C. 2014. Future Arctic climate changes: Adaptation and mitigation time scales. *Earth's Future,* 2**,** 68-74.

OVIEDO, A. F. & BURSZTYN, M. 2016. The Fortune of the Commons: Participatory Evaluation of Small-Scale Fisheries in the Brazilian Amazon. *Environmental management,* 57**,** 1009-1023.

OVIEDO, A. F., MITRAUD, S., MCGRATH, D. G. & BURSZTYN, M. 2016. Implementing climate variability adaptation at the community level in the Amazon floodplain. *Environmental Science & Policy,* 63**,** 151-160.

PAIN, R. 2004. Social geography: participatory research. *Progress in human geography,* 28**,** 652.

PAPROCKI, K. & CONS, J. 2014. Life in a shrimp zone: aqua-and other cultures of Bangladesh's coastal landscape. *Journal of Peasant Studies,* 41**,** 1109-1130.

PARRY, M., ARNELL, N., HULME, M., NICHOLLS, R. & LIVERMORE, M. 1998. Adapting to the inevitable. *Nature,* 395**,** 741-741.

PATTON, M. Q. 1999. Enhancing the quality and credibility of qualitative analysis. *Health services research,* 34**,** 1189.

PEACOCK, E., TAYLOR, M. K., LAAKE, J. & STIRLING, I. 2013. Population ecology of polar bears in Davis Strait, Canada and Greenland. *The Journal of Wildlife Management,* 77**,** 463-476.

PEARCE, T., FORD, J., WILLOX, A. C. & SMIT, B. 2015. Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic,* 68**,** 233.

PEARCE, T., SMIT, B., DUERDEN, F., FORD, J. D., GOOSE, A. & KATAOYAK, F. 2010. Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. *Polar Record,* 46**,** 157-177.

PELLING, M. 2010. *Adaptation to climate change: from resilience to transformation*, Routledge.

PELLING, M. 2011. *Adaptation to climate change: from resilience to transformation,* London and New York, Routledge.

PELLING, M., HIGH, C., DEARING, J. & SMITH, D. 2008. Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations. *Environment and Planning A,* 40**,** 867-884.

PELLING, M., O'BRIEN, K. & MATYAS, D. 2015. Adaptation and transformation. *Climatic Change,* 133**,** 113-127.

PELLOWE, K. & LESLIE, H. 2019. Heterogeneity among clam harvesters in northwest Mexico shapes individual adaptive capacity. *Ecology and Society,* 24.

PETRESCU, D., PETCOU, C. & BAIBARAC, C. 2016. Co-producing commons-based resilience: lessons from R-Urban. *Building Research & Information,* 44**,** 717-736.

PIELKE, R., PRINS, G., RAYNER, S. & SAREWITZ, D. 2007. Climate change 2007: lifting the taboo on adaptation. *Nature,* 445**,** 597-598.

PIGGOTT-MCKELLAR, A. E., MCNAMARA, K. E., NUNN, P. D. & WATSON, J. E. 2019. What are the barriers to successful community-based climate change adaptation? A review of grey literature. *Local Environment,* 24**,** 374-390.

POOLE, K. G., GUNN, A., PATTERSON, B. R. & DUMOND, M. 2010. Sea ice and migration of the Dolphin and Union caribou herd in the Canadian Arctic: an uncertain future. *Arctic***,** 414-428.

PUSHPALATHA, K. B. C. & CHANDRASOMA, J. 2010. Culture-based fisheries in minor perennial reservoirs in Sri Lanka: variability in production, stocked species and yield implication. *Journal of Applied Ichthyology,* 26**,** 98-103.

RANASINGHE, R. & CHENG, L. 2018. Tourism-induced mobilities and transformation of indigenous cultures: where is the Vedda community in Sri Lanka heading to? *Journal of Tourism and Cultural Change,* 16**,** 521-538.

RANAWEERA, L. 2015. A Case Report: the Coastal Vedda Community Trapped in the Civil War in Sri Lanka, Heritage as Prime Mover in History, Culture and Religion of South and Southeast Asia, Sixth International Conference of the South and Southeast Asian Association for the Study of Culture and Religion (SSEASR), Center for Asian studies of the University of Kelaniya, Sri Lanka. p.50.

REDMAN, C. 2014. Should sustainability and resilience be combined or remain distinct pursuits? *Ecology and Society,* 19.

REED, M., PODESTA, G., FAZEY, I., GEESON, N., HESSEL, R., HUBACEK, K., LETSON, D., NAINGGOLAN, D., PRELL, C. & RICKENBACH, M. 2013. Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. *Ecological Economics,* 94**,** 66-77.

REEDY, D., SAVO, V. & MCCLATCHEY, W. 2014. Traditional Climatic Knowledge: Orchardists' perceptions of and adaptation to climate change in the Campania region (Southern Italy). *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology,* 148**,** 699-712.

REYER, C. P., BROUWERS, N., RAMMIG, A., BROOK, B. W., EPILA, J., GRANT, R. F., HOLMGREN, M., LANGERWISCH, F., LEUZINGER, S. & LUCHT, W. 2015. Forest resilience and tipping points at different spatio-temporal scales: approaches and challenges. *Journal of Ecology,* 103**,** 5-15.

RIHOUX, B. 2006. Qualitative comparative analysis (QCA) and related systematic comparative methods recent advances and remaining challenges for social science research. *International Sociology,* 21**,** 679-706.

RITCHIE, D. A. 2014. *Doing oral history,* New York, Oxford University Press.

RIVAL, L. 2009. The resilience of indigenous intelligence. *In:* HASTRUP, K. (ed.) *The question of resilience: social responser to climate change.* Copenhagen: The Royal Danish Academy of Sciences and Letters.

ROBINSON, L. W. & BERKES, F. 2011. Multi-level participation for building adaptive capacity: Formal agency-community interactions in northern Kenya. *Global Environmental Change,* 21**,** 1185-1194.

RODRÍGUEZ, M. V., DAVIDSON-HUNT, I. & BERKES, F. 2019. Social-ecological memory and responses to biodiversity change in a Bribri Community of Costa Rica. *Ambio-Biodiversity Change and Human Adaptation***,** 1-12.

ROSE, G. 1997. Situating knowledges: positionality, reflexivities and other tactics. *Progress in human geography,* 21**,** 305-320.

ROSEGRANT, M. W., DEY, M. M., VALMONTE-SANTOS, R. & CHEN, O. L. 2016. Economic impacts of climate change and climate change adaptation strategies in Vanuatu and Timor-Leste. *Marine Policy,* 67**,** 179-188.

ROUX, M.-J., TALLMAN, R. F. & MARTIN, Z. A. 2018. Small-scale fisheries in Canada's Arctic: Combining science and fishers knowledge towards sustainable management. *Marine Policy,* xxx**,** xxx-xxx.

RUIZ-CASTELL, M., MUCKLE, G., DEWAILLY, É., JACOBSON, J. L., JACOBSON, S. W., AYOTTE, P. & RIVA, M. 2015. Household crowding and food insecurity among Inuit families with school-aged children in the Canadian Arctic. *American Journal of Public Health,* 105**,** e122-e132.

SALAS, S., BARRAGÁN-PALADINES, M. J. & CHUENPAGDEE, R. 2018. *Viability and Sustainability of Small-Scale Fisheries in Latin America and The Caribbean,* London, Springer.

SANTIAPILLAI, C., WIJEYAMOHAN, S., BANDARA, G., ATHURUPANA, R., DISSANAYAKE, N. & READ, B. 2010. An assessment of the human-elephant conflict in Sri Lanka. *Ceylon Journal of Science (Biological Sciences),* 39.

SAVO, V., MORTON, C. & LEPOFSKY, D. 2017. Impacts of climate change for coastal fishers and implications for fisheries. *Fish and Fisheries,* 18**,** 877-889.

SCANNELL, L. & GIFFORD, R. 2010. Defining place attachment: A tripartite organizing framework. *Journal of environmental psychology,* 30**,** 1-10.

SCHIPPER, E. L. F., AYERS, J., REID, H., HUQ, S. & RAHMAN, A. (eds.) 2014. *Community-based adaptation to climate change: scaling it up,* London: Routledge.

SCHMITT, K., ALBERS, T., PHAM, T. & DINH, S. 2013. Site-specific and integrated adaptation to climate change in the coastal mangrove zone of Soc Trang Province, Viet Nam. *Journal of Coastal Conservation,* 17**,** 545-558.

SCHROEDER, D. & GEFENAS, E. 2009. Vulnerability: Too vague and too broad? *Cambridge Quarterly of Healthcare Ethics,* 18**,** 113-121.

SCOONES, I. 1998a. Sustainable rural livelihoods: a framework for analysis. *IDS working paper* 72.

SCOONES, I. 1998b. Sustainable rural livelihoods: a framework for analysis. *IDS Working Paper 72.* Sussex, UK: Institute of Development Studies.

SCREEN, J. A. & SIMMONDS, I. 2010. The central role of diminishing sea ice in recent Arctic temperature amplification. *Nature,* 464**,** 1334.

SEGGEL, A. & DE YOUNG, C. 2016. Climate change implications for fisheries and aquaculture: summery of the findings of the Intergovernmental Panal on Climate Change fifth assessment report. *FAO Fisheries and aquaculture technical paper.* Rome: Food and Agriculture Organization of the United Nations.

SELIGMANN, C. G. & SELIGMANN, B. (eds.) 1911. *The veddas,* Cambridge: Cambridge University Press.

SELIM, S. A., BLANCHARD, J. L., BEDFORD, J. & WEBB, T. J. 2016. Direct and indirect effects of climate and fishing on changes in coastal ecosystem services: a historical perspective from the North Sea. *Regional Environmental Change,* 16**,** 341-351.

SHERMAN, M., BERRANG-FORD, L., LWASA, S., FORD, J., NAMANYA, D. B., LLANOS-CUENTAS, A., MAILLET, M. & HARPER, S. 2016. Drawing the line between adaptation and development: a systematic literature review of planned adaptation in developing countries. *Wiley Interdisciplinary Reviews: Climate Change,* 7**,** 707-726.

SHORT, N., LEBLANC, A. M., SLADEN, W. E., CARBONNEAU, A. S. & ALLARD, M. 2011. Seasonal Surface Displacement Derived from InSAR, Pangnirtung, Nunavut; Geological Survey of Canada, Canadian Geoscience Map 67, 2012; 1 sheet; 1 CD-ROM, doi: 10.4095/289607.

SHYAM, S. S., SHRIDHAR, N. & FERNANDEZ, R. 2017. Climate change and need for proactive policy initiatives in Indian marine fisheries sector. *Climate Change,* 3**,** 20-37.

SIMONOVIC, S. P. 2017. Adaptation to climate change: risk management. *In:* KOLOKYTHA, E., OISHI, S. & TEEGAVARAPU, R. S. V. (eds.) *Sustainable Water Resources Planning and Management Under Climate Change.* Singapore: Springer.

SINGH, S. J. 2009. Complex Disasters: The Nicobar Islands in the Grip of Humanitarian Aiod. *Geographische Rundschau International Edition,* 5**,** 48-56.

SMIT, B., BURTON, I., KLEIN, R. J. & STREET, R. 1999. The science of adaptation: a framework for assessment. *Mitigation and adaptation strategies for global change,* 4**,** 199-213.

SMIT, B., BURTON, I., KLEIN, R. J. & WANDEL, J. 2000. An anatomy of adaptation to climate change and variability. *Climatic change,* 45**,** 223-251.

SMIT, B. & WANDEL, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global environmental change,* 16**,** 282-292.

SMITH, A. & STIRLING, A. 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society,* 15.

SMITH, H. & BASURTO, X. 2019. Defining small-scale fisheries and examining the role of science in shaping perceptions of who and what counts: A systematic review. *Frontiers in Marine Science,* 6**,** 236.

SOFAER, S. 2002. Qualitative research methods. *International Journal for Quality in Health Care,Oxford Journals,* 14**,** 329–336.

SPEERS, A. E., BESEDIN, E. Y., PALARDY, J. E. & MOORE, C. 2016. Impacts of climate change and ocean acidification on coral reef fisheries: an integrated ecological–economic model. *Ecological economics,* 128**,** 33-43.

SPINNEY, J. A. 2010. *Perceptions of Vulnerability to" severe" Weatehr in Pangnirtung, Nunavut.* School of Graduate and Postdoctoral Studies, University of Western Ontario.

STOJANOVIC, T., MCNAE, H. M., TETT, P., POTTS, T. W., REIS, J., SMITH, H. D. & DILLINGHAM, I. 2016. The “social” aspect of social-ecological systems: a critique of analytical frameworks and findings from a multisite study of coastal sustainability. *Ecology and Society,* 21.

STOKOLS, D., LEJANO, R. & HIPP, J. 2013. Enhancing the resilience of human–environment systems: A social ecological perspective. *Ecology and Society,* 18.

STRAUSS, A. & CORBIN, J. 1990. *Basic of Grounded Theory Methods,* Thousand Oaks, CA: Sage.

STRAUSS, A. L. 1987. *Qualitative analysis for social scientists,* Cambridge, NY, Cambridge University Press.

STRUNZ, S. 2012. Is conceptual vagueness an asset? Arguments from philosophy of science applied to the concept of resilience. *Ecological Economics,* 76**,** 112-118.

SUMAILA, U. R., CHEUNG, W. W., LAM, V. W., PAULY, D. & HERRICK, S. 2011. Climate change impacts on the biophysics and economics of world fisheries. *Nature climate change,* 1**,** 449.

TALEB, N. N. 2007. *The black swan: The impact of the highly improbable,* US, Random House.

TALEB, N. N. 2012. *Antifragile: Things that gain from disorder,* New York, Random House Incorporated.

TANNER, T., LEWIS, D., WRATHALL, D., BRONEN, R., CRADOCK-HENRY, N., HUQ, S., LAWLESS, C., NAWROTZKI, R., PRASAD, V. & RAHMAN, M. A. 2015. Livelihood resilience in the face of climate change. *Nature Climate Change,* 5**,** 23-26.

TAYLOR, G. & BLAKE, B. J. 2015. Key informant interviews and focus groups. *In:* CHESNAY, M. D. (ed.) *Nursing research using data analysis: Qualitative designs and methods in nursing.* NY: Springer.

TENGÖ, M., HILL, R., MALMER, P., RAYMOND, C. M., SPIERENBURG, M., DANIELSEN, F., ELMQVIST, T. & FOLKE, C. 2017. Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. *Current Opinion in Environmental Sustainability,* 26**,** 17-25.

TERMEER, C. J., DEWULF, A. & BIESBROEK, G. R. 2016. Transformational change: governance interventions for climate change adaptation from a continuous change perspective. *Journal of Environmental Planning and Management***,** 1-19.

TRUELOVE, H. B., CARRICO, A. R. & THABREW, L. 2015. A socio-psychological model for analyzing climate change adaptation: A case study of Sri Lankan paddy farmers. *Global Environmental Change,* 31**,** 85-97.

TSCHAKERT, P., DIETRICH, K., TAMMINGA, K., PRINS, E., SHAFFER, J., LIWENGA, E. & ASIEDU, A. 2014. Learning and envisioning under climatic uncertainty: an African experience. *Environment and Planning A,* 46**,** 1049-1068.

TSCHAKERT, P., ELLIS, N., ANDERSON, C., KELLY, A. & OBENG, J. 2019. One thousand ways to experience loss: A systematic analysis of climate-related intangible harm from around the world. *Global Environmental Change,* 55**,** 58-72.

TURNER, B. L., KASPERSON, R. E., MATSON, P. A., MCCARTHY, J. J., CORELL, R. W., CHRISTENSEN, L., ECKLEY, N., KASPERSON, J. X., LUERS, A. & MARTELLO, M. L. 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the national academy of sciences,* 100**,** 8074-8079.

TURNER II, B. 2010. Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science? *Global Environmental Change,* 20**,** 570-576.

TURNER, S. & COEN, S. E. 2008. Member checking in human geography: interpreting divergent understandings of performativity in a student space. *Area,* 40**,** 184-193.

VAISMORADI, M., JONES, J., TURUNEN, H. & SNELGROVE, S. 2016. Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice,* 6**,** 100-110.

VAN DIJK, T. A. 2015. Critical discourse analysis. *In:* TANNEN, D., HAMILTON, H. E. & SCHIFFRIN, D. (eds.) *The handbook of discourse analysis.* New Delhi, India: John Wiley & Sons, Inc.

VAN LEEUWEN, T. 2015. Critical discourse analysis. *The International Encyclopedia of Language and Social Interaction*, 1-7.

VAN NES, E. H., ARANI, B. M., STAAL, A., VAN DER BOLT, B., FLORES, B. M., BATHIANY, S. & SCHEFFER, M. 2016. What Do You Mean,'Tipping Point'? *Trends in Ecology & Evolution,* 31, 902-904.

VAN PUTTEN, I., METCALF, S., FRUSHER, S., MARSHALL, N. & TULL, M. 2014. Fishing for the impacts of climate change in the marine sector: a case study. *International Journal of Climate Change Strategies and Management,* 6, 421-441.

VISWANATHAN, M., AMMERMAN, A., ENG, E., GARLEHNER, G., LOHR, K. N., GRIFFITH, D., RHODES, S., SAMUEL-HODGE, C., MATY, S. & LUX, L. 2004. Community-based participatory research: Assessing the evidence: Summary. Evidence-based practice center, north-Carolina.

VOSS, R., QUAAS, M. F., SCHMIDT, J. O. & KAPAUN, U. 2015. Ocean acidification may aggravate social-ecological trade-offs in coastal fisheries. *PloS one,* 10, 1-8.

WALKER, B., CARPENTER, S., ANDERIES, J., ABEL, N., CUMMING, G., JANSSEN, M., LEBEL, L., NORBERG, J., PETERSON, G. D. & PRITCHARD, R. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation ecology,* 6, 14.

WALKER, B., GUNDERSON, L., KINZIG, A., FOLKE, C., CARPENTER, S. & SCHULTZ, L. 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and society,* 11, 13.

WALKER, B., HOLLING, C. S., CARPENTER, S. R. & KINZIG, A. 2004. Resilience, adaptability and transformability in social--ecological systems. *Ecology and society,* 9, 5.

WALKER, B. & SALT, D. 2006. *Resilience thinking: sustaining ecosystems and people in a changing world,* Washington, DC, Island Press.

WALLERSTEIN, N. B. & DURAN, B. 2006. Using community-based participatory research to address health disparities. *Health promotion practice,* 7, 312-323.

WATSON, R. T., ZINYOWERA, M. C., MOSS, R. H. & DOKKEN, D. J. 1998. The regional impacts of climate change: an assesment of vulnerability, A Special Report of IPCC Working Group II. Cambridge: IPCC.

WESTLEY, F., OLSSON, P., FOLKE, C., HOMER-DIXON, T., VREDENBURG, H., LOORBACH, D., THOMPSON, J., NILSSON, M., LAMBIN, E. & SENDZIMIR, J. 2011. Tipping toward sustainability: emerging pathways of transformation. *AMBIO: A Journal of the Human Environment,* 40**,** 762-780.

WHEELER, T. & VON BRAUN, J. 2013. Climate change impacts on global food security. *Science,* 341**,** 508-513.

WIJENAYAKE, W. H. H. K., AMARASIGHE, U. S. & DE SILVA, S. S. 2016. Application of a multiple-criteria decision making approach for selecting non-perennial reservoirs for culture-based fishery development: Case study from Sri Lanka. *Aquaculture,* 459**,** 26-35.

WILLIAMS, D. R. & PATTERSON, M. E. 2008. Place, leisure, and well-being. *In:* EYLES, J. & WILLIAMS, A. (eds.) *Sense of place, health and quality of life.* Surrey, UK: Ashgate.

WODAK, R. & MEYER, M. 2015. *Methods of critical discourse studies,* London, Sage.

YAHYA SALIMI, Y., SHAHANDEH, K., MALEKAFZALI, H., LOORI, N., KHEILTASH, A., JAMSHIDI, E., FROUZAN, A. S. & MAJDZADEH, R. 2012. Is Community-based Participatory Research (CBPR) Useful? A Systematic Review on Papers in a Decade. *International Journal of Preventive Medicine,* 3**,** 386–393.

YAMADA, S., GUNATILAKE, R. P., ROYTMAN, T. M., GUNATILAKE, S., FERNANDO, T. & FERNANDO, L. 2006. The Sri Lanka tsunami experience. *Disaster Management & Response,* 4**,** 38-48.

YAMANE, A. Rethinking vulnerability to climate change in Sri Lanka. 9th International conference on Sri Lanka Studies, 28th–30th November, 2003.

YIN, R. K. 2013. *Case study research: Design and methods,* New York, Sage publications.

YIN, R. K. 2014. *Case study research: Design and methods,* New York, Sage publications.

YOW, V. R. 2014. *Recording oral history: A guide for the humanities and social sciences,* New York, Rowman & Littlefield.

ZAVALETA, C., BERRANG-FORD, L., FORD, J., LLANOS-CUENTAS, A., CÁRCAMO, C., ROSS, N. A., LANCHA, G., SHERMAN, M. & HARPER, S. L. 2018. Multiple non-climatic drivers of food insecurity reinforce climate change maladaptation trajectories among Peruvian Indigenous Shawi in the Amazon. *PloS one,* 13**,** e0205714.

ZIKMUND, W. G. 2003. *Business research methods,* New Delhi, South-western cengage learning.

ZOYSA, S. R. 2018. *Fishing, Mobility and Settlerhood, Coastal Socialites in Postwar Sri Lanka,* MARE Publication Series 20, Springer international Publishing AG, part of Springer Nature.

Appendix A

Supplemental material for Chapter 2

Section A1: Key mismatches and complementarities

Development resilience began with the intention of a political and institutional challenge focusing on reconciling development and humanitarian orientations (Bousquet et al., 2016). For instance, development resilience is defined as the "capacity over time of a person, household or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks. If and only if that capacity is and remains high over time, then the unit is resilient" (Barrett and Constas, 2014: 14626). Barrett and Constas propose a human development trajectory (nonlinear curve) that crosses thresholds of three zones of poverty: the non-poor zone, chronic poverty zone and humanitarian emergency zone (where most attention is needed) (Figure: section A2). Common to both areas are unique challenges, such as poverty, inequality and unsustainable social-ecological systems pathways that can pose a threat to human welfare and global sustainability (Béné et al., 2015). Many scholars have recognized that the stimulation of these domains can create useful outcomes for addressing common challenges such as food security, chronic poverty, climate change, and human and environmental health at a global to local scale (Béné et al., 2014, Bousquet et al., 2016, Brown, 2016). Development research is concerned about the most vulnerable groups and their interactions with natural resources, which allows for more relations with social-ecological systems resilience (Barrett and Constas, 2014).

Social-ecological systems resilience contributions to development concerns begin with a systemic approach focusing on complexities and the dynamic nature of interlinked social-ecological systems, including the role of specific actors and institutions (Berkes et al., 2003). Social-ecological systems resilience also focuses on trajectories with the theoretical contribution of the 'adaptive cycle' and 'panarchy' (more details: section A3) (Gunderson and Holling, 2002, Berkes and Ross, 2016). The scale of human activities includes the speed, spread and connectivity of globalization that brings extra complexity to social-ecological systems (Homer-Dixon et al., 2015). This interconnectedness of humans in the globalized modern society can, at different levels, circulate and cascade across countries and regions (Österblom et al., 2015, Folke, 2016). In this context, the objective of the trajectories in social-ecological systems resilience is to identify the 'safe and just' pathways for social-ecological systems, not to breach ecosystem boundaries (an unsafe pathway) or undermine human rights (an unjust pathway) (Leach et al., 2013).

As described, both schools of resilience look at trajectories of change, aiming their corresponding interests inherent to each domain. SES resilience promotes viable trajectories within SES boundaries, while, in contrast, development resilience is committed to promoting positive trajectories for the wellbeing of the most vulnerable. Furthermore, development resilience is aimed primarily at the household level and not commonly at other levels, such as social and economic groups or the SES level (Bousquet et al., 2016).

Resilience thinking and development studies share multiple common interests. Bousquet et al. (2016) describe the multiple convergences of these two schools of resilience. First is the importance of diversity as a means of improving resilience as well as maintaining institutional robustness in a human development setting (Ostrom, 2005). Second is a dynamic perspective that focuses on trajectories to analyze attributes such as endowment, capital and capacities (Walker and Salt, 2006, Barrett and Constas, 2014). Third are tipping points along the trajectories and traps, occurring when the tipping point cannot be crossed (van Nes et al., 2016). Fourth is the importance of social capital, for example, for conservation, development or postdisaster recovery (Aldrich and Meyer, 2015). Fifth is the importance of learning as a meeting point for SES and development resilience domains (Bousquet et al., 2016).

The notion of resilience has been criticized by many scholars, including the authors of development studies (Smith and Stirling, 2010, Brown and Westaway, 2011, Hatt, 2013, Brown, 2014, Redman, 2014, 2016). First, resilience rarely addresses the question of "resilience for whom?" Carpenter et al. (2001) raise this question by comparing selected resilience properties in lake districts and rangelands SES. Second, the prevailing understanding of resilience focuses on the persistence of the system by maintaining the status quo (Brown, 2014). This understanding reinforces existing power relationships and structures without aiming to address root causes. Third, the systems approach underplays the internal or endogenous drivers, so it focuses on a system which is disturbed by external or exogenous drivers (Brown, 2016).

Fourth, resilience thinking is commonly criticized for its failure to account for power and politics. Beymer-Farris et al. (2012) describe two common assumptions in resilience studies: a) in considering resilience as an outcome of the action, much of the SES literature assumes there is consensus on the 'desired state.', b) resilience is identified as a process for overlooking conflicts over resources and power asymmetries. Based on this, Brown (2014) argues that resilience studies have not sufficiently considered whose needs must be met and the politics of their distribution and management, focusing instead on the management of ecosystem services for human well-being and development. Furthermore, she points out that "resilience is depoliticized and does not take account of the institutions within which practices and management are embedded" (Brown, 2014: 3).

Fifth, resilience is criticized for aiming for short-term stability rather than long-term sustainability (Smith and Stirling, 2010, Brown, 2016). Sustainability is also considered a concept with multiple meanings and interpretations, and both sustainability and resilience are criticized for leading to technical solutions, downplaying the social and political (Redman, 2014).

Sixth, there has been criticism of the way in which resilience ideas are transferred from the systems perspective and the natural sciences to the social science context (Brown, 2014). Hatt (2013) highlights the lack of integration of social science ideas into this transference. Cote and Nightingale (2012: 475) oppose the idea that the resilience in SES "evolved through the application of ecological concepts to society assuming that social and ecological system dynamics are essentially similar."

Finally, there are some general critiques, such as that the resilience field was dominated by a small network of schoolers—discursive dominance (Brown, 2016). Furthermore, the concept is vague and normative (Strunz, 2012), for instance, possessing a lack of disinsertion between resilience and adaptive capacity (Smit and Wandel, 2006). Moreover, in some literature, vulnerability is considered an antonym of resilience (Lei et al., 2014). Some of these criticisms of resilience not only highlight the mismatches among resilience and development studies, but also allow 'resilience' to co-evolve by opening opportunities for collaboration.

Section A2: Development resilience theory

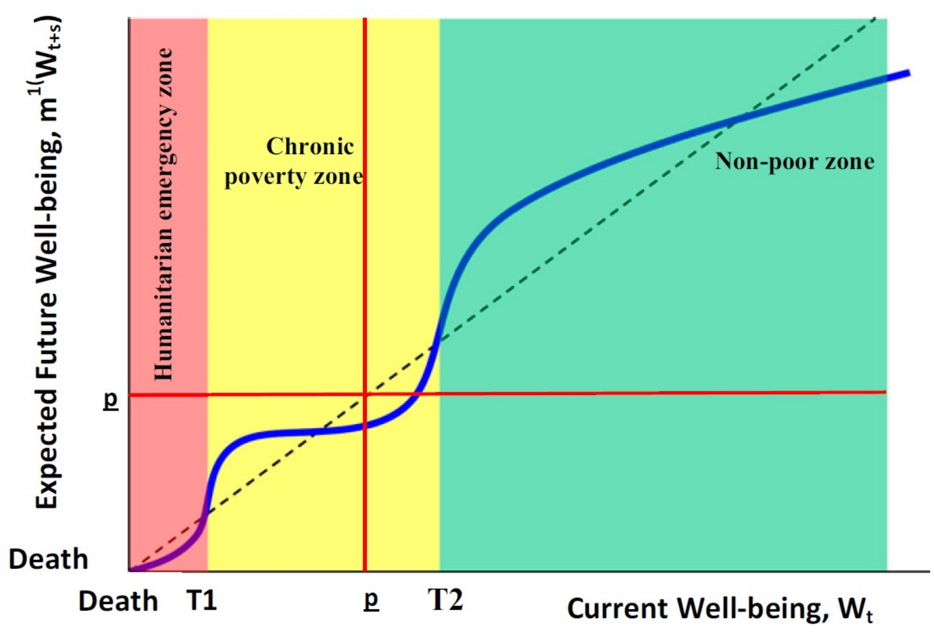


Figure Appendix B: Nonlinear expected well-being dynamics with multiple stable states.
Source: Barrett and Constas (2014: 14626)

Section A3: Adaptive cycle and Panarchy

The adaptive cycle and panarchy are core concepts developed from ecological studies of resilience (Gunderson and Holling, 2002). This concept contrasts with more linear versions of development and has being applied in the more interdisciplinary analysis of SES (Berkes et al., 2003, Bousquet et al., 2016, Brown, 2016). "Adaptive cycle is a way of describing the progression of a social-ecological system through various stages of organization and function" (Brown, 2016: 74). The adaptive cycle involves assumptions and is derived from empirical research on the dynamics of ecosystems; it focuses on the process of destruction and reorganization, which are often neglected for growth and conservation, and provides a more comprehensive understanding of complex system dynamics (Gunderson and Holling, 2002). The system evolves along a trajectory; its state progresses through various speeds through different phases of growth, release and reorganization (Walker and Salt, 2006, Bousquet et al., 2016). Four distinct phases have been identified: 1). growth or exploitation (r), 2). conservation (K), 3). collapse or release (omega: Ὠ) and 4). reorganization (alpha: α). Bousquet et al. (2016) propose the adaptive cycle as a fundamental unit to understand complex systems, from cell to ecosystems to societies. Details about the adaptive cycle are well-documented in many publications (Gunderson and Holling, 2002, Berkes et al., 2003: 16, Walker and Salt, 2006: 74, Bousquet et al., 2016: 5, Brown, 2016: 73).

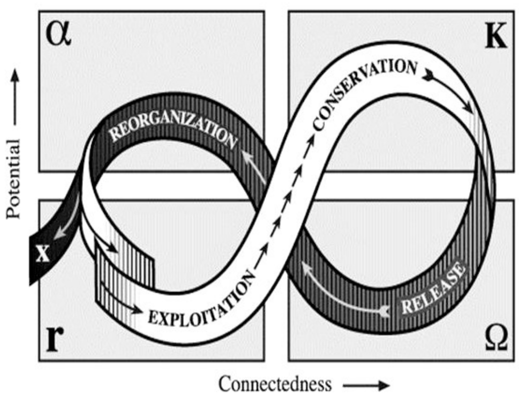


Figure Appendix C: Adaptive cycle
Source: http://www.resalliance.org/adaptive-cycle

The idea of panarchy is drawn from the concept of the adaptive cycle (Berkes and Ross, 2016). SES have multiple stable states rather than single equilibrium and structures and functions that cover a wide range of scales (for example, temporal and spatial) (Walker and Salt, 2006, Brown, 2016). These structures and processes are linked across scale and can occur both top-down and bottom-up, making it difficult to understand the dynamics of change happening in one level or scale without considering the other scales or levels (Brown, 2016). Panarchy is a cross-scale, nested set of adaptive cycles (Gunderson and Holling, 2002, Garmestani et al., 2009, Berkes and Ross, 2016, Brown, 2016). Popular illustrations of panarchy consist of three levels: large and slow, intermediate size and speed, and small and fast; two important connections are 'revolt' and 'remember' (Brown, 2016: 76).

> *"Where fast and small events […] overwhelm slow and large ones, as in the spread of a fire from the ground to the crown of a tree and then to a whole stand of trees, such a feedback is referred to as "revolt"….."Remember" is the opposite of "revolt", a feedback from larger and slower levels downward to smaller and faster levels, indicating a stabilizing function."* (Berkes and Ross, 2016: 187).

Section A4: Results dissemination

Method	Description
Scientific publications	***Published*** Galappaththi, E.K., Ford, D.J., Bennett, E.M. (2020). Climate change and adaptation to social-ecological change: The case of Indigenous people and culture-based fisheries in Sri Lanka. Climatic Change (published online: https://doi.org/10.1007/s10584-020-02716-3). Galappaththi, E.K., Ford, J., Bennett, E., Berkes, F. 2019. Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada. *Journal of Environmental Management,* 250 (109534): 1-11. Galappaththi, E.K., Ford, J., Bennett, E. 2019. A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy,* 92, 17-26. ***Upcoming*** Galappaththi, E.K., Ford, J., Bennett, E., Berkes, F. Adapting to climate change in small-scale fisheries: Insights from indigenous communities in the global north and south.
Research posters	Can an Arctic turbot fishery adapt to climate change? An empirical study from the Pangnirtung coastal community in Baffin Island, Nunavut, Canada. ArcticNet Annual Scientific Meeting, Ottawa, Canada (2018). How do Inuit fishers experience and respond to climate change? Empirical evidence from the Pangnirtung community in Nunavut, Canada. Arctic Change, ArcticNet Annual Scientific Meeting, Quebec City, Canada (2017).
Talks and presentations	***Presentations*** Adapting to climate change in small-scale fisheries: Insights from indigenous communities in the global north and south, 4th Annual McGill Northern Research Day; Highlighting Early Career Researchers Leadership, 2020 Adapting to climate change in small-scale fisheries: Insights from indigenous communities in the global north and south, Center on Food Security and the Environment (FSE), Stanford University, 2019. Opportunities for climate change adaptation: comparative research on Indigenous fisher communities in the Canadian Arctic and Eastern Sri Lanka, How the McGill Northern Engagement Grant (MNEG) help my research and the community? McGill North engagement grant presentations, 3rd Annual McGill Northern Research Day; Highlighting Early Career Researchers Leadership, 2019 How do Coastal Vedda fishers experience and respond to climate change? Empirical evidence from the Eastern Sri Lanka. 3rd World Small-Scale Fisheries Congress, Chiang Mai, Thailand, 2018 Opportunities for adaptation: Case studies from the Canadian Arctic and Eastern Sri Lanka indigenous fisheries. 5th Asia-Pacific Climate Change Adaptation Forum, Adapting and Living under 2°C: Bridging Gaps in Policy and Practice, Colombo, Sri Lanka, 2016 ***Talks***

	Title: Indigenous fishing communities' adaptation to climate change Place: Stanford University, California, 2019 Audience: 100 undergraduate students studying 'Human Society and Environmental Change' lecture series (ES112) Title: Indigenous adaptations to climate change in marine social-ecological systems Place: Center for Ocean Solutions (COS), Stanford University, 2019 Audience: COS team Title: Can an Arctic turbot fishery adapt to climate change? An empirical study from the Pangnirtung coastal community in Baffin Island, Nunavut, Canada Place: Pangnirtung, Nunavut, Canada, 2019 Audience: Inuit community members Title: How do Inuit fishers experience and respond to climate change? Empirical evidence from the Pangnirtung community in Nunavut, Canada. Place: Pangnirtung, Nunavut, Canada, 2018 Audience: Inuit community members
Media and newspapers	***Magazine article*** Resilience in the Arctic: facing the future, *The Circle*, The WWF Arctic Program, 4, 2019 Title: Following the fish: Climate change and community fisheries in the Arctic https://indd.adobe.com/view/6455bdc8-97b1-41cb-b0e6-a80c1a5c9fff ***Newspaper articles*** Climate change and indigenous people in the Canadian Arctic *The Island*, June 20, 2018 http://www.island.lk/userfiles/image/2018/06/20/climate.jpg *Sunday Observer*, June 24, 2018, P.72 http://epaper.sundayobserver.lk/?id=72&tday=2018/06/2 *Divaina*, June 17, 2018, P.12 http://epaper.dinamina.lk/art.asp?id=2018/06/21/pg30_0&pt=p&h= *Dinamina*, June 21, 2018, P.30 http://archives.dinamina.lk/epaper/?id=30&tday=2018/06/21
Local discussion groups	Throughout the research in both Inuit and Coastal-Vedda communities, various informal discussion groups were organized (in addition to focus group discussions). The discussion groups aimed to create a dialog and thoughtful discussion among the community about the importance of adaptation to change and (adaptive) capacity-building based on the study results. I organized 13 discussion groups in the Inuit community and 19 discussion groups in the Coastal-Vedda community. Participants ranged from 2-5 per group and consisted of community and local organization leaders, youth, and fisherwomen.

Reference cited:

ALDRICH, D. P. & MEYER, M. A. 2015. Social capital and community resilience. *American Behavioral Scientist,* 59**,** 254-269.
BARRETT, C. B. & CONSTAS, M. A. 2014. Toward a theory of resilience for international development applications. *Proceedings of the National Academy of Sciences,* 111**,** 14625-14630.

BÉNÉ, C., BARANGE, M., SUBASINGHE, R., PINSTRUP-ANDERSEN, P., MERINO, G., HEMRE, G.-I. & WILLIAMS, M. 2015. Feeding 9 billion by 2050–Putting fish back on the menu. *Food Security,* 7**,** 261-274.

BÉNÉ, C., NEWSHAM, A., DAVIES, M., ULRICHS, M. & GODFREY-WOOD, R. 2014. Review article: resilience, poverty and development. *Journal of International Development,* 26**,** 598-623.

BERKES, F., COLDING, J. & FOLKE, C. (eds.) 2003. *Navigating social-ecological systems: building resilience for complexity and change,* New York: Cambridge University Press.

BERKES, F. & ROSS, H. 2016. Panarchy and community resilience: Sustainability science and policy implications. *Environmental Science & Policy,* 61**,** 185-193.

BEYMER-FARRIS, B. A., BASSETT, T. J. & BRYCESON, I. 2012. Promises and pitfalls of adaptive management in resilience thinking: the lens of political ecology. *In:* PLIENINGER, T. & BIELING, C. (eds.) *Resilience and the cultural landscape.* Cambridge: Cambridge University Press.

BOUSQUET, F., BOTTA, A., ALINOVI, L., BARRETEAU, O., BOSSIO, D., BROWN, K., CARON, P., D'ERRICO, M., DECLERCK, F. & DESSARD, H. 2016. Resilience and development: mobilizing for transformation. *Ecology and Society,* 21.

BROWN, K. 2014. Global environmental change IA social turn for resilience? *Progress in Human Geography,* 38**,** 107-117.

BROWN, K. 2016. *Resilience, development and global change,* New York, Routledge.

BROWN, K. & WESTAWAY, E. 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual review of environment and resources,* 36**,** 321-342.

CARPENTER, S., WALKER, B., ANDERIES, J. M. & ABEL, N. 2001. From metaphor to measurement: resilience of what to what? *Ecosystems,* 4**,** 765-781.

COTE, M. & NIGHTINGALE, A. J. 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Progress in Human Geography,* 36**,** 475-489.

FOLKE, C. 2016. Resilience (Republished). *Ecology and Society,* 21**,** 44.

GARMESTANI, A., ALLEN, C. & GUNDERSON, L. 2009. Panarchy: discontinuities reveal similarities in the dynamic system structure of ecological and social systems. *Ecology and Society,* 14.

GUNDERSON, L. H. & HOLLING, C. S. (eds.) 2002. *Panarchy: understanding transformations in human and natural systems,* Washington: Island press.

HATT, K. 2013. Social attractors: a proposal to enhance "resilience thinking" about the social. *Society & Natural Resources,* 26**,** 30-43.

HOMER-DIXON, T., WALKER, B., BIGGS, R., CRÉPIN, A.-S., FOLKE, C., LAMBIN, E., PETERSON, G., ROCKSTRÖM, J., SCHEFFER, M. & STEFFEN, W. 2015. Synchronous failure: the emerging causal architecture of global crisis. *Ecology and Society,* 20.

LEACH, M., RAWORTH, K. & ROCKSTRÖM, J. 2013. Between social and planetary boundaries: Navigating pathways in the safe and just space for humanity. *ISSC and UNESCO editors, World social science report 2013, changing global environments.* Paris, France: OECD Publishing and UNESCO Publishing.

LEI, Y., YUE, Y., ZHOU, H. & YIN, W. 2014. Rethinking the relationships of vulnerability, resilience, and adaptation from a disaster risk perspective. *Natural hazards,* 70**,** 609-627.

ÖSTERBLOM, H., JOUFFRAY, J.-B., FOLKE, C., CRONA, B., TROELL, M., MERRIE, A. & ROCKSTRÖM, J. 2015. Transnational corporations as 'keystone actors' in marine ecosystems. *PloS one,* 10.

OSTROM, O. 2005. Understanding institutional diversity. *Princeton: Princeton University Press,* 17**,** 8.

REDMAN, C. 2014. Should sustainability and resilience be combined or remain distinct pursuits? *Ecology and Society,* 19.

SMIT, B. & WANDEL, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global environmental change,* 16**,** 282-292.

SMITH, A. & STIRLING, A. 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society,* 15.

STRUNZ, S. 2012. Is conceptual vagueness an asset? Arguments from philosophy of science applied to the concept of resilience. *Ecological Economics,* 76**,** 112-118.

VAN NES, E. H., ARANI, B. M., STAAL, A., VAN DER BOLT, B., FLORES, B. M., BATHIANY, S. & SCHEFFER, M. 2016. What Do You Mean,'Tipping Point'? *Trends in Ecology & Evolution,* 31**,** 902-904.

WALKER, B. & SALT, D. 2006. *Resilience thinking: sustaining ecosystems and people in a changing world,* Washington, DC, Island Press.

Appendix B

Supplemental material for Chapter 3

Box B1: Caribou out-migration.

"…caribou hunting is no longer a major thing…that kind of really has an impact, because now we are more dependent on the food from the ocean. That has to do with the fact that we have very few caribou in this region, it apparently has to do to some extent with climate change, …one winter, I think it was in the early 2000s, that was really milled, and we had lot of rain, and so the land was covered with several inches of ice. The caribou couldn't eat, get to that food [for so long that] caribou starved during that time. Then apparently the herds also migrated to other places. But this community was known for the name of it is 'Pangniqtuuq' which is the name for bull caribou, it was known to have plenty of caribou…" –Elder/hunter/fisher (KII)

Note: Government of Canada weather data confirmed an unusual amount of rain and high monthly mean temperatures during the months of November and December in the early 2000s.

Box B2: Limitation of knowledge co-production process.

Indicators: Pangnirtung Inuit were not directly involved in the development of the Table 1 indicators. The indicators were initially developed based on an extensive review of SES resilience, development, and Indigenous literature. However, we received Inuit consent to use these indicators for the study through several key local informants and local research assistants. Interestingly, we did not observe specific activities, interests, or concerns with respect to the use of these indicators. Further, we should note that Inuit participants were well-aware of the ultimate goal of the indicators, which is to compare climate responses of Sri Lankan Coastal-Vedda and Arctic Inuit. In this paper, we present only the Arctic case study.

Translations: We had to use translators (Inuktitut-English) to talk to certain community respondents and groups. We acknowledge that certain relevant information might have been lost/obscured in translation. Many words in the Inuktitut language do not have parallel words in the English language. Therefore, the translations are often circumscribed, rather than translated. We were unable to track such missing information. Rather, we minimised the impacts to the study by using multiple translators and other methods, including participant observations.

Box B3: Glossary and acronyms.

PO (Participant observation): The goal is to advance one's understanding of a natural setting (i.e., the people, environment, and interactions within and among the system) by becoming a part of everyday interactions—observer gains firsthand knowledge by being in or around the social setting being investigated.

SSI (Semi-structured interviews): The aim is to compare participants' in-depth responses with individual diversity and flexibility. Interviews are more than 'a chat'; they are a verbal exchange of information in which one person (the interviewer) asks questions of another person (the interviewee), with the interviewee answering the questions.

FGD (Focus group discussions): The aim is to gain knowledge about a specific topic or need by interviewing a group of individuals directly affected by the particular issue or area of interest—a small group of people discussing a topic or issue defined by a researcher.

KII (Key informant interviews): Key informants are the individuals, or a group of people, who possess specific skills, knowledge, experience, and/or specialized background on the research project or project participants. They can also be someone who can effectively represent the target research sample (participants) and their activities to the researcher. KII help to get specific information related to research that difficult to access through other methods such as PO, SSI, and FGD.

DFO (Department of Fisheries and Oceans): Canadian federal government department responsible for developing and implementing fisheries policies across the country. DFO is one of the key co-management partners for the Pangnirtung Arctic char and turbot fisheries.

HTA (Hunters and Trappers Association): Community organization responsible for managing hunting, fishing, and trapping activities to ensure that the community has a good country food supply. This organization is owned and managed by Inuit of Pangnirtung. HTA is the key co-management partner from the community for the Pangnirtung Arctic char and turbot fisheries.

RWO (Regional Wildlife Organization): RWO represents multiple HTAs at the regional level. It oversees local harvesting practices and the regional management of Inuit country food.

NWMB (Nunavut Wildlife Management Board): NWMB is a territorial government institution responsible for wildlife management activities in the Nunavut settlement area. It is one of the key co-management partners for the Pangnirtung Arctic char and turbot fisheries.

GN (Government of Nunavut): This is the Government of Nunavut local office located in Pangnirtung. It focuses on economic development and the funding aspects of the fishers and community fisheries. For example, GN sponsors programs that support fishers by providing loans for upgrading their fishing gear and snowmobiles.

NTI (Nunavut Tunngavik Incorporated): This regional organization oversees negotiations for Inuit rights aimed at treaties and land claims. NTI negotiates for Inuit rights in the context of fisheries co-management.

Manifest content analysis: This is aimed at the objective, surface, or concrete content. For example, assume that the phrase ‘climate change’ appears many times in a text.

Latent content analysis: This is aimed at the underlining or implicit meanings, e.g., whether ‘climate change’ is mentioned in the text in an approving or disapproving manner.

Box B4: Inuit understanding of the definitions of characteristics of the resilience-based framework.

ᓇᔪᒐᖅ: ᐃᓄᓐᓄᑦ ᐃᓂᒋᔭᖅ ᖃᐅᔨᒪᔭᐅᓂᖓᓄᑦ ᐊᑦᑐᐊᓂᖃᕐᓗᓂᓗ. ᓇᔪᒐᕐᒥᓄᑦ ᐊᑦᑐᐊᓂᖃᖅᐸᖅ ᑐᑭᓯᔭᐅᓯᒪᓂᖓᓄᑦ ᐃᓄᐃᑦ ᐊᕙᑎᓗ ᓇᔪᖅᑕᖓ ᖃᐅᑕᒫᑦ (ᐃᓅᓯᖏᑎᒍᑦ, ᐃᓕᖅᑯᓯᕐᒥᑎᒍᑦ, ᖃᓄᐅᙱᑦᑎᐊᕐᓂᖏᓐᓄᑦᓗ).
Place: Social and physical space that has attachment to Inuit. Attachment to place is understood as the bonding that occurs between people and their meaningful environments (livelihoods, culture, and wellbeing).

ᐃᓅᓂᕐᒥᓄᑦ: ᐃᓄᐃᑦ (ᐃᒻᒥᓐᓄᑦ ᑲᑐᔾᔨᖃᑎᒌᑉᐸᑕᓘᓐᓃᑦ) ᓇᒻᒥᓂᖅ ᐃᓯᒪᓕᐅᕈᓐᓇᖅᑐᖅ ᑕᐃᒪᓐᓇ ᐊᑐᖅᑕᐅᖏᓐᓇᕐᒥ ᐃᓄᓐᓄᑦ.
Human agency: Inuit (individual or collective) capacity to act independently in making their own decisions as part of the process of the Inuit way of life.

ᑲᑐᔾᔨᖃᑎᒌᓐᓂᒃᑯᑦ : ᑲᑐᔾᔨᖃᑎᒌᓐᓂᒃᑯᑦ ᐊᐅᓚᔾᔭᒋᐊᕈᑎᖏᑦ (ᑲᑐᔾᔨᖃᑎᒌᓐᓂᒃᑯᓘᓐᓃᑦ) ᒪᕐᕉᑉᐸᑎᒃ ᐊᒥᓲᑉᐸᑕᓘᓐᓃᑦ ᐱᓇᓱᐊᒐᐅᔪᒧᑦ ᑎᑭᐅᑎᓇᓱᒃᑲᒥᒃ.
Collective action: Action taken together (or shared) by a group of two or more people to meet a common desired objective.

ᓱᕕᐅᔪᑦ\ᐱᓕᕆᕕᐅᔪᑦ: ᑲᑐᔾᔨᖃᑎᒌᖑᔪᑦ ᐱᔾᔪᔾᔨᓇᓱᐊᖅᐸᑦᑐᑦ ᐊᖏᖃᑎᒌᓐᓂᒃᑯᑦ ᓄᓇᓕᓐᓄᑦ ᐱᓇᓱᐊᖅᑕᐅᔪᒥᒃ (ᐆᑦᑑᑎᒋᓗᒍ, ᐊᐅᓚᑦᑎᔩᑦ ᐱᓕᕆᖃᑎᒌᑦᑐᑦ ᓱᓕᕆᕕᐅᔪᓂ).

Institutions: Local organizations that facilitate collective action that meets local goals (for example, co-managed institutions).

ᖃᐅᔨᒪᔨᑕᐅᕙᑦ: ᖃᐅᔨᒪᖃᑎᒌᓐᓂᒃᑯᑦ ᑲᔪᓰᓐᓇᖅᑐᖅ (ᕿᒥᕐᕈᔭᐅᓯᒪᕙᑦ, ᐊᑐᕐᓯᒪᓂᖏᑎᒍᑦ, ᐃᓚᓐᓂᐊᕈᑎᐅᕙᒥᓃᑦ, ᐱᕙᓐᓇᕐᓯᓯᒪᓂᖏᑎᒍᑦ) ᑕᒃᑯᖕᒪᖕᒪᓪᓗᑎᒃ ᐃᓄᐃᑦ ᐃᖃᓗᒐᓱᒃᕙᑎᖏᓐᓄᑦ (ᓇᕙᖅᑕᐅᓰᓪᓘᓐᓃᑦ) ᑭᖑᕚᕇᓄᑦ ᑐᓂᔭᐅᓯᒪᕙᑦ ᐃᓕᖅᑯᓯᕐᒥᑎᒎᖅᑐᓂ; ᑕᑯᒃᓴᐅᕙᖅ ᐃᓄᐃᑦ ᐃᓕᖅᑯᓯᖓᑎᒍᑦ ᑭᓇᐅᓂᕆᔭᖏᑎᒍᑦ.

Knowledge systems: Co-evolving cumulative body of knowledge and practice (observations, experience, lessons, skills) related to Inuit fisheries systems (or a place) and handed down through generations by cultural transmission; reflects the Inuit cultural identity.

ᐃᓕᓐᓂᖅ: ᐃᓅᖃᑎᒌᑎᒍᑦ ᐃᓕᑉᐸᓪᓕᐊᓂᖅ, ᐊᖏᖃᑎᒌᓐᓂᒃᑯᑦ ᑲᔪᓰᓐᓇᕐᓂᖅ ᕿᒥᕐᕈᓂᒃᑯᓪᓗ ᐃᓄᓐᓄᑦ ᐊᑐᖅᑕᐅᕙᓂᒃ ᐱᕚᓪᓕᑎᑦᑎᓇᓱᐊᖅᑎᓪᓗᒋᑦ ᐊᐅᓚᑦᑎᑎᓪᓗᒋᑦ ᐊᑐᖅᑕᐅᕚᒃᑐᒥᒃ ᐊᕙᑎᒥᒃ.

Learning: Social learning, which itself refers to collective action and reflection that occurs among Inuit as they work to improve the management of human-environment interactions.

Co-management structure for Pangnirtung Arctic char and turbot fisheries

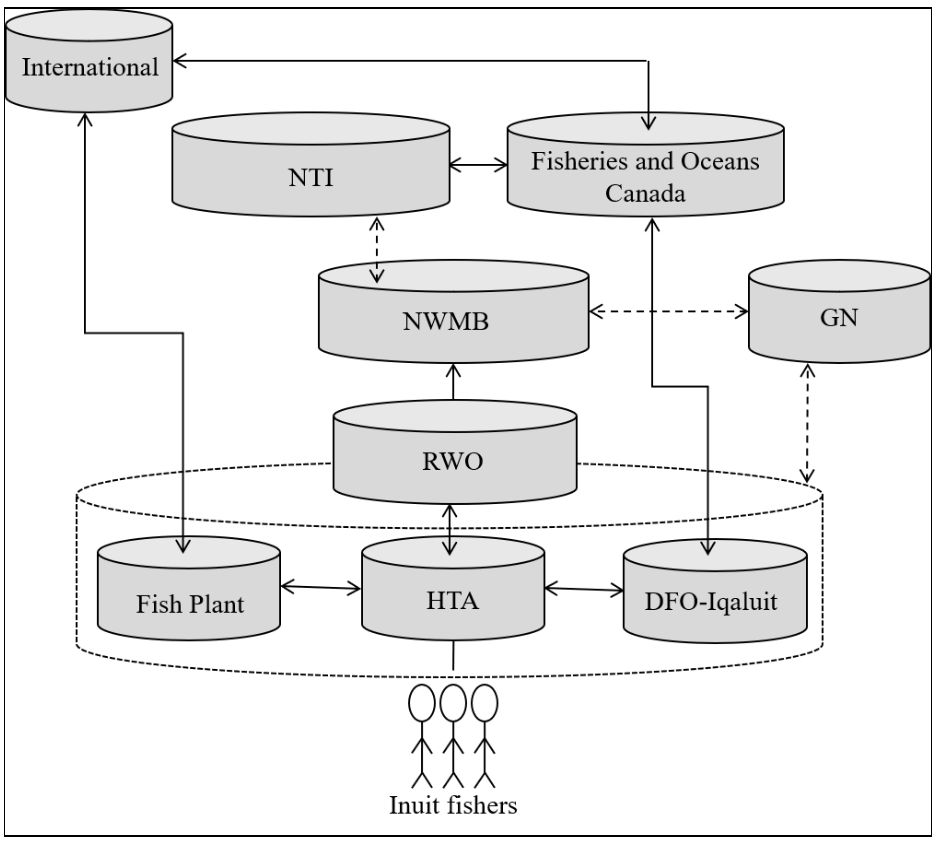


Figure B1: Co-management structure for Pangnirtung Arctic char and turbot fisheries.

Quotas are based on the fiscal year and the HTA decides when the water bodies are fished (summer versus winter). The Pangnirtung HTA has been the license holder for the exploratory char fisheries and designates a quota for its membership. Also, the Pangnirtung HTA has been the license holder for the Cumberland Sound Turbot fishery and advises the DFO on which members shall be added to the license. The HTA should advise Fish Plant and DFO about the fishers who will be fishing under issued license. As part of the fisheries co-management process, feedback about fisheries activities is transmitted to such stakeholders as the DFO, HTA and NWMB. For instance, a fisheries extension officer from the DFO visited the turbot fishing field during the season to ensure the fishery was running according to federal government quotas and other DFO regulations. Also, a local wildlife management officer from the NWMB pays regular visits to Arctic char fishing lakes to monitor and record activities. The fish plant is the community's most influential employer in terms of fishery activities. The fish plant is the main reason for the co-existence of Arctic char and turbot commercial fisheries, and purchases fish from Inuit fishers, then processes and ships the fish to local and international markets.

Table B1: Key themes of the interview guide.

Key themes	Examples of types of questions asked
Change	What kinds of changes have you experienced over the last 30 years? Have such changes affected your life? How? What are the implications of such changes? How do you respond to such changes?
Place	How long have you been living here in Pang? Do you like living here? Are you considering moving to another community or city if possible? Why you like it here (Pang)?
Human agency	How many people have jobs in your home? What are the fishing activities you do? Char or turbot or both? Why do you do both? What kind of fishing gear and tools do you use? How do you face difficult times when you don't have food or money? How did you spend last year's turbot fishing money?
Collective action/collaboration	What is your family members' involvement in fishing? Do you share country food with others? How do you do that? What kind of help do you get from other people for anything including fishing and hunting? Are you willing to share your fishing tools/gear with others?
Institutions	What is the fish plant's role in community fisheries? Who issues licences for char and turbot? How do they do that and what is the process? Who else is involved in the co-management of char and turbot fisheries? Are there any other partners? How are fishing quotas and fishing periods decided? How flexible is this process? What is your contribution to this co-management process?
Knowledge system	How did you learn your fishing and survival skills on sea-ice? From whom? How does warming affect char migration and fisheries? What are the good fishing spots and how do you track such locations? How did you learn on-ice turbot processing techniques?
Learning	How did you learn such knowledge or skills? What kinds of avenues do you have to learn about the fishing way of life? How did school education help? Why did you quit/stop school? Do you use the internet? For what purposes?
Other	Are you comfortable with discussing the above topics? Can you think of any topics that we have not included in the research but that you think would be important? After hearing about the project, would you be interested in participating in it?

Table B2: Sample profiles of SSI respondents (n=62).

Variable	Number of respondents (%)
Gender	
Female	18 (29)
Male	44 (71)
Age*	
<20	1 (2)
20-39	24 (39)
40-59	22 (35)
60-79	14 (23)
80-99	1 (2)
Occupation	
Fishing	62 (100)
Hunting/trapping	36 (58)
Art-related work (for example, carving, painting, crafts)	27 (44)
Tourism-related work (for example, translating, outfitting servicers)	7 (11)
Income support (government income assistance program)	18 (29)
Work for other entities (for example, construction, fish plant, northern store, daycare, hamlet office)	13 (21)

*Regardless of age, Inuit possess a cumulative body of Indigenous and local knowledge, practice, and belief, evolving through the adaptive process and handed down through generations by cultural transmission.

Table B3: Framework indicators and Inuit adaptive responses.

Characteristics	Indicators/areas of adaptive responses	Responses to systems change
Place	Fishery	Two co-existing (wild capture fisheries)
	Types of fisheries	Subsistence and commercial
	No. of fish species	Two
	Food diversity (protein supply—access to edible animals throughout the year)	n=20 (high)
Human agency	Use of advanced technology	GPS, VHF radios, advanced rifles (84%)
	Livelihood diversity (# of livelihood activities involved—occupational multiplicity)	n= 6 (low)
	Access to # of assets needed for fishing activities	x= 3.8, s=1.1 (high)
	Fishing gear diversity (access to # of different fishing gear)	x= 4.0, s=0.9 (high)
	Access to loans	Via Fish Plant and Nunavut government
Collective action and collaboration	Sharing fish	Observed in subsistence fishery
	Sharing fishing gear	Observed
	Sharing of weather information	Through internet and social media
	Sharing of information related to fishing operations	Observed in commercial fishery
	Social networks	Through internet-based social media and community radio
	Level of use of collective action for problem-solving	Observed
Institutions	Fishery management approach	Adaptive co-management
	Key local institution	HTA
	Structure	Multi-level
	Way of functioning	Mostly top-down

	Adaptive nature in functionality	Flexibility observed
ILK systems	Identified knowledge areas	Arctic char, turbot, fishing techniques, fish processing, local environment knowledge
	Level of application of ILK	Some aspects of ILK identified are not used anymore
	Weakening of knowledge systems	Observed
	What bridges the weakening knowledge gap	Advanced technology
Learning	Level of diversity of learning opportunities	Relatively less diverse opportunities
	Key ways of learning (top three)	From elders/parents/extended family members (84%), learning-by-doing (13%), via internet, via school education

Table B4: Ways in which Inuit fishers respond to change.

Characteristics	Quotes from fishers
Place	*"Springtime is warmer now. We used to keep long lines, usually more than twelve hours [but] now I keep about five hours, but less turbot for me. I am ok with what we have now…"* *"Kids… we think children [are] owned by everyone in the community. We raise any kid to give them a better life"* *"…this [Pangnirtung] is where I born … I belong here [Pangnirtung]…"*
Human agency	*"Our elders told [us] not to go when it rainy or foggy, but we go out now whenever with GPS."*
Collective action and collaboration	*"Fish plant giving me weather information and I inform them [fishers] through radio. If you [fishers] caught more fish, you go to radio and ask people to pick up or give it to elders."* *"…of course we help each other, like I have a broken part here, or my winch broke, they said instead of ok … use mine."*
Institutions	*"Pang fisheries give long lines, ropes, and hooks and you can pay back later as money or fish…"* *"…they [hamlet and HTA] were not used to helping old days and now they do … HTA used to help with gas … but not anymore."*
ILK systems	*"We use caribou skin as a bait or to trick fish … learned that from elders…"* *"Now I leap my shack on land close to shore, because ice can break any time unexpectedly. I do fishing around that [pointing to a fishing spot] area."*
Learning	*"...my father was teaching about the weather. How weather is going to be bad, what are the signs, before it gets hot or colder. Younger generations, they go hunting. But they don't look at the clouds. I want them to look at the signs.*

Table B5: Key characteristics of (adaptive) co-management and methods of advancing adaptation.

Characteristics of adaptive co-management	Description	Methods of advancing adaptation
Partnerships between government and local people (or groups)	DFO, HTA, and NWMB directly co-manage Arctic char and turbot fisheries, while NTI, GN, and RWO are also partners in the decision-making process. An Inuit-owned private-entity fish plant informally has a large influence on the operation of the overall co-management process.	-Increase the range/richness of information available for effective decision-making. -Diverse stakeholder interests will improve the flexibility of the fisheries management process, to adjust to changing conditions.
Vertical and horizontal linkages for resource	Federal government (DFO) and provincial government (GN/NWMB) entities are	-Improve the feedback spreading process that improves the

governance	connected to the community organisations (HTA) with the support of private sector industry organisations such as the fish plant.	productivity of the fisheries management system (for example, lessons from the previous fishing seasons, weather, and fish population updates).
Sharing of responsibility, authority, and power	The community organization HTA is the co-management licence holder for Arctic char and turbot fishing. For example, the HTA uses a lottery system to make decisions about issuing licences for commercial char fishing.	-Improve the sense of belongingness (or place attachments) within the fisheries management process (for example, HTA). -Actively include Inuit (as ILK holders) to improve the effectiveness of decision-making to cope with community-level changes.
Learning-by-doing	Considering the size of fish populations and migratory patterns, the fish quota will be reviewed annually based on the best available science and traditional knowledge. Community fishers are part of the fish population monitoring program.	-Allow for learning-by-doing, reassess present knowledge, and constantly co-produce new knowledge for use in coping with new conditions. -Co-produce knowledge through a learning-by-doing process to increase adaptive capacity.
Adaptive management	Fisher will select commercial fishing areas (from eligible areas as licences permit) for turbot (Cumberland Sound) and Arctic char (lakes) based on the prevailing/changing weather and sea ice conditions. Inuit have certain flexibility in terms of reaching the fish quotas; for instance, turbot quotas have not been reachable in the past couple of years (except for 2018) due to weather and sea ice conditions. Flexibility is part of the co-management process.	-Maintain flexibility in the co-management process (for example, decision-making, enforcement) to allow for continuous adjustment to new conditions.

Table B6: Four place-specific attributes that shape community adaptations.

Attributes	Description
Inuit worldviews	Change has become a way of life for the Pangnirtung Inuit. Inuit accept change and try to live with it. From outpost camps to present-day life in Pangnirtung, Inuit have experienced a diverse array of shocks and stressors, but have survived. Place attachment and cultural identity are supportive aspects that allow Inuit to stay together as a community despite change. This Inuit way of thinking (worldview) supports community resilience and adaptation to change, including climate change.
Inuit-owned institutions	Inuit-owned institutions such as fish plant will redistribute fishery resources back to the community, as wages (fish processing labour), employment insurance for turbot fishers, community charity work (via a soup kitchen—community foodbank) and profits for the local Inuit board of directors. The HTA is directly involved in co-managing char and turbot commercial fisheries to support Inuit livelihoods. These institutions support adaptive strategies such as diversification and the co-management of co-existing fisheries.
Sharing and	Organised food sharing (the HTA has some government subsidies; when people bring

collaboration culture	seal and char, they purchase it from hunters and then the HTA makes it available to the community). Also, unorganised food sharing (going on the radio and saying, "Look, I got a seal; come on over and help yourself") minimises the uneven distribution of food (including fish) among the community. Such food sharing minimises the vulnerabilities related to food insecurity and improves social cohesion.
ILK systems	For some Inuit, the most effective way of learning is learning-by-doing and practicing with elders. Thus, apart from school education, ILK influences Inuit fishers' way of life. Inuit have access to traditional knowledge (via elders), local knowledge (via elders/locals), scientific knowledge (via the internet and government programs) and co-produced knowledge, which increases the range of data available for decision-making.

Appendix C

Supplemental material for Chapter 4

Table C1: Key themes of the interview guide.

Key themes	Examples of types of questions asked
Change	What kinds of changes have you experienced over the last 30 years? Have such changes affected your life? How? What are the implications of such changes? How do you respond to such changes?
Place	How long have you been living here in Kunjankalkulam? Do you like living here? Are you considering moving to another community or city if possible? Why do you like it here?
Human agency	How many people have jobs in your home? What are the fishing and aquaculture activities you do? Tank fishing or beach seine or both? Why do you do both? What kind of fishing gear and tools do you use? How do you face difficult times when you don't have food or money? How did you spend your most recent fishing money?
Collective action/collaboration	What is your family members' involvement in aquaculture? Do you share food (fish, meat, rice) with others? How do you do that? What kind of help do you get from other people for anything including tank fishing, farming, gardening, and other activities? Are you willing to share your fishing tools/gear with others?
Institutions	What is the RFO role in community aquaculture? Who issues licences for reservoir aquaculture? How do they do that and what is the process? Who else is involved in the co-management of reservoir aquaculture? Are there any other partners? How are fish stocking quantities and fishing periods decided? How flexible is this process? What is your contribution to this co-management process?
Knowledge system	How did you learn aquaculture techniques? From whom? How does warming affect aquaculture? What are the good fishing spots and how do you know such locations? How did you get rainwater collecting tanks?
Learning	How did you learn to do elevated gardening and animal rearing? What kinds of avenues do you have to learn about the fishing way of life? How did school education help? Why did you quit/stop school? Do you know about the internet and use it? How often do you use cell phones?

Table C2: Sample profiles of SSI respondents (n=74).

Variable	Number of respondents (%)
Gender	
Female	28 (38)
Male	46 (62)
Age	
<20	4 (5)
20-39	21 (28)
40-59	32 (43)
60-79	17 (23)

80-99	0 (0)
Income level of families in C$/month (64 families in the community)	
<50	8 (12)
50-99	21 (33)
100-149	19 (30)
150-199	11 (17)
>200	5 (8)

Table C3: Details of FGDs held in coastal-Vedda community.

Theme of FGD meetings (translated versions)	FGD #	# of participants	Gender ratio (male: female)
Coastal-Vedda…who are we?	1	6	6:0
Understand the changes faced by Coastal-Vedda-1	2	5	4:1
Understand the changes faced by Coastal-Vedda-2	3	7	4:3
What is environment and climate change to Coastal-Vedda	4	4	4:0
What 30 years of war brought to Coastal-Vedda	5	8	3:5
Village tank and Coastal-Vedda-1	6	4	4:0
Village tank and Coastal-Vedda-2	7	4	3:1
Village tank and Coastal-Vedda-3	8	3	2:1
Collaborate with stakeholders	9	5	5:0
Commercial fishing and marketing	10	7	7:0
Women fishers-1	11	4	4:0
Women fishers-2	12	5	5:0
Knowledge systems and learning	13	8	6:2
Livelihood diversification	14	7	6:1
Wild elephant conflicts	15	6	2:4
Adaptation and living with the change	16	8	5:3
Adaptive responses	17	7	5:2

Table C4: Aquaculture species.

Fish type	Common name (*Scientific name*)
Tilapia	Nile tilapia (*Oreochromis niloticus*) Gift tilapia (*Oreochromis mossambicus*)
Carp	Catla (*Catla catla*)
	Rohu (*Labeo rohita*)
	Mrigal carp (*Cirrhinus cirrhosis*)
	Common carp (*Cyprinus carpio*)
Indigenous fish	Giri kanaya (*Labec dussumieri*)
Prawn	Giant freshwater prawn (*Macrobrachium rosenbergi*)

Table C5: Types of knowledge adopted by Coastal-Vedda.

Type of knowledge	Description
Knowledge about fishing spots	-Fisherwomen's knowledge about day-time fishing spots in shallow areas and how to change spots during rainy/dry seasons based on the reservoir water level. -Fishermen's knowledge about night-time fishing spots in the deep areas of the reservoir.
Operational knowledge about reservoir aquaculture	-Knowledge of freshwater aquaculture species. -How to handle fingerlings and the fish stocking process. -Harvesting methods and appropriate fishing gear (for example, correct mesh size). -Pen-culture-related operations.
Knowledge about weather	-For example, rain can be expected if more stars are clearly visible or if more

predictions	fireflies are around.
Knowledge about collective action	-Coastal-Vedda have a historical tradition of collective action. Coastal-Vedda apply this knowledge to face their challenges, creating cooperatives, associations, and other groups to work efficiently and effectively.
Knowledge about climate adaptation	-Through involvement in NGO programs, Coastal-Vedda have learned how to face weather extremes and difficult situations. For example, they have learned how to raise animals (chicken and goats) in high elevated cages, how to engage in high elevated gardening, how to collect rainwater to re-use for gardening, and how to save money through saving clubs.
Knowledge about how to survive in disaster or emergency situations	-How to make a floating structure from bamboo or banana tree in case of floods. -How to follow specific procedures in case of an emergency such as a terrorist attack, an animal attack (elephant), or a natural disaster (tsunami).
Knowledge about wild elephants	-Usual wild elephant trail and behaviour; understand the associated risk level. -How to deal with unexpected wild elephant encounters.
Co-produced knowledge	-By working together and sharing and learning from each other, and by working with NGOs and NAqDA, Coastal-Vedda combine and co-produce new knowledge.

Table C6: Types of learning opportunities available for Coastal-Vedda fishers.

Type of learning opportunity	Description
Learning-by-doing	Learning-by-doing is a common practice among Coastal-Vedda. It applies, but is not limited, to fisheries and aquaculture activities. For example, reservoir aquaculture management through RFOs is a learning-by-doing process. Coastal-Vedda consistently research fishing spots, the timing for fingerling stocking, locations for the pen culture, the setting of nets for commercial fisheries, and learning by trial and error.
Through local institutions	Being a part (as a member/leader) of a local institution, Coastal-Vedda learn how to manage community cooperatives to cope with common challenges. Community-based institutions provide a supportive atmosphere in which to practice collective action. Fishers learn by practicing aquaculture as a group, sharing their experiences, and learn within. The community has numerous local societies, clubs, and associations with specific aims. For example, RFO facilitates co-learning aimed at the development of reservoir aquaculture.
Through stakeholder institutions	Active participation in local institutions exposes Coastal-Vedda to various external learning sources such as (non)government institutions and development projects. This creates diverse learning opportunities that help improve the adaptive capacity of Coastal-Vedda to deal with SES change. For instance, this is how Coastal-Vedda co-learned some adaptive responses with the NGO program, such as how to use and save money (cash).
From parents and elders	Coastal-Vedda learn about their culture and language as well as acquire traditional knowledge (for example, hunting, collecting wild honey and medicinal plants) from their elders and/or extended family members (for example, parents, grandparents, cousins, and friends).
Co-learning	As a community, by working together, practicing collective action within local institutions, and collaborating with stakeholder organizations, Coastal-Vedda fishers co-learn the necessary aspects to develop adaptive capacity to face change.

Table C7: Ways in which Coastal-Vedda fishers respond to SES change.

Characteristics	Quotes from fishers
Place	*"...our [Coastal-Vedda] ancestors coming from inlands…we [Coastal-Vedda] are connected to them [Vedda]… now we speak bit different [than Vedda language] because we are living this area [eastern Sri Lanka] for 1000 years now… "* *"…we [Coastal-Vedda] have being living this area [Kunjankalkulam] since 1960s…we can do both fish culture and rice farming, if have enough water [in reservoir]…"* *"…we know this forest well and we don't want to move [migrate], this is who we are…"*
Human agency	*"…this tank gives us fish year around, but we can grow fish bigger if we have more water in*

	it [reservoir]…" *"…we do many things [livelihoods] to live here…life is hard but we live…"*
Collective action and collaboration	*"…this [during an RFO meeting] is how we work here…we gathered often to discuss our issues, common challenges…"* *"… gather peacefully and discuss is the only way to find solutions to common problems…"*
Institution	*"…we are getting tremendous support from gentlemen [referring to extension officers] from NAqDA to our community aquaculture…if we ask for help [from] our aquaculture, they [NGO] will help us"*
ILK systems	*"…NGOs helped us and trained how to save money through saving clubs…how to collect rainwater…"* *"…now we know how to culture fish…"* *"…to live here, you should know about wild elephants…"*
Learning	*"…we all [Coastal-Vedda community] learnt from government and NGO people…'* *"…everyday learning from everyone…including animal and forest…by learning-by-doing…"*

Table C8: Diversification as an adaptation strategy.

Type of diversification	Description	Methods of advancing adaptation
Aquacultured species	Using seven or eight fish/prawn culture species including tilapia, carp, and Indigenous fish varieties.	-Improve nutritional (protein) diversity for subsistence -High fish species diversity improves the resilience of natural reservoir/aquatic system
Fisheries	Practicing both subsistence (led by fisherwomen) and commercial (led by fishermen) fishing	-Both males and females significantly contribute to fisheries and aquaculture activities—minimising the gender power gap and improving cohesion in fisheries -Improve Coastal-Vedda's wellbeing through commercial fishery
Livelihood	Involved in numerous activities such as home gardening, rice farming, beach seine, animal rearing, trapping and hunting, collecting wild honey, forest wood collecting and selling, and government income support	-Increases opportunities to engage in a wide range of year-round seasonal income-generating activities -Steady income over the year can reduce vulnerability to food insecurity -Increases buying power (material) and improves wellbeing
Institutions	Multi-level institution structure consists of three different (mixed) governance regimes (communal, government, and non-governmental) and works at different levels (community, regional, and national)	-Increase access to broad range of information required for effective decision-making that supports adaptation to change -Receive broad range of adaptation support/training (including funding) for community adaptation programs
Knowledge systems	Use various types of knowledge systems surrounding fishing, aquaculture operation, weather predictions, collective action, climate adaptation responses, and wild elephants and disaster situations	-Reduce risk and vulnerability of various adverse changes -Improve coping, adaptive, and transformative capacities (Béné et al., 2014) of Coastal-Vedda through knowledge co-production to face changes including climate change
Learning opportunities	Access to diverse opportunities to learn such as: learning-by-doing, through local institutions, external stakeholders, and elders, and co-learning as a community	-Improve adaptive capacity through learning-by-doing -Co-learning and adopting adaptive responses to changing Coastal-Vedda way of life -Improve community's collective adaptive capacity to change

Table C9: Key characteristics of (adaptive) co-management and methods of advancing adaptation.

Characteristics of adaptive co-management	Description	Methods of advancing adaptation
Partnerships between government, NGO, and local leadership (or organizations)	NAqDA and RFO directly co-manage the reservoir aquaculture, while the Department of Fisheries, IFF, and NFF are also influential partners in the decision-making process. RFO is the key community-level partner representing all Coastal-Vedda. Various NGOs have partnered through MOUs to provide support in the form of resources, but are not involved in decision-making.	-Increase the range/richness of the information and resources available for effective decision-making. -Diverse stakeholder interests will improve the flexibility of the fisheries management process to adjust to changing conditions.
Vertical and horizontal linkages for resource governance	Multi-level fisheries associations have links through their leaders/representatives for fisheries- and aquaculture-related information sharing. Government institutions (NAqDA, Department of Fisheries) horizontally link with community RFO to provide support through advising, monitoring, and reservoir aquaculture management.	-Improve the feedback spreading process that improves the productivity of the resource management system (for example, lessons from the previous culture seasons, weather, and aquaculture knowledge updates).
Sharing of responsibility, authority, and power	RFO officials (president, secretary, and treasurer) are responsible for community-level reservoir aquaculture operations and have the power to make community-level decisions. The RFO must contribute (financially) to the stocking of fish fingerlings. The NAqDA extension officers oversee these processes.	-Improve the sense of belongingness (or place attachments) within the fisheries management process (for example, collective action around RFO). -Improve the adaptive capacity so that it can be self-sustained over the long term.
Learning-by-doing	Coastal-Vedda as an institution (RFO) co-learn with NAqDA, NGOs, and other stakeholder organizations—e.g., learning from the past mistakes of culture systems and practicing new (pen) culture systems. This co-management process allows Coastal-Vedda to continuously acquire new knowledge.	-Allow for learning-by-doing, reassess present aquaculture practices, and constantly co-produce new knowledge for use in coping with new conditions. -Co-produce knowledge through a learning-by-doing process to increase adaptive capacity.
Adaptive management	Certain aspects of the co-management practice remain flexible—e.g., the amount of fingerling stocking and its species composition, the stocking time is subject to change based on feedback from the previous cycle, and/or prevailing changes such as weather. Further, funding sources will change over time based on the funding availability in government, RFO, and NGOs.	-Maintain flexibility in the co-management process (for example, decision-making, enforcement, funding) to allow for continuous adjustment to new conditions.

Table C10: Four place-specific attributes that shape community adaptations.

Attributes	Description
Cultural identity	Over the last three decades, Coastal-Vedda have undergone many social, political, and

and worldviews (Escobar, 2008)	environmental changes. They are still trying to accept and live with these changes. As a minority group in Sri Lanka, Kunjankalkulam people try to maintain their 'Coastal-Vedda' cultural identity and unity against the backdrop of the Sri Lankan *Wanniya-laeto* population. This way of thinking (worldview) supports community resilience and adaptation to social change.
Co-management of aquaculture (Galappaththi and Berkes, 2015b)	Support and guidance from government and non-governmental organizations plays an important role in building the adaptive capacity and resilience of Coastal-Vedda by providing resources such as new knowledge (technical knowledge about aquaculture), funding (fish stocking in the reservoir), and adaptive training (savings clubs, rainwater collection tanks).
Flexibility (Cinner et al., 2018b)	This reflects opportunities that Coastal-Vedda have to switch between adaptive responses and captures the diversity of potential adaptation options available. For example, Coastal-Vedda can switch between multiple income activities as livelihood options or can have a range of aquaculture options such as subsistence, commercial, or pen culture fisheries for their livelihoods.
ILK systems and learning (Rodríguez et al., 2019)	The use of different kinds of knowledge in daily life increases resilience in Coastal-Vedda SES. For example, with the absence of the internet and limited access to formal education, Coastal-Vedda engage in 'learning-by-doing' and extract knowledge from various sources through a multi-level institution structure. Multiple learning opportunities and diverse knowledge increase the range of information/options available for effective decision-making in daily life.

Figure C1: Field photos.

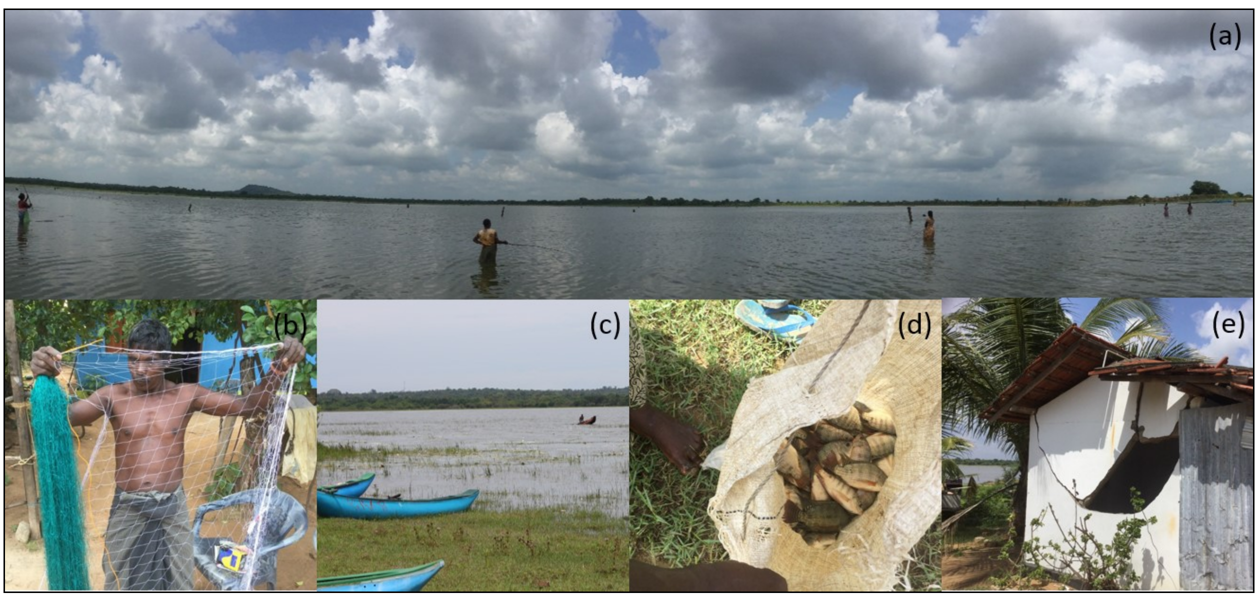


Figure C1: (a) Day-time fisherwomen fishing for food, (b) Fishermen getting ready for night-time fishing, (c) Fish landing site, (d) Fish harvest from day-time fishing, (e) Recent attack by wild elephants.

Box C1: Non-aquaculture-related local institutions.

Coastal-Vedda use numerous community-based organizations for specific common activities. For example, the Rural Development Society focuses on village development activities (road, drinking water), the Women Development Society focuses on small development projects for women (handicrafts), the Indigenous Society focuses on maintaining the Indigenous identity and is linked to the national Indigenous federation, the Temple Society focuses on the spiritual development of the community, the Youth Club focuses on the development of the younger generation and on projects that develop skills and promote education, the Savings Club encourages people to save money for use in difficult situations, and the Indigenous Women's Art Club supports art-related activities for women. All these societies and clubs are registered with the Divisional Secretariat office of Vakarai. These societies collaborate with various NGOs in the region and are involved in various development projects.

Box C2: Glossary.

PO (Participant observation): The goal is to advance one's understanding of a natural setting (i.e., the people, environment, and interactions within and among the system) by becoming a part of everyday interactions—observer gains firsthand knowledge by being in or around the social setting being investigated.

SSI (Semi-structured interviews): The aim is to compare participants' in-depth responses with individual diversity and flexibility. Interviews are more than 'a chat'; they are a verbal exchange of information in which one person (the interviewer) asks questions of another person (the interviewee), with the interviewee answering the questions.

FGD (Focus group discussions): The aim is to gain knowledge about a specific topic or need by interviewing a group of individuals directly affected by the particular issue or area of interest—a small group of people discussing a topic or issue defined by a researcher.

KII (Key informant interviews): Key informants are the individuals, or a group of people, who possess specific skills, knowledge, experience, and/or specialized background on the research project or project participants. They can also be someone who can effectively represent the target research sample (participants) and their activities to the researcher. KII help to get specific information related to research that difficult to access through other methods such as PO, SSI, and FGD.

Manifest content analysis: This is aimed at the objective, surface, or concrete content. For example, assume that the phrase 'climate change' appears many times in a text.

Latent content analysis: This is aimed at the underlining or implicit meanings, e.g., whether 'climate change' is mentioned in the text in an approving or disapproving manner.

Critical discourse analysis: This explores the connections between the use of language and the social and political contexts in which it occurs. It explores issues such as cultural differences, gender, ethnicity, ideology, and identity, and how these are all constructed and reflected in texts.

Appendix D

Supplemental material for field data collection

Document D1: Informed Consent.

Climate Change Adaptation Research Group

Department of Geography

REB File No: 52-0617

Researcher: Eranga Galappaththi
805 Sherbrook Street West
Montreal, Quebec
Canada H3A 0B9
General Office (514) 398-4111
Fax: (514) 398-7437
www.ccadapt.ca

Research Project Title: Opportunities for climate change adaptation: comparative research on Indigenous fisher communities in the Canadian Arctic and Eastern Sri Lanka

Researcher: Eranga Kokila Galappaththi

I am currently in the process of collecting data for my PhD research. The purpose of the study is to examine and evaluate opportunities for resilience building and vulnerability reduction (i.e., adaptation) with respect to the impacts of climate change on remote Indigenous fisher populations. I am a Ph.D. student in the Department of Geography at McGill University, Montreal, Canada. I am working under the supervision of Dr. James Ford. This research has already been approved by the Research Ethics Board at McGill University, Canada. This consent letter, a copy of which will be left with you for your records and reference, is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more details about anything mentioned here, or information not included here, please feel free to ask for clarification. Please take the time to read this carefully and to understand this information.

In the course of the research, we will discuss a series of questions that will help me understand the existing situation in terms of adaptation to climate change in your fishing village. Specific aspects such as what the specific climatic impacts and experiences are, how you respond to those impacts, what the existing forms of collaborations for fisheries management are, what the local government's involvement is to fishery, and what the local actions are to improve local fisheries will be covered during the research process. You will be asked to participate in an interview session that will last between 30 minutes and one hour. If more time is required, a subsequent meeting can be arranged at your convenience. These interviews may be conducted at your place of work, your home, or another location of your preference. After the interview, if the need arises, you may be contacted for further clarification.

Your responses to the individual interview during the several sessions of research will be documented in a notebook. However, your name will not be recorded with your responses to ensure that your identity remains confidential. The interviews will be transcribed and organized in a file and the written transcripts will be coded in such a way that it will not be possible to make direct associations between you and the data you provide. All information generated during analysis and interpretation will be stored in a secure place that only the researcher can access. Moreover, your participation and the information generated will not be discussed with other participants. Towards the end of the research, there will be a group meeting during which I will verify all the information collected during the research process. In this group setting, please be aware that the researcher can ask all participants to respect the confidentiality of these discussions. There exists, however, the risk that some member of the group will not respect this request and will share group discussion information with others. You will have the option to disagree with any such information, in which case the information will be suitably modified per your inputs. Updated research findings will be disseminated on an ongoing basis throughout the project timeline as well as after its completion. The data you provide will be used to complete progress reports and my PhD thesis. It will also potentially be published in academic journals. You will not be identified by name in any such publications.

You are free to decline to participate in this research, withdraw from the study at any time, and/or choose to not answer or discuss any aspects with which you may not be comfortable. If you decline to participate in the study or answer any questions, you will not face any negative consequences. If I have not explained the study clearly, please feel free to ask for clarification or additional information at any time throughout your participation.

If you have any complaints or additional questions about the nature of this research, your concerns may be directed to the research ethics officer at McGill University (1-514-398-6193), deanna.collin@mcgill.ca, or to my supervisor, Dr. James Ford, who may be contacted at 1-514-398-4960, james.ford@mcgill.ca. Please be advised that the staff at these offices speak only English and French.

Each participant will be compensated with $50 worth of gift cards (if you are in Arctic Canada) or a bag full of essential food items (if you are in Sri Lanka).

Thank you for your time and willingness to consider participating in this study!

Consent:

I (the participant) wish to be identified in the report. ____ YES ____ NO

I (the participant) agree to be tape recorded. ____ YES ____ NO

I (the participant) give permission for my photos to be available publicly, such as in articles and presentations.
____ YES ____ NO

I (the participant) have read the above information and I agree to participate in the interview.

Signature: ____________________________

Name: ________________________________

Date: _________________________________

Document D2: Script for Oral Consent.

REB File No: 52-0617

Climate Change Adaptation Research Group

Department of Geography

Researcher: Eranga Galappaththi
805 Sherbrook Street West
Montreal, Quebec
Canada H3A 0B9
General Office (514) 398-4111
Fax: (514) 398-7437
www.ccadapt.ca

Hello. My name is Eranga Galappaththi and I am a Ph.D. student in the Department of Geography at McGill University, Montreal, Canada. I am working under the supervision of Dr. James Ford.

It would be nice to have you as a participant in my study, which aims to understand opportunities for resilience building and vulnerability reduction (i.e., adaptation) with respect to the impacts of climate change on remote Indigenous fisher populations. This research has already been approved by the Research Ethics Board at McGill University, Canada. The purpose of this consent is to give you basic information about the research's intent and what your participation will involve. If you would like more details about something mentioned here, or information not included here, please feel free to ask for clarification.

During this interview process, we will discuss a series of questions that will help me understand the existing situation in terms of adaptation to climate change in your fishing village. Specific aspects such as what the specific climatic impacts and experiences are, how you respond to those impacts, what the existing forms of collaborations for fisheries management are, what the local government's involvement is to fishery, and what the local actions are to improve local fisheries will be covered during the research process. You will be asked to participate in an interview session that will last between 30 minutes and one hour. If more time is required, a subsequent meeting can be arranged at your convenience. These interviews may be conducted at your place of work, your home, or another location of your preference. After the interview, if the need arises, you may be contacted for further clarification.

The interviews will be transcribed and organized in a file, where the written transcripts will be coded in such a way that it will not be possible to make direct associations between you and the data you provide. All the information generated during the analysis and interpretation will be stored in a secure place accessible by only me and my supervisor. Additionally, your participation and the information generated will not be discussed with other participants. By these means, you will have total anonymity and confidentiality.

Your responses to the individual interview during the several sessions of research will be documented in a notebook. However, your name will not be recorded with your responses to ensure that your identity remains confidential. The interviews will be transcribed and organized in a file and the written transcripts will be coded in such a way that it will not be possible to make direct associations between you and the data you provide. All information generated during analysis and interpretation will be stored in a secure place that only the researcher can access. Moreover, your participation and the information generated will not be discussed with other participants. Towards the end of the research, there will be a group meeting during which I will verify all the information collected during the research process. In this group setting, please be aware that the researcher can ask all participants to respect the confidentiality of these discussions. There exists, however, the risk that some member of the group will not respect this request and will share group discussion information with others. You will have the option to disagree with any such information, in which case the information will be suitably modified per your inputs. Updated research findings will be disseminated on an ongoing basis throughout the project timeline as well as after its completion. The data you provide will be used to complete progress reports and my PhD thesis. It will also potentially be published in academic journals. You will not be identified by name in any such publications.

If you have any complaints or additional questions about the nature of this research, your concerns may be directed to the research ethics officer at McGill University (1-514-398-6193), deanna.collin@mcgill.ca, or to my supervisor, Dr. James Ford, who may be contacted at 1-514-398-4960, james.ford@mcgill.ca. Please be advised that the staff at these offices speak only English and French.

Each participant will be compensated with $25 worth of gift cards (if you are in Arctic Canada) or a bag full of essential food items (if you are in Sri Lanka).

Thank you for your time and willingness to consider participating in this study!

Consent:
I (the participant) wish to be identified in the report. ____ YES ____ NO
I (the participant) agree to be tape recorded. ____ YES ____ NO
I (the participant) give permission for my photos to be available publicly, such as in articles and presentations. ____ YES ____ NO
I (the participant) have read the above information and I agree to participate in the interview.
Signature: ____________________________
Name: ________________________________
Date: _________________________________

Document D3: Translated version for Inuit.

ᑎᑎᕋᕐᓯᒪᔪᑦ ᐊᖏᕐᓯᒪᓂᕐᒧᑦ

ᖃᐅᔨᒪᑎᑕᐅᓗᑎᒃ ᐊᖏᕐᓯᒪᓂᖏᑦ

ᓯᓚᐅᑦ ᐊᓯᓪᓕᕐᐸᓪᓕᐊᓂᖓᓄᑦ ᐋᕿᒋᐊᕐᓯᓂᒃᑯᑦ ᖃᐅᔨᓴᕐᑎᑦ

ᓄᓇᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᕝᕙ

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ᖃᐅᔨᓴᕐᓂᖅ ᑕᐅᔭᐅᓂᖓ: ᐱᕕᖃᕐᓂᐅᔪᑦ ᓯᓚᐅᑦ ᐊᓯᓪᓕᕐᐸᓪᓕᐊᓂᖓᓄᑦ ᐋᕿᒋᐊᕐᑕᐅᔪᓐᓇᕐᑐᑦ: ᖃᓄᕐᑐᐳᑕᐅᔪᑦ ᖃᐅᔨᓴᕐᓂᖅ ᐃᖃᓗᒐᓱᒃᑎᐅᔪᓄᑦ ᓄᓇᓕᖏᓐᓂ ᑲᓇᑕᐅᑦ ᐅᑭᐅᕐᑕᕐᑐᖓᓂ ᐊᒻᒪᓗ ᑲᓇᖕᓇᖓᓂ ᓯᕆ ᓛᖕᑲ ᓄᓇᖓᓂ.

ᖃᐅᔨᓴᕐᑎᐅᔪᖅ: ᐃᕋᖓ ᑯᑭᓚ ᒐᓚᑉᐸᕐᑎ Eranga Kokila Galappaththi

ᑎᑎᕋᕐᐸᓕᐊᒐᒪ ᖃᐅᔨᓴᕐᓂᕆᓂᐊᕐᑕᓐᓂᒃ ᐃᓕᓐᓂᐊᕈᑎᓐᓄᑦ ᐊᒃᑐᐊᓂᐊᕐᑐᒥᒃ. ᐱᔾᔪᑎᖃᕐᑐᖅ ᖃᐅᔨᓴᕐᓂᖅ ᑐᑭᓯᓇᓱᒃᑯᒍ ᕿᒥᕈᓗᒍᓗ ᐱᕕᖃᕐᓂᐅᔪᑦ ᐱᑕᖃᐃᓐᓇᕐᑎᑦᑎᓇᓱᒃᑯᓂ ᐊᒻᒪᓗ ᐊᒃᓱᕈᕐᓇᐅᑕᐅᔪᑦ ᒥᑭᒃᓕᒋᐊᕋᓱᒃᑯᑎᑦ (ᓱᕐᓘ ᐋᕿᒋᐊᕐᓯᓂᒃᑯᑦ) ᐱᔾᔪᑎᒋᓪᓗᒍ ᐃᒃᐱᒃᓇᐅᑎᓯᒪᓂᖓ ᓯᓚᐅᑦ ᐊᓯᓪᓕᕐᐸᓪᓕᐊᓂᖓᓄᑦ ᐅᖓᓯᒃᑐᕐᒥᐅᑕᐅᔪᓄᑦ ᐃᖃᓗᒐᓱᒃᑎᐅᔪᓄᑦ. ᓘᒃᑖᖑᓇᓱᒃᓂᕐᒧᑦ ᐃᓕᓐᓂᐊᕐᐸᓪᓕᐊᔪᖓ ᓄᓇᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᕝᕙᖓᓂ, ᒪᓐᑐᕆᐊ ᑲᓇᑕ. ᐊᖓᔪᖄᖃᕐᑐᖓ ᓘᒃᑖᖅ ᔭᐃᒻᔅ ᕗᐊᑦ. ᑖᓐᓇ ᖃᐅᔨᓴᕐᓂᐅᔪᖅ ᐊᖏᕐᑕᐅᓚᐅᕐᓯᒪᔪᖅ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐃᓕᕐᑯᓯᖏᓐᓄᑦ

ᑲᑎᒪᔨᖏᓐᓄᑦ ᐃᓕᓐᓂᐊᕐᕕᒃᔪᐊᒥ ᒪᒋᐅᓪ, ᐊᒻᒪᓗ ᓄᓇᕗᑦ ᖃᐅᔨᓴᑐᓕᕆᔩᒃᑯᓐᓄᑦ, ᑲᓇᑕ. ᑖᓐᓇ ᑎᑎᕋᕐ ᐊᖏᕐᓯᒪᓂᕐᒧᑦ, ᐊᔾᔨᖓᓂᒃ ᐱᑎᑕᐅᓂᐊᕐᑐᑎᑦ ᑎᑎᕋᕐᓯᒪᔪᒥᒃ, ᐃᓚᒋᔭᖓ ᖃᐅᔨᒪᑎᑕᐅᓗᓂ ᐊᖏᕐᓯᒪᓂᕐᒧᑦ. ᖃᐅᔨᒪᔭᕐᑕᒃᓴᑎᓇᔭᐃᑦ ᐅᖃᓕᒫᕈᕕᒋᑦ ᐊᐱᕐᓱᑕᐅᔪᑦ ᑭᓱᓕᕆᒃᒪᖔᑕ. ᑐᑭᓯᒃᑲᓐᓂᕈᒪᒍᕕᑦ ᑕᕝᕙᓂ ᐅᖃᐅᓯᐅᔪᒥ, ᐅᕙᓅᓐᓂᑦ ᖃᓄᑐᐃᓐᓇᖅ ᑐᑭᓯᖏᑦᑐᓂᒃ, ᐊᐱᕆᓂᐊᕐᐳᑎᑦ. ᐅᖃᓕᒫᑦᑎᐊᕐᓂᐊᕐᐸᐃᑦ ᑕᒃᑯᐊ ᑎᑎᕋᕐᓯᒪᔪᑦ.

ᖃᐅᔨᓴᕐᑎᓪᓗᖓ, ᐅᖃᐅᓯᖃᖃᑦᑕᕐᓂᐊᕐᑐᒍᑦ ᐊᐱᕐᓱᕐᐸᒃᑐᖓᓗ ᑐᑭᓯᓇᓱᒃᑐᖓ ᒫᓐᓇ ᖃᓄᐃᓕᖓᖕᒪᖓᑕ ᐃᓕᕐᑯᓯᐅᔪᑦ ᐋᕿᒋᐊᕐᐸᓪᓕᐊᖃᑦᑕᕐᑐᑦ ᓯᓚᐅᑦ ᐊᓯᓪᓕᕐᐸᓪᓕᐊᓂᖓᓄᑦ ᐃᖃᓗᒐᓱᒃᑎᐅᔪᑦ ᓄᓇᓕᖏᓐᓂ. ᐊᑐᓂᓗ ᖃᓄᐃᓕᖓᖕᒪᖓᑕ ᓯᓚᐅᑦ ᐊᓯᓪᓕᕐᓂᖓᓄᑦ ᐃᒃᐱᒃᓇᐅᑎᓯᒪᔪᑦ ᐊᑐᕐᑕᐅᖃᑦᑕᕐᑐᓪᓗ, ᖃᓄᕐᓗ ᓄᓇᓕᒃᓂ ᒐᕙᒪᐅᔪᑦ ᐃᓚᐅᖃᑕᐅᒃᒪᖔᑕ ᐃᖃᓗᒐᓱᒃᓂᕐᒧᑦ, ᐊᒻᒪᓗ ᓄᓇᓕᒃᓂ ᖃᓄᐃᓕᐅᕈᑕᐅᔪᑦ ᐱᕐᑯᓯᒋᐊᕐᑕᐅᓇᓱᒃᑎᓪᓗᒍ ᐃᖃᓗᒐᓱᒃᓂᖅ. ᐊᐱᕆᔭᐅᖃᑦᑕᕐᓂᐊᕐᑐᑎᑦ ᐃᓚᐅᔪᒪᒃᒪᖔᕐᐱᑦ ᐊᐱᕐᓱᕐᑕᐅᔪᒪᒍᕕᑦ ᐃᑲᕋᐅᑦ ᐊᕙᖓᓂᒃ ᐊᐱᕐᓱᕐᑕᐅᓚᔭᕐᐳᑎᑦ ᐅᕙᓅᓐᓂᑦ ᐃᑲᕋᓕᒫᒥᒃ. ᐱᕕᖃᒃᑲᓐᓂᕈᒪᒍᑦᑕ, ᑭᖑᓪᓕᕐᒥᒃ ᐅᐸᒃᑕᐅᒃᑲᓐᓂᕈᓐᓇᕋᔭᕐᑐᑎᑦ. ᑖᒃᑯᐊ ᐊᐱᕐᓱᕐᓂᐅᔪᑦ ᐃᓗᐊᓇᔭᕐᓂ ᐃᓂᖃᕐᓗᑎᒃ ᖃᖓᒃᑯᓪᓗ ᐃᓪᓄᑦ ᐃᓗᐊᓇᔭᕐᓂ, ᐊᖏᕋᕐᓂ ᐃᖃᓇᐃᔭᕐᕕᒃᓂᓗᓐᓃᑦ ᐊᓯᖏᓐᓂᓗᓐᓃᑦ ᐃᓗᐊᓇᔭᕐᓂᒃ. ᐊᐱᕐᓱᓃᕈᑦᑕ, ᐱᔭᕆᐊᖃᕈᓂ ᖃᐅᔨᒋᐊᕐᕕᐅᒃᑲᓐᓂᕋᔭᕐᐳᑎᑦ ᑐᑭᓯᒋᐊᖃᓐᓂᕆᐊᖃᕈᓂ.

ᑭᐅᔾᔪᑎᒋᔭᑎᑦ ᐊᐱᕐᓱᕐᑕᐅᑎᓪᓗᑎᑦ ᑎᑎᕋᕐᑕᐅᕙᓪᓕᐊᓂᐊᕐᑐᑦ. ᑭᓯᐊᓂ ᐊᑏᑦ ᑎᑎᕋᕐᑕᐅᔾᔭᐊᖏᑦᑐᖅ ᑭᓇᐅᓂᕐᓂᒃ ᓇᓗᓇᐃᕐᓯᒪᔾᔭᐊᖏᑦᑐᖅ ᑲᖑᓇᕐᑎᑕᐅᓂᐊᕐᑐᖅ. ᐊᐱᕐᓱᕐᓂᖅ ᑎᑎᕋᕐᑕᐅᓂᐊᕐᑐᑦ ᐊᒻᒪᓗ ᐅᖃᓕᒫᒐᐅᓗᑎᒃ ᓈᓴᐅᑎᒃᑯᑦ ᐋᕿᒃᓯᒪᓗᑎᒃ ᑭᓇᐅᓂᕐᓂᒃ ᖃᐅᔨᒪᔾᔭᐅᔾᔪᐊᕐᓂᖏᑦᑐᖅ. ᑕᒪᕐᒥᒃ ᑎᑎᕋᕐᑕᐅᔪᑦ ᐊᒻᒪᓗ ᖃᓪᓗᓈᑎᑐᓕᕐᑕᐅᔪᑦ ᐃᓂᖃᕐᑎᑕᐅᓂᐊᕐᑐᑦ ᓴᕿᔮᖏᑦᑐᒥ ᖃᐅᔨᓴᕐᑎᑐᐊᒧᑦ ᑕᑯᔭᐅᖃᑦᑕᕐᓗᑎᒃ. ᐊᒻᒪᓗᑦᑕᐅᖅ, ᐃᓚᐅᖃᑕᐅᓃᑦ ᑎᑎᕋᕐᑕᐅᔪᓪᓗ ᐅᖃᐅᓯᐅᔾᔭᐊᖏᑦᑐᑦ ᐊᓯᖏᓐᓄᑦ ᐊᐱᕐᓱᕐᑕᐅᔪᓄᑦ. ᐱᔭᕆᓕᕈᑦᑕ ᖃᐅᔨᓴᕐᓂᑦᑎᓐᓂᒃ , ᑲᑎᒪᖃᑎᒌᒃᓂᐊᕐᒥᔪᑦ ᓇᓗᓇᐃᕐᓂᐊᕐᑕᒃᑲᓗ ᐅᖃᐅᓯᐅᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᑎᓪᓗᖓ. ᐊᖏᕈᒪᒍᕕᑦ ᐃᓱᒪᒃᓱᕐᑐᑎᑦ

ᐋᒃᑲᓯᒪᒍᕕᑦ ᑎᑎᕋᕐᑕᐅᓯᒪᔪᒥᒃ, ᐋᕿᒋᐊᕐᑕᐅᔪᓐᓇᕐᓂᐊᕐᑐᑦ ᐅᖃᐅᓯᕆᔭᐃᑦ ᒪᓕᒃᑐᒍ. ᐅᖃᐅᓯᕆᔭᐃᑦ ᐊᑐᕐᑕᐅᒐᔭᕐᑐᖅ ᐅᓂᒃᑳᓕᐊᖑᔪᒧᑦ ᐊᒻᒪᓗ ᐃᓕᓐᓂᐊᕈᑎᒧᑦ. ᐅᖃᓕᒪᒐᒃᑯᓪᓗ ᓴᕿᑕᐅᑐᐃᓐᓴᓇᐊᖃᓇᓪᓗᓂ. ᓇᑯᓇᐃᕐᓯᒪᔾᔮᕆᐊᖏᑦᑐᖅ ᑭᓇᐅᓃᑦ.

ᐃᓱᒪᕐᓱᕐᑐᑎᑦ ᐋᑲᓯᒪᒍᕕᑦ ᐃᓚᐅᔪᒪᖏᒃᑯᕕᑦ ᐊᐱᕐᓱᕐᓂᕐᒧᑦ, ᖃᖓᑐᐃᓐᓇᕐᓗ ᓄᖃᑉᐸᓐᓇᕐᑐᑎᑦ, ᐊᒻᒪᓗ ᑭᐅᔪᒪᖏᒃᑯᕕᑦ ᓇᓕᐊᒃᓂᑐᐃᓐᓇᖅ ᐃᓱᒪᕐᓱᕐᒥᔪᑎᑦ, ᐅᖃᐅᓯᕆᔪᒪᖏᑕᑎᓪᓗ ᐃᓱᒪᒃᓱᕐᒥᔪᑎᑦ. ᐋᒃᑲᕋᓗᐊᕈᕕᑦ ᑭᐅᔪᒪᖏᒃᑯᕕᓪᓗᓐᓇᓃᑦ ᓇᓕᐊᒃᓂᑐᐃᓐᓇᖅ ᐊᐱᕐᑯᑎᒥᒃ ᖃᓄᐃᑦᔪᑎᒋᔾᔮᕆᐊᖏᑦᑐᖅ. ᑐᑭᓯᓇᖏᑐᐊᕈᒪ ᐊᐱᓇᖅᑲᑦᑕᕐᓗᑎᓪᓗ ᑐᑭᓯᒋᐊᒃᑲᓐᓂᖅᑲᑦᑕᕐᓗᑎᑦ.

ᐃᓗᐊᓇᖏᑕᖅᑲᕕᑦ ᐅᕙᓅᓐᓂᑦ ᐃᓱᒪᓗᑎᖅᑲᕕᑦ ᐊᐱᖅᑯᑎᒃᓴᓂᒃᓅᓐᓂᑦ ᖃᐅᔨᓴᕐᓂᐅᑉ ᒥᒃᓵᓄᑦ, ᑐᕋᕐᑎᑕᐅᓂᐊᕐᑐᑦ ᐃᓱᒫᓗᑎᕆᕙᑎᑦ ᑲᒪᔨᐅᔪᒧᑦ ᐃᓕᓐᓂᐊᕐᕕᒃᔪᐊᕐᒥ ᐅᕗᖓ ᐅᖄᓚᓗᑎᑦ (1-514-398-6193), deanna.collin@mcgill.ca, ᐅᕙᓅᓐᓂᑦ ᐊᖓᔪᖅᑳᖓᑦ ᓅᒃᑕᖅ ᔭᐃᒻᔅ ᕗᐊᑦ Dr. James Ford, ᐅᕗᖓ ᐅᖄᓚᐅᑕ 1-514-398-4960, james.ford@mcgill.ca. ᖃᐅᔨᒪᓂᐊᕐᐳᑎᑦ ᖃᓄᖅᑐᓇᑎᑐᑦ ᐅᐃᕙᑎᑐᖅᑐ ᐅᖃᖅᓚᒍᓐᓇᕐᑐᑐᐊᖑᖓᑕ.

ᐊᑐᓂ ᐊᐱᕐᓱᕐᑕᐅᔪᑦ ᐊᑭᓕᕐᑕᐅᓂᐊᕐᑐᑦ ᓂᐅᕕᕈᓐᓇᐅᑎᒥᒃ $25 (ᑲᓇᑕᒥ ᐅᑭᐅᕐᑕᕐᑐᓂᖓ) ᐊᒻᒪᓗ ᓂᐅᕕᐊᕐᑲᐅᑎ ᓂᕿᕐᑲᕐᓗᓂ (ᓱᓇ ᒫᖅᑲ ᓄᓇᕐᑲᕐᑐᑦ).

ᖁᔭᓐᓇᒦᒃ ᐃᓚᐅᔪᒪᒐᕕᑦ ᐊᐱᕐᓱᕐᑕᐅᓂᒃᑯᑦ!

ᓇᑯᓇᐃᕐᓯᓯᒪᔪᖅ ᐱᔪᓐᓇᐅᑎᖃᕐᓂᖓᓂᒃ ᐊᐱᕐᓱᕐᑕᐅᔪᖅ: "ᑐᓴᐅᒪᑎᑕᐅᑦᑎᐊᕐᑐᖓ ᑐᕋᖓᐅᔪᒥᒃ ᐊᐱᕐᓲᕐᑕᐅᔪᒥᒃ ᐱᓕᕆᐊᖑᔪᒥᒃ. ᑐᑭᓯᔭᒃᑲᓗ ᑐᕋᖓᐅᔪᑦ ᐊᒻᒪᓗ ᐊᖏᕐᑐᖓ ᐊᐱᕐᓱᕐᑕᐅᔪᒪᓪᓗᖓ. ᑲᖑᓇᕐᑎᑕᐅᓂᐊᕐᓂᖏᓐᓂᒃᓗ ᑐᑭᓯᔪᖓ ᑭᓯᐊᓂ ᐊᖏᕐᓯᒪᒍᒪ ᓴᕿᑕᐅᒐᔭᕐᑐᖓ. ᑐᑭᓯᓪᓗᖓᓗ, ᖃᖓᑐᐃᓐᓇᕐ ᐊᐱᕐᓱᕐᑕᐅᔪᒪᔪᓐᓃᕈᒪ ᓄᖃᑉᐸᓐᓇᕐᑐᖓ ᖃᓄᐃᒋᐊᕈᑕᐅᖏᓪᓗᓂᓗ. "

ᐊᖏᕐᓂᖅ:

ᓇᑯᓇᐃᕐᑕᐅᖃᑦᑕᕆᒪᔪᖓ ᑭᓇᐅᓂᓐᓂᒃ ᐅᓂᒃᑲᓕᐊᒃᑯᑦ ____ ᐄ ____ ᐋᒃᑲ

ᐊᖏᕐᑐᖓ ᓂᐱᓕᐅᕐᑕᐅᔪᒪᓪᓗᖓ ____ ᐄ ____ ᐋᒃᑲ

ᐅᖃᓖᕐᓯᒪᔭᕋ ᑐᕋᖓᐅᔪᑦ ᐊᒻᒪᓗ ᐊᖏᕐᑐᖓ ᐃᓚᐅᖃᑕᐅᔪᒪᓪᓗᖓ ᐊᐱᕐᓱᕐᓂᒃᑯᑦ.

ᐊᑎᓕᐅᕆᔫᑦ: ____________________________

ᐊᑎᖓ (ᑎᑎᕋᕐᓗᒍ) : ________________________________

ᐅᓪᓗᖓ ᐊᖏᕐᓂᖓᑕ: ________________________________

ᑕᐅᑐᒃᑑᑦ ᐊᑎᖓ ᐊᑎᓕᐅᕆᓯᖓᓗ: ________________________________

Document D4: Translated version for Coastal-Vedda.

வாய்வழி ஒப்புதலுக்கான ஸ்கிரிப்ட்
REB கோப்பு எண்: 52-0617

காலநிலை மாற்றம் தழுவல் ஆராய்ச்சி குழு
புவியியல் துறை
ஆராய்ச்சியாளர்: எரங்கா கலப்பதி
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வணக்கம். எனது பெயர் எரங்கா கலப்பதி மற்றும் நான் பி.எச்.டி. கனடாவின் மாண்ட்ரீல், மெக்கில் பல்கலைக்கழகத்தில் புவியியல் துறையில் மாணவர். நான் டாக்டர் ஜேம்ஸ் ஃபோர்டின் மேற்பார்வையில் பணிபுரிகிறேன்.

எனது ஆய்வில் நீங்கள் ஒரு பங்கேற்பாளராக இருப்பது மகிழ்ச்சியாக இருக்கும், இது தொலைதூர பழங்குடி மீனவர் மக்கள் மீது காலநிலை மாற்றத்தின் தாக்கங்கள் தொடர்பாக பின்னடைவு கட்டிடம் மற்றும் பாதிப்புக் குறைப்புக்கான வாய்ப்புகளை (அதாவது தழுவல்) புரிந்துகொள்வதை நோக்கமாகக் கொண்டுள்ளது. இந்த ஆராய்ச்சிக்கு ஏற்கனவே கனடாவின் மெக்கில் பல்கலைக்கழகத்தில் ஆராய்ச்சி நெறிமுறைகள் வாரியம் ஒப்புதல் அளித்துள்ளது. இந்த ஒப்புதலின் நோக்கம், ஆராய்ச்சியின் நோக்கம் மற்றும் உங்கள் பங்கேற்பு என்ன என்பது பற்றிய அடிப்படை தகவல்களை உங்களுக்கு வழங்குவதாகும். இங்கே குறிப்பிடப்பட்டுள்ள ஏதாவது அல்லது இங்கே சேர்க்கப்படாத தகவல்களைப் பற்றிய கூடுதல் விவரங்களை நீங்கள் விரும்பினால், தயவுசெய்து விளக்கம் கேட்க தயங்க.

இந்த நேர்காணல் செயல்பாட்டின் போது, உங்கள் மீன்பிடி கிராமத்தில் காலநிலை மாற்றத்திற்கு ஏற்றவாறு இருக்கும் நிலைமையைப் புரிந்துகொள்ள உதவும் தொடர்ச்சியான கேள்விகளை நாங்கள் விவாதிப்போம். குறிப்பிட்ட காலநிலை தாக்கங்கள் மற்றும் அனுபவங்கள் என்ன, அந்த பாதிப்புகளுக்கு நீங்கள் எவ்வாறு பதிலளிப்பீர்கள், மீன்வள நிர்வாகத்திற்கான ஒத்துழைப்புகளின் வடிவங்கள் என்ன, மீன் பிடிப்பதில் உள்ளூர் அரசாங்கத்தின் ஈடுபாடு என்ன, உள்ளூர் மீன்வளத்தை மேம்படுத்த உள்ளூர் நடவடிக்கைகள் என்ன போன்ற குறிப்பிட்ட அம்சங்கள் ஆராய்ச்சி செயல்பாட்டின் போது மறைக்கப்படும். 30 நிமிடங்கள் முதல் ஒரு மணி நேரம் வரை நீடிக்கும் ஒரு நேர்காணல் அமர்வில் பங்கேற்கும்படி கேட்கப்படுவீர்கள். அதிக நேரம் தேவைப்பட்டால், உங்கள் வசதிக்கு ஏற்ப அடுத்த கூட்டத்தை ஏற்பாடு செய்யலாம். இந்த நேர்காணல்கள் உங்கள் வேலை செய்யும் இடம், உங்கள் வீடு அல்லது உங்கள் விருப்பத்தின் மற்றொரு இடத்தில் நடத்தப்படலாம். நேர்காணலுக்குப் பிறகு, தேவை ஏற்பட்டால், மேலும் தெளிவுபடுத்த உங்களை தொடர்பு கொள்ளலாம்.

நேர்காணல்கள் ஒரு கோப்பில் படியெடுக்கப்பட்டு ஒழுங்கமைக்கப்படும், அங்கு எழுதப்பட்ட டிரான்ஸ்கிரிப்டுகள் உங்களுக்கும் நீங்கள் வழங்கும் தரவிற்கும் இடையே

நேரடி தொடர்புகளை ஏற்படுத்த முடியாத வகையில் குறியிடப்படும். பகுப்பாய்வு மற்றும் விளக்கத்தின் போது உருவாக்கப்பட்ட அனைத்து தகவல்களும் நானும் எனது மேற்பார்வையாளரும் மட்டுமே அணுகக்கூடிய பாதுகாப்பான இடத்தில் சேமிக்கப்படும். கூடுதலாக, உங்கள் பங்கேற்பு மற்றும் உருவாக்கப்பட்ட தகவல்கள் பிற பங்கேற்பாளர்களுடன் விவாதிக்கப்படாது. இந்த வழிகளில், உங்களுக்கு மொத்த பெயர் மற்றும் இரகசியத்தன்மை இருக்கும்.

ஆராய்ச்சியின் பல அமர்வுகளின் போது தனிப்பட்ட நேர்காணலுக்கான உங்கள் பதில்கள் ஒரு குறிப்பேட்டில் ஆவணப்படுத்தப்படும். இருப்பினும், உங்கள் அடையாளம் ரகசியமாக இருப்பதை உறுதிசெய்ய உங்கள் பதில்களுடன் உங்கள் பெயர் பதிவு செய்யப்படாது. நேர்காணல்கள் ஒரு கோப்பில் படியெடுக்கப்பட்டு ஒழுங்கமைக்கப்படும் மற்றும் எழுதப்பட்ட டிரான்ஸ்கிரிப்டுகள் உங்களுக்கும் நீங்கள் வழங்கும் தரவிற்கும் இடையே நேரடி தொடர்புகளை ஏற்படுத்த முடியாத வகையில் குறியிடப்படும். பகுப்பாய்வு மற்றும் விளக்கத்தின் போது உருவாக்கப்படும் அனைத்து தகவல்களும் ஆராய்ச்சியாளரால் மட்டுமே அணுகக்கூடிய பாதுகாப்பான இடத்தில் சேமிக்கப்படும். மேலும், உங்கள் பங்கேற்பு மற்றும் உருவாக்கப்பட்ட தகவல்கள் பிற பங்கேற்பாளர்களுடன் விவாதிக்கப்படாது. ஆராய்ச்சியின் முடிவில், ஒரு குழு கூட்டம் இருக்கும், இதன் போது ஆராய்ச்சி செயல்பாட்டின் போது சேகரிக்கப்பட்ட அனைத்து தகவல்களையும் சரிபார்க்கிறேன். இந்த குழு அமைப்பில், இந்த விவாதங்களின் ரகசியத்தன்மையை மதிக்குமாறு பங்கேற்பாளர் அனைவரையும் ஆராய்ச்சியாளர் கேட்கலாம் என்பதை நினைவில் கொள்க. எவ்வாறாயினும், குழுவின் சில உறுப்பினர்கள் இந்த கோரிக்கையை மதிக்க மாட்டார்கள் மற்றும் குழு விவாத தகவல்களை மற்றவர்களுடன் பகிர்ந்து கொள்வார்கள் என்ற ஆபத்து உள்ளது. இதுபோன்ற எந்தவொரு தகவலுடனும் உடன்பட உங்களுக்கு விருப்பம் இருக்கும், இந்த விஷயத்தில் உங்கள் உள்ளீடுகளுக்கு ஏற்றவாறு தகவல் மாற்றப்படும். புதுப்பிக்கப்பட்ட ஆராய்ச்சி முடிவுகள் திட்ட காலக்கெடு முழுவதும் மற்றும் அது முடிந்தபின்னர் தொடர்ந்து பரப்பப்படும். நீங்கள் வழங்கும் தரவு முன்னேற்ற அறிக்கைகள் மற்றும் எனது பிஎச்.டி ஆய்வறிக்கையை முடிக்க பயன்படுத்தப்படும். இது கல்வி இதழ்களிலும் வெளியிடப்படும். அத்தகைய எந்த வெளியீடுகளிலும் நீங்கள் பெயரால் அடையாளம் காணப்பட மாட்டீர்கள்.

இந்த ஆராய்ச்சியின் தன்மை குறித்து உங்களுக்கு ஏதேனும் புகார்கள் அல்லது கூடுதல் கேள்விகள் இருந்தால், உங்கள் கவலைகள் மெக்கில் பல்கலைக்கழகத்தின் ஆராய்ச்சி நெறிமுறை அலுவலருக்கு அனுப்பப்படலாம் (1-514-398-6193), deanna.collin@mcgill.ca, அல்லது எனது மேற்பார்வையாளர் டாக்டர் ஜேம்ஸ் ஃபோர்டுக்கு 1-514-398-4960 என்ற எண்ணில் தொடர்பு கொள்ளலாம், james.ford@mcgill.ca. இந்த அலுவலகங்களில் உள்ள ஊழியர்கள் ஆங்கிலம் மற்றும் பிரஞ்சு மட்டுமே பேசுகிறார்கள் என்பதை தயவுசெய்து அறிவுறுத்தவும்.

ஒவ்வொரு பங்கேற்பாளருக்கும் $ 25 மதிப்புள்ள பரிசு அட்டைகள் (நீங்கள் ஆர்க்டிக் கனடாவில் இருந்தால்) அல்லது அத்தியாவசிய உணவுப் பொருட்கள் நிறைந்த பையில் (நீங்கள் இலங்கையில் இருந்தால்) இழப்பீடு வழங்கப்படும்.

இந்த ஆய்வில் பங்கேற்பதைக் கருத்தில் கொள்ள உங்கள் நேரம் மற்றும் விருப்பத்திற்கு நன்றி!
ஒப்புதல்:

நான் (பங்கேற்பாளர்) அறிக்கையில் அடையாளம் காண விரும்புகிறேன்.
____ ஆம் ____ இல்லை

நான் (பங்கேற்பாளர்) டேப் பதிவு செய்ய ஒப்புக்கொள்கிறேன்.
____ ஆம் ____ இல்லை
கட்டுரைகள் மற்றும் விளக்கக்காட்சிகள் போன்ற எனது புகைப்படங்கள் பொதுவில் கிடைக்க நான் (பங்கேற்பாளர்) அனுமதி அளிக்கிறேன்.
____ ஆம் ____ இல்லை
நான் (பங்கேற்பாளர்) மேற்கண்ட தகவல்களைப் படித்திருக்கிறேன், நேர்காணலில் பங்கேற்க ஒப்புக்கொள்கிறேன்.
கையொப்பம்: ________________________
பெயர்: ___________________________
தேதி: ____________________________