



Towards Taking Farmers Seriously:
Contributions of farmer knowledge to food systems
adaptation to climate change

Bernard Soubry

Hertford College
Environmental Change Institute
School of Geography and Environment
University of Oxford

supervised by

Dr. Kate Sherren (Dalhousie University)
Dr. Thomas F. Thornton (University of Alaska, Southeast / University of Oxford)

Submitted as partial fulfilment of the degree of
Doctor of Philosophy

17 February 2021

The solutions [...] will have to be local, and there will have to be a myriad of them. The scientists, moreover, will have to suffer the responsibility of applying their knowledge at home, sharing the fate of the place where their knowledge is applied.

Wendell Berry, "Going to Work"

I was disappointed [when I met you], because when [...] I read your [Oxford] credentials, I was like: 'I don't know, I don't like those guys. I think they're full of shit, myself.'

Farmer interview, February 2018

Abstract

The effects of climate change on land-based food systems are, and will continue to be, devastating. To preserve lives and livelihoods, policy in the food-climate nexus must help to build resilience and adapt successfully to these changes. Yet farmers, whose tacit knowledge makes them experts in food systems adaptation and whose livelihoods are directly affected by shifts in policy, are conspicuously absent from planning discussions. This is the case in three Eastern Canadian Maritime provinces—Nova Scotia, New Brunswick, and Prince Edward Island—where provincial adaptation planning does not consider climate change a threat to food systems.

This thesis explores the potential and current contributions of farmers' knowledge to adaptation of regional and global food systems. From an empirical perspective, I explain how farmer knowledge has been sidelined in research and policy discussions and demonstrate how farmer-led collective action successfully builds adaptive capacity to climate change. I also contribute to ongoing theoretical discussions by deconstructing the meaning of “resilience” in the context of the implementation of the term in policy in the food-climate nexus.

Its original contributions to research come in three published papers which primarily focus on small-scale vegetable producers in the Maritimes region as a case study of how farmers adapt markets and farms without policy support. Fieldwork insights draw from two sets of semi-structured interviews, conducted and analyzed through grounded theory methodology.

First, I present a systematic literature review of farmer perceptions of climate change in the academic literature. I argue that while the literature certainly recognizes farmers' participation in land management as an essential component of successful adaptation, their knowledge is largely perceived as provisional and open for verification by scientists, rather than trustworthy.

Then, I consider collective action in the food system and its implications for endogenous, grass-roots climate adaptation strategies. Building on interviews conducted in the Maritimes over 2017-2018, the paper suggests that collective action substantively contributes to

adaptation and should be supported by adaptation policy, rather than overturned by top-down policies which dictate changes and adaptations.

Finally, I examine disjointed definitions of the term “resilience” between farmer participants and Canadian climate policy, pointing to the problematic nature of boundary objects in climate and food policy. Building on the notion that resilience is not a politically neutral term, the paper uses the example of studies from Canadian government committees to point out how a loose definition of resilience can entrench the status quo rather than enable necessary adaptations.

The thesis argues that farmer knowledge on successful adaptation is nowhere near as present in adaptation planning processes as the literature suggests it is, or ought to be. It shows that farmers can and do capably generate successful adaptations for entire food systems through collective action with other food system actors. The thesis also warns that while these adaptations require external support, the institutional mechanisms currently in place tend to reinforce the status quo rather than communicate felt impacts or enable transformative change in food systems.

Table of Contents

Abstract.....	ii
Table of Contents.....	iv
List of Figures.....	viii
List of Tables.....	ix
Acknowledgements	x
1. Introduction.....	1
1.1 The purpose of this thesis	1
1.2 Research questions	5
1.3 Thesis structure.....	6
2. Literature review	9
2.1 Food systems and climate adaptation	9
2.1.1 What is a food system?.....	9
2.1.2 How does climate change impact food systems?	14
2.1.3 Current trends in climate adaptation.....	22
2.2 Resilience theory and the climate-food nexus.....	28
2.2.1 What does resilience mean? A field guide to bifurcations	28
2.2.2 How does resilience relate to adaptive capacity?	32
2.2.3 Problems with resilience: discourse and policy.....	36
2.2.4 Is resilience even applicable to policy?	37
2.3 Farmer knowledge and climate adaptation.....	40
2.3.1 What is farmer knowledge?.....	40
2.3.2 Why is farmer knowledge often ignored?	43
2.4 Conclusion.....	47
3. Case study context: the Canadian Maritimes	49
3.1 Agriculture in the Canadian Maritimes	50
3.1.1 Agricultural practice in the Maritimes.....	50
3.1.2 Case study: small-scale vegetable producers.....	52
3.2 Food system vulnerability to climate change	55
3.2.1 On-farm risks.....	56
3.2.2 Infrastructure-based risks	58
3.2.3 Current adaptation planning	59
4. Methodology	63
4.1 Primary data.....	63

4.1.1	Grounded theory methodology	63
4.1.2	Data generation.....	66
4.1.3	Data analysis.....	73
4.1.4	Relational accountability	76
4.2	Secondary data.....	78
4.2.1	Literature review.....	78
4.2.2	Thematic and discourse analysis	80
4.3	Conclusion	82
5.	Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007-2018.....	83
	Abstract.....	83
	Key words	83
5.1	Introduction	84
5.1.1	Why talk about perception?.....	88
5.1.2	Considering the global North-South divide in climate research.....	89
5.2	Methods	91
5.2.1	Data collection.....	91
5.2.2	Analysis	93
5.3	Results	97
5.3.1	Study areas, author affiliations, and research methods	97
5.3.2	Farm production and farmer perceptions.....	99
5.3.3	Defining “perception”.....	101
5.4	Discussion.....	102
5.4.1	Why did most papers cover the Global South?	102
5.4.2	The field does not yet understand its farmers.....	104
5.4.3	The colonial undertones of the North/South divide.....	108
5.4.4	Implications for future research.....	111
5.5	Conclusions	113
6.	Farming Along Desire Lines: Collective Action and Food Systems Adaptation to Climate Change.....	117
	Abstract.....	117
	Key words	117
6.1	Introduction	117
6.2	Methods	121
6.2.1	Research area: the Maritime provinces of Canada	121

6.3	Data Collection and Analysis	124
6.3.1	Grounded Theory Methodology	124
6.3.2	Data Collection and Analysis	124
6.4	Results	128
6.4.1	Types of collective action.....	129
6.4.2	Impacts of collective action.....	137
6.4.3	Relating collective action to climate resilience	138
6.5	Discussion.....	140
6.5.1	Heterogenous groups, shared concerns	140
6.5.2	How does collective action affect food system actors?.....	143
6.5.3	Policy implications of collective action.....	146
6.6	Conclusion	151
	Acknowledgements.....	152
7.	"You keep using that word...": Disjointed definitions of resilience in food systems adaptation.....	153
	Abstract	153
	Key words	153
7.1	Introduction	153
7.2	Resilience as a boundary object in agriculture and climate change	157
7.3	Methods	160
7.3.1	Small-scale farmers and food system actors.....	161
7.3.2	Canadian climate policy documentation.....	165
7.3.3	Thematic analysis: comparison	167
7.4	Results	167
7.4.1	Farmer interviews	168
7.4.2	Canadian climate and food policy discourse	172
7.5	Discussion.....	176
7.5.1	Diverging definitions of resilience for food systems.....	177
7.5.2	Why be resilient?	179
7.5.3	Implications for climate and food policy.....	183
7.6	Conclusions	189
	Acknowledgements.....	190
	Funding	191
8.	Conclusion.....	192
8.1	Summary of research insights.....	192

8.1.1	Insights from papers	193
8.1.2	Cumulative insights of the thesis.....	196
8.2	Research limitations	200
8.3	Implications for research and policy	201
8.3.1	Future research in the food-climate nexus.....	202
8.3.2	Food-climate policy	203
9.	References	206
10.	Appendices	235
10.1	Appendix: Supervisory statements	235
10.2	Appendix: Research Outreach	237
10.3	Appendix: Participant outreach	240
10.3.1	Participant recruitment	240
10.3.2	Sample introductory e-mail	244
10.3.3	Participant Follow-Up	245
10.3.4	Participant consent form.....	246
10.4	Appendix: Interview guides.....	249
10.5	Appendix to Chapter 5: List of reviewed papers.....	251
10.6	How this thesis was impacted by the COVID-19 pandemic	258
	Impacts on fieldwork prior to university closing:	258
	Impacts on the final preparation of the thesis:	258

List of Figures

Figure 2.1 Different conceptions of the relationship between resilience, vulnerability, and adaptive capacity in the global environmental change literature.....	Error! Bookmark not defined.
Figure 3.1 The Canadian Maritime provinces..	50
Figure 3.2 Proportion of total farms by size in the Maritime provinces, 1976-2016	51
Figure 3.3 High tunnel typical of intensive growing in the Maritimes	53
Figure 4.1 Respondents (black dots) in relation to agricultural land capability (shaded green).	69
Figure 4.2 A memo about collective action performed in later analysis stages	73
Figure 4.3 The grounded theory coding process.	74
Figure 4.4 Screen capture from NVIVO 12 showing intermediate and granular-level coding for a single high-level code.....	75
Figure 5.1 Discourse of farmers' perceptions by region	101
Figure 6.1 Desire line, Brighton, UK	119
Figure 6.2 Proportion of total farms by size in the Maritime provinces, 1976-2016.	122
Figure 6.3. Respondents in relation to agricultural land capability.....	125
Figure 6.4 Collective action can build adaptive capacity in the food system	144
Figure 6.5. Ohio State University walkways adapted from desire paths.....	148
Figure 7.1 Interviewee locations relative to agricultural land distribution.....	163
Figure 7.2 Diverging definitions of resilience between farmers and agricultural policy	178

List of Tables

Table 2.1 Seven definitions of resilience with respect to their degree of normativity	31
Table 4.1 Breakdown of participants by type and region.....	67
Table 4.2 Sample questions from interviews (see Appendix 4 for full interview guide).....	70
Table 5.1 Countries included in each region	94
Table 5.2 Farmers' perceptions as characterized by reviewed articles	96
Table 5.3 Examples of discourse typology.....	96
Table 5.4 North-South differences in climate change perceptions research	99
Table 6.1 Interview respondents by region	127
Table 6.2. Categories of collective action	128
Table 6.3. Categories and expressions of collective action.....	136
Table 7.1 Interventions by type of affiliation.....	167
Table 8.1 Synthesis of papers and links to research questions.....	195

Acknowledgements

Writing a thesis is deeply lonely work that cannot happen without a great number of people.

My deepest thanks go out first and foremost to the farmers, farm workers, government officials, food sellers, and market managers who shared their knowledge, experience, and hopes in interviews and conversations. To my supervisors, Kate Sherren and Tom Thornton: thank you for taking me on, guiding me along, and making me a better researcher. À mes parents, Michèle Nadeau et Réginald Soubry, et à mes sœurs Dominique, Élisabeth, et Madeleine: merci d'être là. Je vous aime.

Thanks to the wonderful and various housemates and friends who kept me fed, watered, distracted, and laughing over the years. A special mention to the Kindling crew, who have taught me more than most how to struggle well for a kinder world.

Thank you to my colleagues and friends in the bike mechanics world, who—in the kindest, most supportive way—could not have given less of a shit about my doctorate. Your indifference towards my academic life, and your support in my journey as a mechanic and a rider, kept me sane.

My friends and colleagues at the Environmental Change Institute challenged me, championed me, and stuffed my stomach with Friday tea. My co-writers at the Earth Negotiations Bulletin remind me to see the world for all its breadth and complexity and to write it down without a single adverb.

The following organizations and families provided me with the shelter and time to write, without which I would surely have given myself up to the dark gods of hotdesking: Community Forests International; Dalhousie University; Kate Harris and Kate Neville; Friedel and Sam; Four Seasons Farm; Graham MacDonald of the Land and Food Lab at McGill University; Ferme Agricola; Grazing Days Farm; and Thèsez-vous? (bonne tomate!).

Thank you to the people at the Pierre Elliott Trudeau Foundation, from whom I gained crucial funding and a circle of brilliant friends. Thank you to the Rhodes Trust, which gave me funds, free yoga classes, and unimaginable privileges over four years and beyond. I still don't believe in the moral authority of wealth. I will continue to work with all my heart towards a world in which you no longer exist.

This thesis is for Emily Mann.

1. Introduction

1.1 The purpose of this thesis

In my early twenties, I made my living as a farmer by the Bay of Fundy in Eastern Canada. My back ached from hauling harvests; my fingertips cracked from dry soil. I helped feed people. I thought I could stay apprenticed to the craft forever, but I had started on my farming journey just as climate change became impossible for me to ignore.

It was clear that the impact of climate change would be devastating to food systems. In the valley where I farmed in Nova Scotia, older farmers started complaining about warmer autumns, lack of rain, impossibly harsh winds rattling greenhouses, and new pests appearing. Projections show that changes in precipitation, temperatures, wind, and extreme events will have deeply negative consequences for food production (FAO et al., 2018; W. N. Smith et al., 2013; UPEI Climate Lab, 2017; Vasseur et al., 2008). These include crop failures and nutritional losses; increased soil degradation; uncertain or intensified precipitation; and more frequent extreme-weather events (FAO et al., 2018; IPCC, 2014d). Transportation and storage infrastructure are increasingly vulnerable, impeding distribution and supply chains (Ericksen et al., 2009; S. J. Vermeulen et al., 2012). The nature of the global market implies that the financial and physical hardship caused by climate impacts will fall primarily upon rural populations, especially food producers (Hallegatte et al., 2016). These impacts are wide-ranging and unevenly distributed (John Ingram, Ericksen, et al., 2010).

The Canadian Maritime provinces have a long history of agricultural production, but a neoliberal turn in government policy in recent decades has left smallholders bereft of climate

adaptation support, much like many farming populations in the Global South (Himanen et al., 2016; Lieske et al., 2015; McLaughlin, 1987; Rahman & Hickey, 2019; Savard et al., 2016).

The region is representative of the world in another harrowing way: even in conservative climate change scenarios, its food system faces deep disturbance, leading to possible food insecurity for many and loss of livelihood for the actors who underpin it (Agrawal, 2008; Arnold & Fenech, 2017; Hallegatte et al., 2016).

What does successful adaptation to climate change look like in these circumstances—and what are the conditions necessary to bringing it about? Adequate responses to these questions have been slow to materialize, including in the Maritimes. Those provisions which have been put in place by governments are loosely monitored; poorly fit to scale; and judged largely insufficient (Auditors General of Canada, 2018; Mertins-Kirkwood, 2019). Patterns of climate policy which delay action—waiting either for enough damage to require an emergency disaster response, or top-down initiatives from national bodies—risk encountering a situation too dire to be able to successfully adapt (Ostrom, 2010b; Pelling & Manuel-Navarrete, 2011).

National governments often invoke the need to build "resilience" to climate change into food systems (Government of Canada, 2015; UNFCCC, 2017). In both theory and policy, however, the term is unclear and fraught. Depending on the definition employed, resilience is concerned with maintaining the essential function of a system; facilitating change and transformation; or something in between (Pizzo, 2015; M. Scott, 2013). Historically, food systems adaptation policy has focused on mechanistic attributes of systems such as crop modelling (Porter et al., 2017) and maintaining the status quo of continually increasing food production in spite of

environmental conditions (Beilin et al., 2012; Darnhofer, Fairweather, et al., 2010; FAO et al., 2018; Porter et al., 2017). As a farmer, these methods were completely alien to my own understanding of resilience. They have been criticized in other areas of adaptation theory as well. It's now clear that social processes and relationships are key determinants of resilience and successful adaptation (Adger et al., 2005; Adger, Quinn, et al., 2012; Tompkins & Adger, 2005). Darnhofer et al. (2016) have suggested that, for farmers, resilience aspires much more toward transformation than stability. Could farmers' flexibility and understanding inform the slow-turning cogs of adaptation policy?

In this thesis, I explore the potential and actual contributions of farmer knowledge to the global goal of successful adaptation for regional and global food systems. I do so partly by exploring how farmer knowledge has, like other local and indigenous knowledges, been sidelined across climate policy fora, whether out of ignorance or vested interests in maintaining certain social and economic hegemonies (Bjørkhaug et al., 2012; Laforge et al., 2017; Sumane et al., 2017). I investigate the meaning of “resilience” in order to examine the broader social and political forces which influence its definition and implementation in food policy.

Because I have limited my case study to small-scale vegetable farms, the research in this thesis focuses on vegetable production in land-based food systems. Livestock and perennial crops are an important and non-negligible aspect of land-based food systems, but they are affected differently by climate change (IPCC, 2019b). I focused on one type of yield in this thesis to keep the research load manageable. There has been significant work on the impacts

of climate change on other forms of food systems, such as water-based (Dubey et al., 2017), Indigenous, and non-agricultural food systems (Rotz & Wood, 2018; Wiebe et al., 2011). I choose not to explore them here not out of a lack of interest, but for the sake of concision.

I aim to contribute to both the discussion and implementation of resilience and climate adaptation policy for food systems at regional and global levels. While the literature of the past decade has been rich in debate, it has largely failed to penetrate public discourse, or even discussions within government institutions (Corner et al., 2016). Following calls from several action-based researchers (see, among others, Blay-Palmer et al., 2016; Sumane et al., 2017; van Bers et al., 2016), I attempt to position the papers in this thesis so as to critically reflect on the state of the literature and its practical contributions to climate and food systems governance. Kentucky farmer and writer Wendell Berry is right: it is not sufficient for climate scientists—or climate social scientists, as I’ve come to call myself—to argue about the theoretical implications of their work amongst themselves (Berry, 2003), or to throw up their hands at the thought of an impenetrable so-called science-policy interface (Bednarek et al., 2018; Gluckman, 2016). The scale of the current climate crisis demands radical political ambition and social mobilization; the research that informs them must be just as bold, just as rigorous, and just as concerned with questions of equity and justice.

Much of the work I consider important to this research has taken place outside the thesis. I have been, throughout the execution of this research project, an expert witness to the Senate of Canada; an informal consultant to the Nova Scotia Departments of Agriculture and of Environment; and a lecturer and presenter to farmers, agricultural organizations, and

policymakers. While this advocacy and outreach are not specifically reflected in the thesis document, they remain an essential part of transparent communication and of bridging scientific and farmer knowledges in the policy-making process. Information on my outreach activities can be found in Appendix 2 (research outreach).

This thesis aims to galvanize conversations on what successful adaptation looks like in the Maritimes and in food systems more generally. I chose the Maritimes region as a case study because it is one of my homes. In light of this bias, I also declare a vested interest in its successful adaptation to climate change. Although this document reflects a rigorous research process, it also unapologetically works towards the healing of the world.

1.2 Research questions

This thesis aims to understand current opportunities for farmer knowledge and its associated endogenous¹ adaptation to contribute to the successful adaptation of food systems to climate change. Using smallholder farmers in the Canadian Maritimes as a case study, it asks the overarching question: **what are the implications of the current practice of sidelining farmer knowledge in research and policy for building food systems adaptation to climate change?**

Within this scope of inquiry, the thesis addresses three empirical sub-questions:

¹ A number of terms are used to describe adaptations which are of local origin, and often self-directed. “Autonomous” adaptation speaks to a separate nature from the planned kind but does not quite point to adaptations restricted to a particular community. “Autochthonous” adaptation would provide a clearer link to human-ecosystem relations which inspire adaptations, but is not currently in common usage (Thornton et al., 2019). In this thesis, I describe “autonomous” adaptations separate from “planned” adaptations, and consider “endogenous” adaptations, meaning adaptations coming from within a particular group, with all their relationships, both social and ecological.

- What is the role of farmer knowledge in informing avenues for research and policy on food systems adaptation to climate change?
- How do farmers' endogenous adaptation practices emerge and interact with planned adaptive structures in land-based food systems?
- What opportunities and challenges exist in building successful food systems adaptation policies which complement existing endogenous efforts and local knowledge?

These questions are addressed in different ways in the following chapters. Table 8.1 gives an overview of how each sub-question is explored by each of the three research papers.

1.3 Thesis structure

This thesis focuses on three research papers, all of which have been published or are under review in peer-reviewed journals at the time of submission. I am the lead author and principal researcher for all three articles, though my co-supervisory team have made substantive contributions to each (see Appendix 1). The chapters which precede them provide context for the various theoretical approaches that inform the research and detail the methodologies which informed data collection and analysis.

Chapter 2 reviews the literature which informs the research papers, focusing on three areas of the literature and highlighting the gaps that my research has identified. Firstly, it considers the current state of climate change adaptation theory and policy as these relate to food systems. Secondly, it considers the concept of resilience as it relates to food systems, highlighting a serious rift in resilience theory which endures in climate policy. Finally, the review looks at

the role of farmer knowledge and expertise in research and policy related to climate change, linking it to other forms of local and Indigenous knowledges.

Chapter 3 provides a brief overview of my case study area, with a focus on the state of agriculture in the Canadian Maritimes; its vulnerability to climate change; and the present state of adaptation policy in the region. It introduces them as a case study of small-scale agriculture in a food system with minimal interactions with policy.

Chapter 4 gives an overview of the methodological theory which informs my research practice, concentrating on grounded theory methodology; participant observation; and thematic analysis. The chapter provides a summary of how I selected participants and literature for data generation and collection, as well as how data were analyzed in each research process. Each paper provides a more detailed explanation of the specific methods it uses.

The next three chapters are each a main research paper. **Chapter 5** presents a review of farmer “perceptions” of climate change in the academic literature. It argues that while the literature certainly recognizes farmers' participation in land management as an essential component of successful adaptation, their knowledge is largely perceived as provisional and open to verification by scientists, rather than trustworthy. **Chapter 6** considers collective action in the food system and its implications for endogenous, grass-roots climate adaptation strategy. It suggests that collective action should be viewed as a *desire line* from which adaptation policy can be drawn, rather than relying on top-down policies to dictate changes and adaptations.

Chapter 7 examines disjointed definitions of the term “resilience” between farmer respondents in the case study and Canadian climate policy, pointing to the problematic nature of boundary objects in climate and food policy. Building on the notion that resilience is not a politically neutral term, it uses the example of committee studies from the Canadian government, including one in which I was a participant, to point out how a loose definition of resilience can serve to entrench status quo agendas rather than advance transformative adaptation.

Chapter 8 summarizes the findings of this thesis and its implications for theory, research practice, and climate adaptation policy. It also presents possible avenues for future research based on the limitations of the current project and the lessons learned in bringing it to term.

Included at the end of the document are a series of appendices which provide more context for the research project, including interview guides and an anonymized list of participants.

As noted above, Chapters 1-4 give context for the methods and the case study used in chapters 5-7. I have taken care not to unnecessarily repeat information which already exists in the research papers. Due to their nature as published papers, however, certain language and figures are inevitably repeated between the papers and their contextual chapters.

2. Literature review

Before presenting the insights from my research, I want to explore three facets of research literature which provide essential context to this thesis' research questions. The first is the current state of climate impacts on food systems, and the necessity of a food systems perspective more generally. The second is the problematic nature of "resilience" as a concept in both academic literature and adaptation policy. The third is how farmer knowledge is treated in research and in policy, and the ways in which it can inform responses to the impacts of climate change. This chapter provides the necessary background to the research project as a whole without attempting to be an exhaustive exploration of each concept; rather, it aims to provide the context required for readers to engage with each individual empirical paper. The full literature reviews relevant to those papers are contained in chapters 5-7.

2.1 Food systems and climate adaptation

Adopting a food systems perspective is essential to comprehend how climate change affects food production, distribution, and consumption, as well as how adaptation measures can be put into place to protect livelihoods and food security. I first explain what is meant by a "food systems" perspective in the literature, as well as arguments for its use. Second, I summarize climate-related impacts and risks to global food systems. Finally, I explore some of the critical gaps in climate-food research and policy raised in the literature.

2.1.1 What is a food system?

The basic definition of a "food system" encompasses all of the food-related activities and transformations in which humans participate (John Ingram et al., 2016; S. J. Vermeulen et al.,

2012). The main steps of these include the manufacture and distribution of inputs, such as fertilizers; the work of agricultural or aquacultural production; primary and secondary processing activities; the storage, transport, and distribution of food; the retail and marketing of food as a consumer product; the transformation, consumption, and management of food in domestic and commercial spheres; and the treatment and disposal of waste (S. J. Vermeulen et al., 2012). The definition of a food system broadens when one considers all of the activities and institutions which govern food chain activities and their related outcomes: policy, regulations, and trade all affect food systems (Hospes & Brons, 2016; John Ingram et al., 2012). All humans participate in food systems in some way, and with different objectives; they are therefore bound to them by sociocultural mores and guidelines (Cohn et al., 2017; John Ingram et al., 2016). Importantly, while food systems can be considered by researchers at a global level, there is no one "global food system": rather, food is a mesh of interdependent, interlinked, sometimes nested systems that operate at multiple scales (Schipanski et al., 2016).

More recently, the literature has moved beyond the production-consumption supply chain to consider issues of governance, power, and agency in food systems. The Committee on World Food Security's High-Level Panel of Experts (HLPE) has redrawn its definition of food systems, arguing that a food systems lens should consider inputs from ecosystems, as well as human, energy, economic, and health systems (HLPE, 2020a). Its updated definition calls for food systems governance and policy to be scrutinized, noting that governance systems "[seek] to shape the ways in which drivers of food system change affect food systems, consumer behaviours, and the rules by which supply chain actors must operate" (HLPE, 2020a, p. 12). Building on the FAO's definition of sustainability in food systems, the HLPE argues that a

sustainable food system is productive and prosperous; equitable and inclusive; respectful and empowering; resilient; regenerative; and healthy and nutritious (FAO et al., 2020; HLPE, 2020a). These qualities go beyond the initial definitions of food systems, and thus necessarily involve a perspective that includes human rights; food and land governance; and human and ecosystems health, among others.

The need for a food systems perspective that also includes ecological, health, and political systems has emerged from the realization that research and policy have historically mistaken production capacity as an indicator of food security and agricultural health; and from broader trends in systems thinking and grounded analyses of food and agriculture (Erickson et al., 2010; John Ingram et al., 2016). Global discourse around food has historically focused on food security, the state when “all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” (FAO et al., 2020). Yet food security, per its definition, centres not on food production but on human access and agency. More recently, its definition has also been explicitly linked to environmental sustainability, which provides the capacity for healthy ecosystems to undergird continued food production across generations; and human agency, which involves respecting the rights of people and groups involved in food systems to make choices and shape the governance of these systems (HLPE, 2017, 2020a). Ensuring food security across generations is not limited to understanding how to produce enough food to feed people; it invites a holistic perspective "spanning the humanities and social and economic sciences, rather than just biophysical sciences" (John Ingram, 2011, p. 418).

Yet policy related to food security—especially considering shocks such as climate change—has historically emphasized purely agricultural metrics such as crop productivity in its modelling (FAO et al., 2018; John Ingram, 2011; Knowler & Bradshaw, 2007). A number of researchers have pointed out that food systems modelling related to climate change mainly focuses on impacts on crop productivity (Darnhofer, 2014; John Ingram et al., 2012; Porter et al., 2017; Rosenzweig et al., 2018) without significantly considering direct socioeconomic or political impacts. Moreover, while the work of high-level expert panels can expand the definition of food systems and food security in line with calls from civil society (Edelman et al., 2014; Fairbairn, 2012; HLPE, 2020a), there remains a gap between the literature and the application of theory at the policy intervention level (Altieri et al., 2015a; Isaac et al., 2018).

Adopting a food systems lens is an exercise in shifting perception of food from a singular process to a multi-level, dynamic set of nested social-ecological systems (Ericksen et al., 2010; HLPE, 2020a; Hospes & Brons, 2016). It changes the focus from production to a more complex understanding of inputs, outputs, opportunities, and vulnerabilities across multiple systems. It is far more complex to implement than a production-based perspective, given that it needs to take into account multiple factors at different levels and scales, many of which must be measured according to different metrics (Rutten et al., 2016; Wheeler & von Braun, 2013). It also allows research and policy to explore the impacts of climate change not only on the production of food, but also the socioeconomic aspects of the food system, including but not limited to questions of labour; political power; international trade; distribution infrastructure; and food sovereignty, among others (C-CIARN, 2002; Clapp & Scott, 2018; Friedmann, 1995; Wiebe et al., 2011).

Including social, political, and economic systems within the scope of food systems has the merit of clarifying both the drivers of change and potential intervention points within a climate change adaptation context. In the context of climate adaptation, this helps reveal the drivers of risk and change on vulnerability and adaptive capacity for food systems (HLPE, 2020a, 2020b; Mason et al., 2021). These include, but are not limited to, the governance of farmers' and seed corporations' intellectual property rights over plant germplasm (Tsioumani, 2021); the continued trend of mergers between industrial agrochemical corporations, and the increased financialization of the agricultural sector (Clapp, 2018; Clapp & Stephens, 2019); and the increasing concentration of land ownership away from smallholders across both the global North and global South (Holtslander, 2015; Nally, 2015). Moreover, including political economy and socio-cultural aspects of food systems in climate adaptation research requires the inclusion of qualitative perspectives in work which has formerly leaned heavily on quantitative modelling (Soubry et al., 2020b). Considering food system actors' agency, as well as the governance structures which restrict or enable them, allows climate adaptation researchers to link into other frameworks around development, human rights, and ecosystems management, creating a more holistic field of research and—hopefully—more successful adaptation programmes at the policy scale.

Climate change affects people differently across cultures, economic standings, sectors, and levels; food systems are no different. A food systems perspective argues that, in order to understand how the climate-food nexus can generate successful adaptation, research and policy dialogues must expand beyond questions of production into concerns of equity, sovereignty, and power—especially in the context of adapting to climate change. Having considered the

importance of a food systems perspective, I now apply the lens to the impacts of climate change on land-based food systems.

2.1.2 How does climate change impact food systems?

Despite the diversity of land-based food systems, it is possible to draw together some common projections of they how are, and will be, affected by climate change. Global assessments agree that increasing global temperatures pose large risks to food security globally and regionally, especially in low-latitude areas (IPCC, 2018b, 2019a). Environmental change will affect crop production and its associated processes; distribution and storage infrastructure; and the socioeconomic structures within and around food systems. I consider each in turn.

Firstly, with regard to crop production, yields are expected to significantly decrease in the long term regardless of region (Chen et al., 2016; Dinesh & Vermeulen, 2016). Increases in average global surface temperature lead to plant stress and subsequent crop failure, reducing yields and thus livelihoods especially in warmer low-latitude areas (Cabas et al., 2010; IPCC, 2014d, 2019a; Porter et al., 2017; Rosenzweig et al., 2018). Warming will also reduce the overall nutritional concentrations of staple crops such as maize and rice, reducing the quality of food products and potentially exacerbating malnutrition (Alexandratos & Bruinsma, 2003; IPCC, 2019a; Rosenzweig et al., 2018). The potentially beneficial impacts of climate change on plants tend to be negated by other factors. Increased levels of atmospheric CO₂ may temporarily boost plant growth, and warmer temperatures allow for longer harvesting seasons (W. N. Smith et al., 2013). However, yield boosting only occurs within specific concentration brackets, after which yields typically decrease; moreover, increased temperatures for harvest are likely to be offset by

colder, wetter springs, meaning that any gains from crops planted later in frost-free autumns may be offset by fewer early plantings (IPCC, 2019a; Soubry, 2017c). Drought and flooding events, both of which have increased in frequency across regions, place significant stress on production and can make soil impossible to cultivate (IPCC, 2019a; Miller et al., 2013). Extreme wind events contribute to higher evaporation in plants, requiring increased investment in irrigation systems (Birkenholtz & Birkenholtz, 2014); they can also put significant strain on season-extension infrastructure such as greenhouses (Comoé et al., 2014; Tilman et al., 2011). Increases in flooding globally due to precipitation, erosion, and sea level rise can cause agricultural land to become contaminated: coastal agricultural areas are increasingly at risk of saltwater intrusion from sea level rise (Arkema et al., 2013; Jellett, 2013; Savard et al., 2016), while areas adjacent to waterways are vulnerable to flooding and associated landslides (Street, 2016). Ground and surface water can be affected by flooding, reducing the minerals available to irrigation systems and contributing to a lowering of nutritional quality in crops, as has previously been observed in Europe and the United States (FAO, 2015; Hallegatte et al., 2016). Moreover, the poleward migration of pests and diseases will negatively affect both crops and the producers responsible for them (Hatfield & Takle, 2014). All these pressures are projected to significantly hinder food security and production.

Secondly, the effects of warming trends and more frequent extreme events puts the global infrastructure for food storage and distribution under significant pressure and risk. Higher latitudes which rely on cold weather to keep temperature stabilization costs low will require additional refrigeration capacity (S. Vermeulen & Dinesh, 2016). As humidity levels increase, so will concomitant risks of spoilage for grains and pulses (S. J. Vermeulen et al., 2012), as well as

vectors for disease which can be transmitted through stored grain or livestock (IPCC, 2019a). Food distribution infrastructure, which is largely centralized and consolidated in the Global North, risks damage to its transportation networks (Boyle et al., 2013; FAO et al., 2018; IPCC, 2014e). For example, more frequent flooding may damage roads and highways, especially in rural areas with lower capacity to rebuild (ACASA, 2016; John Ingram et al., 2016; World Bank, 2015); and high-latitude areas will likely suffer infrastructure losses around roads which depend on ice or permafrost (Manuel et al., 2015; S. J. Vermeulen et al., 2012). The increase in frequency and variety of extreme events, moreover, can lead to severe infrastructure damage or conditions too dangerous for food transporters to traverse, whether for normal food distribution or to provide emergency food aid to communities after a disaster (IPCC, 2019a; Ulrichs et al., 2015).

Thirdly, climate impacts to food systems generate significant social and economic risks beyond those discussed above. Because food is traded as a commodity in a global market, the impact of climate change on commodity prices can be wide-ranging and nonlinear: consumption patterns and seed prices may drastically rise or fall in different regions, even though global production capacity remains stable (Alexandratos & Bruinsma, 2003; Burke & Emerick, 2016; Hallegatte et al., 2012; OECD & FAO, 2017). Estimates from the World Bank suggest that climate-induced price hikes would increase extreme poverty, especially in large-population countries in the Global South (Hallegatte et al., 2016; Hertel et al., 2015). The IPCC notes that rural areas are disproportionately affected by climate impacts on water management, food security, and agriculture-based incomes (IPCC, 2019a). While certain analyses point to an increase in global temperatures as a net benefit to agricultural incomes, economic modelling projects that, "even in

the long run [...], the negative impacts through consumption prices and yields dominate the positive impacts on agricultural incomes in almost all scenarios" (Hallegatte et al., 2016, p. 60).

It is also worth bearing in mind the direct impacts of climate change on agricultural labourers, especially those who may not benefit from standard labour or citizenship protections (Weiler, Otero, et al., 2016). Increased heat and humidity trends will impair the ability of farmers and other production workers to labour outdoors for long periods of time, especially in low-latitude areas (IPCC, 2014a, 2019a). These conditions will make production and day labour difficult, if not dangerous, particularly in larger-scale operations that may not uphold workers' rights (Weiler, 2018; Weiler, Levkoe, et al., 2016). In North America, for example, temporary foreign workers are typically hired through low-wage streams, systematically denied forms of permanent residence, and are rarely provided with adequate social and health-care protections (Madan, 2017; Radel et al., 2018). Climate change will likely exacerbate these social issues and thus contribute to current crises in agricultural production.

The impacts of climate change on food systems are not one-way: global food systems are a significant source of greenhouse gas emissions. Agriculture, forestry, and other land use activities—including global food systems—account for up to 37% of global greenhouse gas emissions (IPCC, 2019c). The sources of these emissions include but are not limited to agricultural inputs, which are sources of nitrous oxide and other gases; methane released through animal agriculture; land degradation and deforestation for agricultural purposes; emissions related to food transportation; the energy required to store and generate packaging for food; and food wasted, which accounts to up to a third of all food produced for consumption, among others

(John Ingram et al., 2012; IPCC, 2019c; S. J. Vermeulen et al., 2012). In this analysis, I focus specifically on adaptation, and therefore have not produced a comprehensive overview of food system impacts on climate change. This is an editorial choice to maintain concision and clarity of narrative, but it's important to bear in mind the complexity of the relationship between climate change and food systems, and to acknowledge the ways in which mitigation and adaptation are often inextricably linked (Fanzo et al., 2017; IPCC, 2019b).

In order to respond to these impacts, endogenous and planned adaptation efforts have sought to change the ways in which food systems operate. I consider some of these efforts below.

2.1.3 The political economy of food: some context informing adaptation

Before discussing trends in climate adaptation, I want to give some context about the global political economy of food systems. This section does not attempt to be comprehensive, but rather to show that power is unequally distributed in the world, and that the same forces which shape food systems shape how they adapt to climate change. In that spirit, I want to consider three recent trends in global food systems:

First, the consolidation of agricultural input corporations—seed and agrochemicals—over the past two decades has reinforced the preponderance of industrial agriculture. Since the “green revolution” of the 1950s and 60s, hybridized seed producers and chemical fertilizer, pesticide, and herbicide producers have grown to a dominant share of the global agri-food inputs market, triggering massive adoption of industrial monocultures to produce crops (Jacques & Jacques, 2012; Jarosz, 2012). This growth led to rapid corporate consolidation in the 1990s and 2000s,

culminating most recently in German chemical giant Bayer's acquisition of Monsanto, the world's largest genetically engineered seed producer (Beaulieu, 2015; Clapp & Purugganan, 2020). Four companies now control three-quarters of the agro-industrial inputs market (Kelloway & Miller, 2019). Seed and chemical giants have invested heavily in agriculture technologies—including, for example, biotechnology—while maintaining an iron grip on intellectual property, thus actively preventing farmers from saving seed or producing new varieties (Altieri & Rosset, 1999; Dale, 2002; Tsioumani, 2021). Thus, the number of firms controlling the dominant agricultural model continues to dwindle, while those firms' powers and influence increase (Clapp, 2018).

Analysts of this consolidation have argued that it has led to a concomitant rise in agrochemical use and loss of agrobiodiversity. Corporations have produced genetically modified seed for monoculture in conjunction with agrochemicals, thus ensuring that producers who use the former are tethered to the latter (Altieri & Rosset, 1999; Mauro & McLachlan, 2008). This relationship has been linked to a host of environmental and human health problems: for example, glyphosate—the main ingredient in Monsanto's most popular herbicide—has been declared likely carcinogenic by the World Health Organization (Clapp et al., 2018; D. Glover, 2010). Moreover, scientists and policymakers alike have expressed concern about a large variety of crops being replaced by patented monocultures, noting that the loss of crop diversity which has occurred over the past fifty years has significantly weakened agroecosystem resilience and contributed to global biodiversity loss (Altieri et al., 2015b; Zimmerer, 2010).

Secondly, the growing presence of financial actors in food systems has exacerbated power and wealth inequity in the world and increased economic and ecological vulnerabilities in agroecosystems. “Financialization”—the growing importance of financial motives and actors in shaping the global economy—has led to large-scale parcels of land being bought up by financial actors for their financial rather than agricultural value (Clapp, 2014; Holtslander, 2015), the emergence of futures trading on food as a commodity (Clapp, 2019; Edelman et al., 2014; Mylona et al., 2016), and—as discussed above—the consolidation of for-profit transnational agrochemical corporations whose aims lie largely with satisfying stakeholder groups.

Critics argue that this trend has transformed the global agri-food sector into one which privileges short-term financial goals over long-term sustainability (Isakson, 2014). The increased financialization of the sector has been traced to exacerbate land grabbing; food price volatility; agrobiodiversity loss; water shortages; and livelihood insecurity (Clapp, 2014; Clapp et al., 2018; Clapp & Purugganan, 2020; Hospes & Brons, 2016; Isakson, 2014; Mooney et al., 2021). Moreover, the presence of financial actors in food systems makes these processes far more difficult to map, and thus reverse. Rather than tracing a banana from tree to plate, an interested critic of the agri-food industry must now understand links between investment funds, derivatives, land purchasing, and name-changing transnational corporations (Clapp, 2015; Goldstein & Newell, 2020). Though the tracking of such corporations may become easier through nascent methodologies (Goldstein & Newell, 2020), the trend of financialization abstracts food from its physical form, and renders it into a commodity derivative only understood by a highly selective group of insiders (Isakson, 2014).

Finally, attempts to regulate these dynamics and to govern food systems at the national or international level are weak and fragmented at best. Political scientists argue that nation-states are primarily concerned with issues of trade competition rather than ecosystem or livelihood sustainability, choosing to uphold trade agreements over environmental treaties which might impinge on agricultural exports (Clapp, 2017; Fischer et al., 2005; Zabel et al., 2014). While there are international bodies which govern food and biodiversity, such as the UN's Food and Agriculture Organization; the International Treaty for Plant and Genetic Resources for Food and Agriculture; and the Convention for Biological Diversity, these are largely seen as ineffective at corporate regulation. They are state-led, and their decisions do not directly affect transnational corporations (Kloppenburger, 2010; Tsioumani, 2021). Their applications are largely voluntary and carry little legal weight outside of countries' enforcement of ratified agreements. They have also failed to agree on positions regarding some of the most contentious aspects of industrial agri-food, such as genetically engineered crops or synthetic biology, and are largely considered antiquated compared to the speed of technological change and corporate consolidation (Earth Negotiations Bulletin, 2017, 2019; Tsioumani, 2021). Moreover, beyond the governance sphere, there is significant disagreement between scientists on how best to characterize and promote a sustainable agriculture: as I discuss below, the debate between frameworks supporting CSA, regenerative agriculture, agroecology, or many other framings makes it possible for transnational corporations to claim sustainability as much as the peasants opposing their objectives (Clapp & Purugganan, 2020; Edelman et al., 2014; Saj et al., 2017).

The project of adaptation to climate change does not take place in a political vacuum. The research papers which follow illuminate some of the ways in which farmers are set aside for the

sake of other political and economic interests. Governance institutions will necessarily make decisions for adaptation policy by balancing a number of factors. The above demonstrates, however, that farmers and agribusiness not equal in global discourse or power.

2.1.4 *Current trends in climate adaptation*

Literature and policy reviews have found that, though multiple forms of adaptation are possible—including transformations in financial flows and supply chain management—most food systems adaptation policy focuses on changing farm practices (Himanen et al., 2016; Smit & Skinner, 2002). Despite this trend, certain civil society and peasant movements have called for changes that address systemic issues in environmental and social justice. Here, I consider three current approaches to climate adaptation for food systems: climate-smart agriculture, regenerative agriculture, and agroecology.

Climate-smart agriculture

The concept of *climate-smart agriculture* (CSA) encompasses approaches geared towards "sustainably increasing agricultural productivity and incomes; [...] adapting and building resilience to climate change [and] reducing and/or removing greenhouse gases emissions, where possible" (FAO, 2013, p. ix). To achieve these, CSA advocates for a number of agricultural and subsidy practices, including the use of new intensification techniques, soil health management, and irrigation, among others (Chandra et al., 2018). The framework has been embraced by United Nations organizations such as the Food and Agriculture Organization and the Framework Convention on Climate Change, and larger monetary organizations such as the World Bank (FAO, 2013; UNFCCC, 2017; World Bank, 2015). In championing "climate-smart" practices,

these institutions emphasize the framework’s “triple win” approach—linking climate mitigation, food production, and global development goals (World Bank, 2015). The concept has heralded a range of financial incentives for countries in the Global South to fund CSA projects from financing organizations, and has been widely adopted among developing countries’ climate adaptation commitments (Chandra et al., 2016; Clapp et al., 2018).

Though the framework has gained traction remarkably quickly at the international level since its first use in 2009 (Taylor, 2018), much of the academic literature on CSA points out just how vague the practices it embraces tend to be. Firstly, its framework as defined is largely concerned with increasing crop productivity, which takes attention away from farm management systems, distribution networks, retail politics, and consumer behaviour (Martinez-Baron et al., 2018; Raj et al., 2017). Moreover, CSA does not promote any new techniques or policies for agricultural adaptation; according to its critics, its discourse largely recycles older, and sometimes contradictory, practices into an amalgam of potential techniques that do not necessarily question established paradigms of food production (Neufeldt et al., 2013; Scherr et al., 2012; Taylor, 2018; Whitfield, 2015). Finally, CSA frameworks have come under scrutiny for perpetuating global inequalities, including intellectual property rights (Tsioumani, 2021), consolidating corporate power through development projects in the Global South (Clapp & Scott, 2018; Newell & Taylor, 2018), and consolidation of land ownership (Beilin et al., 2012). For its critics, CSA “serves to strengthen and reinvigorate the status quo of the post-1980s neoliberal food regime” (Newell & Taylor, 2018, p. 125).

Regenerative agriculture

Another trend in agricultural adaptation to climate change is *regenerative agriculture*, a compendium of agricultural practices which focuses on building soil organic matter and increasing soil-carbon sequestration (Giller et al., 2021). Its purported benefits could hardly be more strongly stated than by the Rodale Institute, which claims that “regenerative organic agriculture can sequester carbon from the atmosphere and reverse climate change” (Rodale Institute, 2014, p. 1). The term invokes the ways in which food systems industrialization has largely removed nutrients and biodiversity from agroecosystems, and supplants this form of agriculture with one that aims to restore ecosystems health and reduce emissions through a transformational turn in agricultural practice (Giller et al., 2021; Gosnell et al., 2019). At its core, it comprises organic farming practices such as cover cropping, residue mulching, composting, and crop rotation; other techniques, such as conservation tillage, are considered “regenerative” despite not being used widely in organic production systems (Rodale Institute, 2014). Since 2016, the term’s use in books, news stories, and film has exploded, and the term has been adopted by a wide range of NGOs, multinational companies, and charitable foundations (Giller et al., 2021).

Some have argued that, though regenerative agriculture brings together a compelling narrative on the failures of industrial agriculture and the ways in which agriculture could change to better adapt, its solutions do not necessarily take into account local realities or cultures (Gosnell et al., 2019). Giller et al. argue that, regenerative agriculture provides a compelling, universalist, but ultimately difficult-to-apply story (2021). Critiques of the kind are compounded by the enormous claims that its proponents make, combined with a relative dearth of empirical studies on the effectiveness of “regenerative” techniques on soil carbon uptake (P. Smith et al., 2019). Finally,

there are significant concerns that regenerative agriculture's uptake by multinational companies means that the term has been co-opted on a surface level, and that—much like “climate-smart” agriculture—any technique could be deemed “regenerative” as long as it fits within a narrative, regardless of its effectiveness on a biological or human level (Gosnell et al., 2019; Newton et al., 2020).

Agroecology

Much like the above two terms, the concept of *agroecology* encompasses a number of practices, and has been used with sometimes competing definitions since the 1980s (Mason et al., 2021). On farms, agroecological practices focus on building diversity within systems, including through crop-livestock mixed, diverse systems; organic soil management; water conservation; and the general enhancement of agrobiodiversity (Altieri et al., 2015a). Where agroecology diverges from regenerative or climate-smart agriculture, however, is in its explicit focus on the social and political dimensions of food systems. Proponents of agroecology argue that its methods of peer-to-peer knowledge dispersion aim to build social capital and defend rural livelihoods in the face of corporate control and an increased concentration of agribusiness (Altieri & Rosset, 1999; iPES Food, 2016; R. Schattman et al., 2014). Studies on agroecology point out that while farmers use its practices to increase nutrient cycling, they also have political motivations, such as to counter macro-scale food systems phenomena; to improve community food security and sovereignty; and to express autonomy and protect themselves from uncertain and uneven market relations (Isaac et al., 2018).

While the agroecology as a political movement has spread internationally, it remains somewhat contained to proponents of smaller-scale, short-circuit food systems—which is unsurprising, considering the fact that it considers a highly corporatized, business-driven model to food systems incompatible with climate adaptation (Cockburn, 2015). The diversity of uptake within the movement has made it difficult to define and apply in a concerted manner in the political sphere: there are different understandings of agroecology as an on-farm practice, as a political movement and tool, and as a science across academic disciplines (Bezner Kerr et al., 2019; Isaac et al., 2018; La Via Campesina, n.d.; MacRae et al., 2013). Though popular among certain contingents of social scientists and social justice-driven activists, agroecology remains outside mainstream climate adaptation frameworks (those led, for example, by the UNFCCC or the World Bank) and corporate pledges (Saj et al., 2017; Taylor, 2018; Webb et al., 2011).

Climate adaptation trends in food systems: less about practices, more about power

All these approaches consider changes at the farm level in order to increase biodiversity and resilience, reduce emissions, and maintain productivity. Reviewing these approaches clarifies the diversity of framings around climate adaptation and food, and also highlights the ways in which political and economic forces can shape adaptation practice and narrative.

CSA, for example, has come under fire for claiming to shift global paradigms of food production while effectively keeping global food systems in the same hands which have guided them over the past fifty years (Chandra et al., 2018; Clapp et al., 2018; Jost et al., 2017). Its overall objective—maintain or increase production levels—pushes aside concerns about the power dynamics that are inherent to land ownership, intellectual property, or workers' rights; in doing

so, CSA regimes risk perpetuating these inequalities (Chandra et al., 2018; Martinez-Baron et al., 2018; Taylor, 2018).

Regenerative agriculture, meanwhile, applies a universalist frame about changes in production methods to an incredibly diverse food system, and places the lion's share of responsibility on individual farmers rather than the producers of agricultural inputs, land managers, or national governments that set agricultural policy (Stock et al., 2014). Its enthusiastic adoption by multinational corporate interest may be a signal that, beyond the purported climate benefits of its practice, its definition is vague enough for its association to benefit those corporations financially without actually tethering them to systemic change (Holt Giménez et al., 2011; Kelloway & Miller, 2019).

Agroecology, though diverse and self-contradictory, approaches climate adaptation from the premise that the forces—social, political, and economic—which have built failing food systems over the past decades must be interrogated and reshaped, and their power structures inverted before any lasting climate adaptation can occur (Edelman et al., 2014; Jansen, 2015).

Unsurprisingly, however, it has little uptake from large-scale agribusiness or international-level adaptation plans.

My purpose is not to suggest that any one approach is most effective, but to drive home how closely linked food systems adaptation framing is to political and economic interests. Regardless of the framing taken up by food system actors, analysis of adaptation approaches must ask: whose interests are being served by these purported solutions? Who are most vulnerable? And

whose voices can be heard when adaptation policy is established? These questions have been championed by development and disaster risk reduction researchers for decades (Adger, 2003; Arora-Jonsson, 2011; Toussaint & Martínez Blanco, 2019); they are essential in food systems adaptation research. The following section applies this principle to another framing in considering food systems adaptation: that of resilience.

2.2 Resilience theory and the climate-food nexus

What follows is not an attempt to catalogue the ways in which resilience is defined in climate change literature: several useful attempts have already been made, and I will refer to them throughout (Bahadur et al., 2010; Brown & Westaway, 2011; Meerow et al., 2016; Nelson et al., 2007; M. Scott, 2013). Rather, I want to focus on three areas in which definitions of resilience tend to bifurcate: its purpose, its fundamental nature, and its relationship with other concepts in adaptation theory. I'll then consider how a lack of clear definition affects how "resilience" has been mobilized in policy. The purpose of this exploration is to demonstrate that the concept of resilience is normative, and that applications of the idea in policy must be made carefully. In articulating some of the many contradictions and confusions that exist in resilience theory at present, I want to ask: what is the point, really, to resilience?

2.2.1 What does resilience mean? A field guide to bifurcations

Likely the best example of how the definition of resilience in research can be confusing is the synthesis provided by the Intergovernmental Panel on Climate Change (IPCC):

***Resilience:** the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also*

maintaining the capacity for adaptation, learning and transformation. (IPCC, 2018a, p. 557)

The paragraph brings up essential questions. Is resilience about coping with shocks, or adapting to trends? Is it about maintaining "essential function", or transforming it? What is the difference between "responding" and "reorganizing"? And what does any of this theoretical pinballing mean in practice? Confused as one may be emerging from the glossary definition, its clauses handily synthesize some of the main historical tensions in resilience theory.

First, the IPCC's definition showcases a tension between what Scott (2013) characterizes as "equilibrium" and "evolutionary" resilience: whether systems "maintain their essential function" or have "the capacity for adaptation, learning, and transformation" (IPCC, 2018a). Earlier climate science assessments, including the IPCC, initially kept to a brief definition: the "amount of change a system can undergo without changing state" (IPCC, 2001, p. 383). When resilience emerged as a concept—first in physics, then in ecology (Folke et al., 2002)—the term was a measure of a system's capacity to absorb change and disturbance while maintaining the same relationships between other variables (Brand & Jax, 2007). The literature around this conception of the term emphasizes a return to a steady state after a short-term disturbance or shock (M. Scott, 2013). Such an understanding of resilience tends to be characterized by a desire for a return to the status quo, to stability as it was known prior to disturbance (Brown, 2011). Yet such a desire invites questions: is the status quo of a system necessarily desirable? What if the system's present conditions invite shock to begin with? What if the system's "resilience" reinforces inequality or oppressive dynamics? In such cases, the transformation of a system may

become necessary to maintaining integrity or avoiding future shocks (Carr, 2019; McManus et al., 2012).

In contrast with this tendency toward "equilibrium resilience" is what Scott characterizes as "evolutionary resilience": a system's ability to cope with shocks through adaptation and transformation. In this understanding of the definition, resilience is the ability to change, learn, and transform while maintaining systemic integrity (M. Scott, 2013). Change or disturbances are anticipated as a natural part of a system's evolution (Darnhofer, 2014; Himanen et al., 2016). Across the literature, "evolutionary" resilience is closely associated with examinations of social-ecological systems (Fikret Berkes, 2009; Bohle et al., 2009; Folke, 2006); encompasses the possibility of adaptive, collaborative networks (Fikret Berkes & Ross, 2013); and takes a largely qualitative approach to how systems and their actors contribute to resilience, seeking out broad indicators rather than specific metrics (Bottrell, 2009).

Between these two forms of resilience is a vast spectrum of articulations of the term, falling somewhere between the conservatism of more mechanistic definitions, which aim to describe a present state, and the radical transformational notions espoused by some adaptation theorists, who prefer a normative approach where resilience is a normative aim. Brand and Jax (2007) provide an exhaustive overview of the definitions of resilience, as do Moser et al. (2019). I won't attempt to reproduce the extensive cataloguing which has already been made, but Table 2.1 (below) gives a sense of some of the major definitions across the field and where they lie on the spectrum.

Table 2.1 Seven definitions of resilience with respect to their degree of normativity
(adapted from Brand & Jax, 2007)

		Definition	Authors
equilibrium ↑	descriptive	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
		The ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change	Adger 2002
		The ability of the system to withstand either market or environmental shocks without losing the capacity to allocate resources efficiently	Perrings 2006
conception	hybrid	The underlying capacity of an ecosystem to maintain desired ecosystem services in the face of a fluctuating environment and human use	Folke et al. 2002
		The capacity of a social-ecological systems to absorb recurrent disturbances (...) so as to retain essential structures, processes and feedbacks	Adger et al. 2005
← evolutionary	normative	The ability of a system to adjust in the face of changing conditions	Pickett et al 2004
		A power-laden framing that creates certain windows of visibility on the processes of change, while obscuring others	Cote and Nightingale 2012

A second way to qualify resilience is its ontology: what is it, and what does it measure? If the term originates in the literature as a metric for a system (Holling, 1973), its different uses have fundamentally altered its nature. Moser et al. (2019) identify three general states that researchers ascribe to resilience. First, some consider it a *system trait*: here resilience refers to specific traits in the object of study, whether its redundancies, connectivity, diversity, or efficiency, among others (Brown & Westaway, 2011; Romero-Lankao & Dodman, 2011; Tyler & Moench, 2012). Secondly, the literature treats it as a *process*, where resilience is the act of integrating local knowledge; collaborative or multilevel governance; or fostering social learning, among others (Bahadur et al., 2010; Biggs et al., 2012; Wilkinson, 2012). Finally, for some, resilience is an *outcome*: literature which follows this perspective focuses on the stability or change of state in a

system, invoking ideas of robustness, risk reduction, or transformation, for example (Ahern, 2011; Matyas & Pelling, 2015; Meerow et al., 2016). These perspectives are not necessarily incompatible. Researchers often alternate between these approaches in the literature, depending on their needs; or combine ontologies in the same research project. Such ontological diversity can cause conflict: Moser et al. note that "debates over interpretations persist within and among fields as if there was a single "correct" [definition]" (2019, p. 26). The reality seems to be that resilience is both definitionally and ontologically compromised across disciplines, within spheres of research, and occasionally within the same project. If its own nature is uncertain, its relationship with other concepts in climate adaptation theory may be more so. To illustrate this point, I want to examine the interaction between resilience and the concept of adaptive capacity.

2.2.2 How does resilience relate to adaptation?

This thesis talks about resilience theory within the context of the project of climate adaptation. Given the nebulous nature how each concept is defined, it may be useful to briefly discuss how each relates to the other.

Adaptation and resilience differ in how they approach human systems and vulnerability, among other concepts. Historically, adaptation has taken an actor-centric view, based on the interventions that humans make within systems to reduce or eliminate vulnerabilities to risk (IPCC, 2014e). It focuses, among other things, on "decision-making and the power to implement these decisions" (Nelson et al., 2007, p. 398). The IPCC distinguishes between *incremental* adaptation, which "maintains the essence and integrity of a system or process at a given scale" (IPCC, 2018a, p. 542), and *transformational* adaptation, which "changes the fundamental

attributes of a socioecological system in anticipation of climate change and its impacts” (IPCC, 2018a, p. 542). A system adapts *to something* by *doing something*: it responds to external stimuli to systems, such as climate change or one of its impacts, by consciously making a small or large change.

A resilience framework to climate change, meanwhile, takes a systems-based approach, beginning from the understanding that change, not stasis, is a central characteristic of systems (Adger et al., 2011). Considering resilience therefore allows for the consideration of how a dynamic equilibrium is kept between human and nonhuman actors and systems. Unlike a traditional adaptation approach, this framing does not seek to eliminate vulnerabilities; rather, it seeks to understand how to maintain a system’s capacity to respond in spite of persistent vulnerabilities (Endfield, 2012). This response capacity may include a transformative component; because systems can experience multiple kinds of stable states, “stresses the importance of preparation for surprises and system renewal” (Nelson et al., 2007, p. 412) , including potentially transformation (Brown, 2015).

Both frameworks converge, however, in trying to identify the necessary components for adaptation. Questions of equity, power, and governance are rife in both adaptation and resilience frameworks. They occur when considering whether actions that aim to reduce vulnerability in one area may in fact increase it in another (Schipper, 2020), or in considering the many ways in which funding institutions control political power, especially in a development context (Eriksen et al., 2021; C. A. Sova et al., 2017). Resilience and adaptation can be mutually generative in practice, allowing for multiple frameworks with which to understand how systems change

(Thorén & Olsson, 2017) and complementing deficiencies in the other. Adaptation planning, for example, can be path-dependent, creating static solutions for static vulnerabilities (Shaw & Maythorne, 2013): by integrating a resilience framework, practitioners integrate the idea that change is constant, and that vulnerabilities will change based on a system's state (Nelson et al., 2007).

One disadvantage of those two frameworks coexisting, however, is that they get confusing, which can cause communities of practice to take up less effective views of how adaptation should work (Carr, 2019). One example of this kind of confusion exists in the idea of “adaptive capacity”. The concept is central in climate change literature, but—much like resilience—has no clear definition for use. The IPCC synthesis definition goes in a few different directions, referring to “the ability of systems, institutions, human and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (IPCC, 2018a, p. 542). As in the case of resilience, this definition reflects the different ways in which adaptive capacity is used without necessarily clarifying any of them. Significant confusion arises, however, in understanding how adaptive capacity and resilience are related. The IPCC's adaptation framework includes depictions of resilience and adaptive capacity as subsets of vulnerability and risk, but the relationship is somewhat less clear in much of the climate literature. Figure 2.1 shows how resilience is as likely to be framed as a subset of adaptive capacity as the reverse in most literature, and that the relationship is further dependent on whether a paper is discussing resilience in the context of disaster risk reduction or environmental change (Cutter et al., 2008; Folke, 2006; Moser et al., 2019).

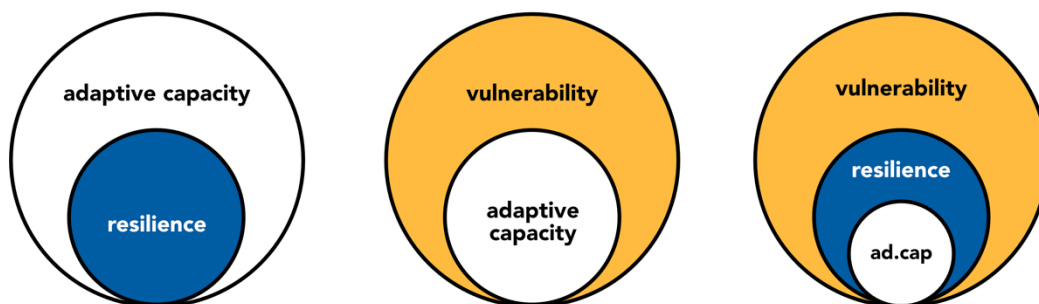


Figure 2.1 Different conceptions of the relationship between resilience, vulnerability, and adaptive capacity in the global environmental change literature, adapted from Cutter et. al (2008). See also Brown and Westaway (Brown & Westaway, 2011), Gallopín (2006), IPCC (IPCC, 2014d), and Engle (2011).

Resilience and adaptation frameworks have thus far failed to produce a cogent understanding of adaptive capacity, or of how to avoid confusing one for the other. Critics of these frameworks point out a lack of clarity in conceptualizing and applying resilience, both in policy and in theory (Brown, 2015), which often translate into policies which have goals running counter to each other (Cutter et al., 2008). Whether resilience is a process or an outcome, or what the root causes of vulnerability truly are, become crucial questions when applied to the field of disaster risk reduction (Ribot, 2014); lack of clarity in these can provoke ineffective action or misuse of funds in even the most optimistic scenarios (Matyas & Pelling, 2015). As I'll now explore, these frameworks are often taken up by institutions without a full understanding of their dynamic nature.

2.2.3 *Problems with resilience: discourse and policy*

Reviewing the breadth of definitions for resilience can teach two important things about resilience which explain why its use continues despite lack of clarity.

The first is that resilience is clearly a *boundary object*: a concept for which so many different definitions have emerged that no one clear understanding of what it means exists in any literature (Brand & Jax, 2007). Boundary objects are useful, particularly in transdisciplinary contexts such as climate adaptation, because they allow disparate opinions and backgrounds to unite over a single concept, thereby creating opportunities for dialogue which might otherwise not have occurred (Martin, 2015). Yet they are less useful when that dialogue does not occur. Without meaningful discussion of the terms in question, they can risk becoming what Lindenmayer & Fischer (Lindenmayer & Fischer, 2007) call *panchrestons* (from the Greek, "good for everything"), theories which fit all cases—and are therefore meaningless. Other disciplines have been witness to this effect, with once-meaningful terms being deployed with little regard for their original definitions. "Ecosystem services", which once referred to a specific set of effects provided by ecosystems toward humans, is now used across a number of disciplines and in a number of physical and cultural contexts (Abson et al., 2014; Combetti et al., 2015). In the case of resilience, discussions have emerged as the concept's context has evolved; the result, however, is that a clear definition has never been more elusive (Carr, 2019; Moser et al., 2019).

This vagueness may be understandable if one considers that as a boundary object, resilience has become a normative term rather than a descriptive one. If its historical meaning aimed for objective metrics (such as a metal's capacity to absorb shock), it is now less a measure of a

system and more a "way of thinking" (Moser et al., 2019). Whether a social system transforms or stays the same in the face of a shock such as climate change is a political, social, and economic choice, not a physical one. One of the ensuing consequences of resilience as a boundary object is that a vague definition may mask its political nature, allowing certain actors in power to invoke measures in the name of "resilience" without explicitly discussing what is meant by the term, and thus hide political, social, and economic consequences (Brown, 2015; Nadasdy, 2007). I explore the potential consequences of resilience as a politicized boundary object in Chapter 7.

What happens when vague terms become entrenched? Critiques of vulnerability studies, for example, have pointed out that certain climate-related concepts have become institutionalized as ways of thinking, funding, and enacting social science (Cameron, 2012). The concept of resilience is not immune to this institutionalization: whole research centres are named after the term. But critics of resilience frameworks have openly wondered whether there is enough agreement on what resilience means for it to be useful in strategies and policy, or whether its value lies exclusively in the academic discourse surrounding it.

2.2.4 Is resilience even applicable to policy?

If resilience means whatever we want it to mean, how can it accurately inform climate and food policy? One current criticism of resilience theory is that research and policy seem disconnected: Moser et al. argue that "despite efforts to incorporate transformation into resilience thinking in some circles, resilience efforts remain focused on maintaining the status quo and incremental change rather than radical transformation" (2019, p. 30). In other words: is resilience theory actually applicable to policy advice anymore, or is it just a self-contained conversation between

researchers? Brown has argued for the necessity of resilience as a perspective in sustainable development, suggesting that it "can potentially enhance [...] our policy responses to enhance well-being and life opportunities, particularly of poor people" (Brown, 2015). Theoretical discussions document an increasingly "social turn" in resilience discourse (Brown, 2014), as the field has considered concepts such as social capital in communities (C. J. Paul et al., 2016); socio-ecological resilience in transformation (Carpenter et al., 2001); and resilience as an organizing principle in grassroots action (Fikret Berkes & Ross, 2013). Though these discussions are often rooted in case studies, there remains little evidence that theory has fed back the other way: that is to say, that resilience theory has proven useful to practitioners, either in grassroots or in policy, to mitigate the effects of climate change (Bahadur et al., 2010; Roesch-McNally et al., 2018).

Additionally, a lack of critical discourse around how resilience is used has allowed for use of the term across policy spheres, especially climate policy, in ways which reinforce and entrench existing power structures. Cote and Nightingale point out that discussions of resilience theory, with some exceptions, tend to focus on the structures of institutions rather than their political, historical, or cultural relationships (Cote & Nightingale, 2012). Hornborg and others have argued that current literature around socioeconomic resilience largely masks power relations, conflicts, and inequality in human systems (2013; see also Jerneck et al., 2011; Ribot, 2014). As a result, resilience becomes politically neutral in discourse when it ought to be recognized as normative, which leaves openings for the term to be co-opted to the politics of its user. Brown's (Brown, 2011, 2015) examinations of resilience frameworks in policy reveal that while resilience as a concept is gaining political traction, its definition captures none of the complexity it usually has

in academic discussions. More often than not, the concept of “resilience” in policy cleaves to a conservative framing and aims to stabilize the economic order by privileging market-based solutions of incremental change rather than radical transformation (Beilin et al., 2012; Brown, 2011, 2015). If its academic discourse is ignored, what substantive purpose is there for resilience theory, especially under the lens of climate adaptation?

I have established that one of the reasons resilience is so pervasive as a concept is its nature as a boundary object, which allows multiple (and sometimes contradictory) ontologies, definitions, and relationships to be ascribed to it without necessarily needing to be resolved. Within research, this variety may be useful: it challenges established ideas and generates interesting frameworks. A boundary object may also enable entrenched institutions to reconceptualize themselves more broadly, given exposure to different ways of thinking. But the lack of critical applications of resilience on the ground calls for further examination.

My interest in the literature surrounding resilience theory focuses on how it contributes to the successful adaptation of food systems to climate change. If resilience can mean anything policymakers want it to mean, there is a risk that food systems policy might reinforce unequal or extractive practices. What outwardly champions successful adaptation may inwardly limit change in order to reinforce the status quo (Beilin et al., 2012; Kenny, 2011; Laforge et al., 2017). Discourse and debate are essential to the theoretical foundations to our disciplines, but research can only serve policy if it understands its own impact, including its institutionalized ideologies, and can communicate its own debates critically.

In the research papers which follow, I'll examine ways in which resilience theory is deployed across the food systems literature and policy landscape. Before that, however, I want to explore the relationship between climate adaptation, food systems, and those most affected by both: farmers themselves.

2.3 Farmer knowledge and climate adaptation

If producers are vulnerable to climate change, they are also best placed to describe its impacts firsthand and inform responses. Recent literature acknowledges farmers' deep engagement in the food system beyond production (Fletcher et al., 2020; MacMillan & Benton, 2014; Sumane et al., 2017). It also recognizes that integrating multiple forms of knowledge, including farmer knowledge, across policy discourse is key to addressing wicked problems such as climate change (Grosfoguel, 2013; Jagers et al., 2019; Meadows & Sustainability Institute, 1999; Turner et al., 2008). It further acknowledges that scientific approaches to land management have largely set farmer experiences aside, along with other crucial aspects of food systems, in favour of more reducible variables (Sherren & Darnhofer, 2018). In what follows, I explore the concept of "farmer knowledge" in the literature, its relationship to climate change, and some of the ways in which it has been ignored or minimized by policy.

2.3.1 What is farmer knowledge?

The concept of "farmer knowledge" emerges from the broader concept of local ecological knowledge (LEK), which is increasingly recognized as a key component of landscape management and policy (Díaz et al., 2015; Falardeau et al., 2019; Jagers et al., 2019; Reed, 2008). LEK encompasses the "dynamic and complex bodies of know-how, practices and skills

developed and sustained over time on the basis of local people's experiences in their environmental and socioeconomic realities" (Sumane et al., 2017, p. 2). It is closely related to the concept of traditional ecological knowledge, which encompasses "the body of knowledge, beliefs, traditions, practices, institutions, and worldviews developed and sustained by indigenous [sic], peasant, and local communities in interaction with their biophysical environment" (Gómez-Baggethun et al., 2013, p. 72). In recent years, advocates have pressed, both in literature and practice, to include LEK in frameworks to manage socioecological systems (Armitage et al., 2009; F Berkes, 2007; P. Olsson, Folke, & Berkes, 2004). Advocates in the literature argue that, while governing institutions are effective at leveraging land management policy, they lack capacity to gather and understand the full contexts of social-ecological systems, which provide much of their day-to-day management and are also strongly affected in top-down management (Plummer & Armitage, 2007). Some propose that LEK can partner with land managers and policymakers to form a model of adaptive "co-management", where local knowledge holders test and revise new forms of management in a dynamic, iterative, often self-organizing process (Folke et al., 2002; P. Olsson, Folke, & Hahn, 2004; Pinkerton, 1989). Many have observed that scientific models of land management and their on-the-ground impacts are vastly improved by the integration of traditional and local knowledges, especially in the case of local adaptations to climate change (Armitage et al., 2009; Bennett, 2016; Fikret Berkes & Ross, 2013; Raymond et al., 2010). Understanding and managing system dynamics becomes a shared responsibility between local knowledge holders and governance institutions: each works to inform the other, fill knowledge gaps, and create shared expertise which enhances local management practices (Agrawal, 1995; P. Olsson, Folke, & Berkes, 2004).

Recent cross-disciplinary scholarship has pointed out that farmer knowledge should be recognized as a valuable contributor to discussions on adapting food and land systems to climate change (F Berkes, 2007; Bush et al., 2019; CCAFS, 2016; FAO et al., 2018; Nelson et al., 2007; Oliver et al., 2012; Raymond et al., 2010). As a form of local ecological knowledge rooted in the practical experience and skill of farmers, farmer knowledge allows them to produce according to specific local conditions. Successful food production depends on an intimate understanding of local conditions and trends (FAO et al., 2018; Vervoort, 2013). It also requires a similar depth of knowledge about the available economic, ecological, and cultural resources in the food system in which they interact (Lamarque et al., 2014; McKitterick et al., 2016; Scoones & Thompson, 1994, 2009). To grow food is to be faced daily with complex, urgent, multivariate problems; decisions must consider the economic, environmental, and human implications of their impacts (Chambers et al., 1989; Darnhofer et al., 2016; Scoones & Thompson, 2009).

Farmers exist in complex networks of food system actors where formal and informal knowledges overlap (Sumane et al., 2017). As close observers of land and food systems, they are thus the “ultimate applied scientists” when facing the challenge of climate change adaptation (Sherren & Darnhofer, 2018, p. 7). There are, of course, limitations to farmers’ knowledge: much like scientific discourse, farmers can be conservative, biased due to their own productivist stances, or can confuse ideology with data (von Glasenapp & Thornton, 2011). Yet the possibility for ideological bias is not sufficient to push aside a whole facet of understanding; scientists, too, can be conservative, or biased, or ideologically slanted. To claim their objectivity would be to assert hegemony of one knowledge form over another (see Foucault & Gordon, 1980). Farmer knowledge can provide crucial insight into local vulnerabilities and assets which would not

necessarily be recognized by policymakers operating at a distance. Including them in management discussions can thus provide access to rural communities and networks otherwise distant from the reach of adaptation policy, which helps policymakers connect with concerns, knowledge, and endogenous innovation on an informal, local level (Oliver et al., 2012; B. M. Smith et al., 2017).

Beyond additional benefits to management, however, it could be argued that the strongest reason for farmers' inclusion in climate adaptation planning for food systems is an ethical one: they are the first to feel the impacts of climate change, and will suffer the consequences of both climate impacts and adaptation policy before most (Hallegatte et al., 2016; IPCC, 2019a; Kenny, 2011; Roesch-Mcnally et al., 2018). Smallholders and large-scale farmers often face similar levels of financial precarity, and will suffer similarly, if in different forms (Niles & Brown, 2017; Shrestha et al., 2017). Considering farmers' needs and insights therefore allows adaptation solutions to be equitable as well as effective (Turner et al., 2008).

2.3.2 Why is farmer knowledge often ignored?

Despite the fact that involving farmer perspectives in management has been well-documented as a useful solution, their voices have historically gone unheard in climate adaptation governance (Bhatasara, 2017; Julie Ingram, 2008; Scoones & Thompson, 2009; Sherren & Darnhofer, 2018; Sumane et al., 2017). This sidelining is principally caused by three reasons: the colonial dynamics of knowledge acquisition in the academy, which have historically obscured the needs and contributions of populations in the global South; the undermining of informal knowledge

structures by formal ones; and a preference for quantitative data over qualitative work in literatures related to agriculture and food systems.

First, the technologies of colonialism have systematically removed adaptation agency from the global South and obscured farmers from international discussions of food systems adaptation. Academic discourse writ large has come under critique for its Northern-centric universalism: Grosfoguel (Grosfoguel, 2013) makes the memorable point that, for all intents and purposes, a single set of Western men from Eurocentric institutions have dictated the boundaries of truth and validity in academic discourse in the past century. Agriculture research has followed a similar path: development efforts in the Global South have often used the structures and technologies of colonialism to achieve their aims and, in doing so, have reinforced them (Escobar, 2012b; Hendrix, 2017; Kloppenburg, 1991). By championing scientific knowledge and the bureaucratization of societies, colonialism's normalization of a homogenized knowledge structure has created a sense of inferiority for local and indigenous knowledge-holders, who may begin to think of themselves as underdeveloped in the face of research inquiries from a seemingly superior global North (Escobar, 2012a; Miller et al., 2013; Murphy, 1987). Despite notable movements of resistance, local responses to crises in the Global South are often dampened by and cleave to structures of the Global North-led research, obscuring the role of farmers in putting forward successful adaptation strategies (Taylor, 2018).

Secondly, farmer knowledge is often considered an informal or “tacit” form of knowledge, which has created a division between “informal” farming knowledge and “formal” scientific knowledge. As I explored above, farmer knowledge is “based in their practical experience, and

often linked to a practical skill” (Sumane et al., 2017, p. 2). Characterizing it in this way highlights farmer knowledge’s close ties to the socioecosystem, but also sets it in opposition to a formal scientific knowledge which aspires to objectivity and generalizability (Carolan, 2006; Houser et al., 2017; Reimer et al., 2014). It also implies that because farmer knowledge is locally focused, it is not applicable outside its local environment. Farmer knowledge can thus be devalued through codification at the hands of industry and science (Eilola et al., 2014; Jansen, 2015). The resulting power dynamic ensures that, from the point of view of informing action and future policy, “scientific knowledge [attains] virtually undisputed intellectual hegemony” (Kloppenburg, 1991, p. 519). The power dynamic reduces farmer knowledge to an informal curiosity, ensuring that, within policy, “farmers [...] are tacitly understood to be rude, crude, and somewhat stupid” (Scoones & Thompson, 2009, p. 49). Little wonder, then, that farmers are largely absent in policy discussions of climate change.

One final cause of the erasure of farmer voices in policy is methodological: a preference in the academic literature for quantitative over qualitative data tends to obscure different complexities and nuances regarding farmer knowledge and climate change. At present, farmer experiences are largely communicated across scientific literature through quantitative datasets—latitudinal surveys, crop models, and other descriptive statistics (IPCC, 2019a; OECD & FAO, 2017; Porter et al., 2017; van Dijk, 2012). Climate-related analyses in food systems literature tend to focus on the material structures of farms, which leads to technical analyses rather than qualitative understandings of the relationships between farmers and food systems (Darnhofer, 2014). Qualitative social science methodologies, which rely on methods such as focus groups, long-form interviews, or participatory research are relatively rare and have received an increasingly

colder reception in agriculture-related journals (Sherren & Darnhofer, 2018). The reasons for a preference toward quantitative work is unclear. It may be because qualitative assessments are harder to review *en masse*, given that they rarely use the same metrics. Regardless of the cause, the consequences are likely to include fewer farmer voices in research literature, and a repositioning of farmer involvement in climate research as data point rather than actor or research collaborator. Farming populations may be involved in quantitative research by giving answers to surveys, but farmers rarely guide the design of this research. This weakens the tenor and quality of their representations in research output and thus obscures potent source of insight for adaptation policy regarding food systems.

Farmer knowledge and climate change: where to from here?

These gaps in the literature around farmer knowledge are potential starting points for future research on climate change adaptation in food systems. How can farmer knowledge contribute to existing frameworks for climate adaptation? The IPCC's "solution space" for climate impacts highlights the importance of local knowledge, calling it a "key element for the [...] systems which influence observations of and responses to climate change" (IPCC, 2014d). If farmers' experiences of climate change are a key element of solutions but have largely been removed from current conversations, how can they be regained, and provide necessary guidance on food systems adaptation policy?

Moreover, given its current paucity in the literature, what does good qualitative research on the food-climate nexus look like? Farmers are only generally involved as data points rather than sources of complex knowledge (Scoones & Thompson, 2009). The question of how qualitative

social science methods can meaningfully contribute to food systems adaptation solutions remains an open one. Exploring qualitative methods may open research discourse beyond a vision of food systems as mostly productivist, drawing attention back to the interactions between production, distribution, transformation, and consumption (John Ingram et al., 2012; Schipanski et al., 2016; S. J. Vermeulen et al., 2013).

2.4 Conclusion

In this discussion of the literature, I explored the state of current discourse along three interconnected areas of concern for climate adaptation and food systems. I considered the need to view climate adaptation from a food systems perspective, because it allows for a more complex understanding of the interactions between actors across all stages in the food life cycle; and I recapitulated the current vulnerabilities of food systems to climate change. I explored the notion of "resilience" in the context of climate adaptation theory, emphasizing that its nature as a boundary object—that is, a term with so many definitions that no single one holds clear dominance—is a mixed blessing. While it allows for discussion across different disciplines, the vague boundaries of the term leave it open to being used to justify status quo policies rather than necessary transformations. Finally, I considered the place of farmer knowledge in the food-climate nexus, arguing that the current corpus of literature places too light an emphasis on farmer perspectives despite the potential contributions they could make to food systems climate adaptation policy.

The theoretical foundations explored herein also point to a broader responsibility of researchers in the food-climate nexus to clarify the purpose and positionality of their research. Broad,

critical, self-reflexive research is needed in climate adaptation theory and practice; the alternative is not only ineffective, but potentially harmful (Adger, Quinn, et al., 2012). Presenting quantitative data as authoritative is not helpful if it fails to engage with qualitative socioeconomic realities; in fact, it may obscure them. Research may be perceived as authoritative by policy if it uses jargon that's in vogue, but these terms can be co-opted far beyond their intended meanings. If climate adaptation research does not hold the actors most affected by climate change at the centre of its work, these terms may be used against them, rather than to safeguard their livelihoods. A critical discourse of food systems, resilience and adaptation, and farmer knowledge, is essential to effective—and just—responses to climate impacts.

3. Case study context: the Canadian Maritimes

This thesis presents a case study for food systems adaptation to climate change by examining three Eastern Canadian provinces of New Brunswick, Nova Scotia, and Prince Edward Island. These provinces are known as the Canadian Maritime provinces (hereafter “the Maritimes”; see Figure 3.1). In this chapter, I present an overview of the case study’s context, considering agricultural practices in the Canadian Maritimes as well as the population of small-scale vegetable producers with which I interacted during my fieldwork. I also summarize the currently projected impacts of climate change on the region, focusing on their effects on the vulnerability of farms and food systems. Throughout the chapter, I highlight some of the realities and challenges of small-scale agriculture in the region through some of my fieldwork photos (see Figs. 3.3, 3.4, 3.5).

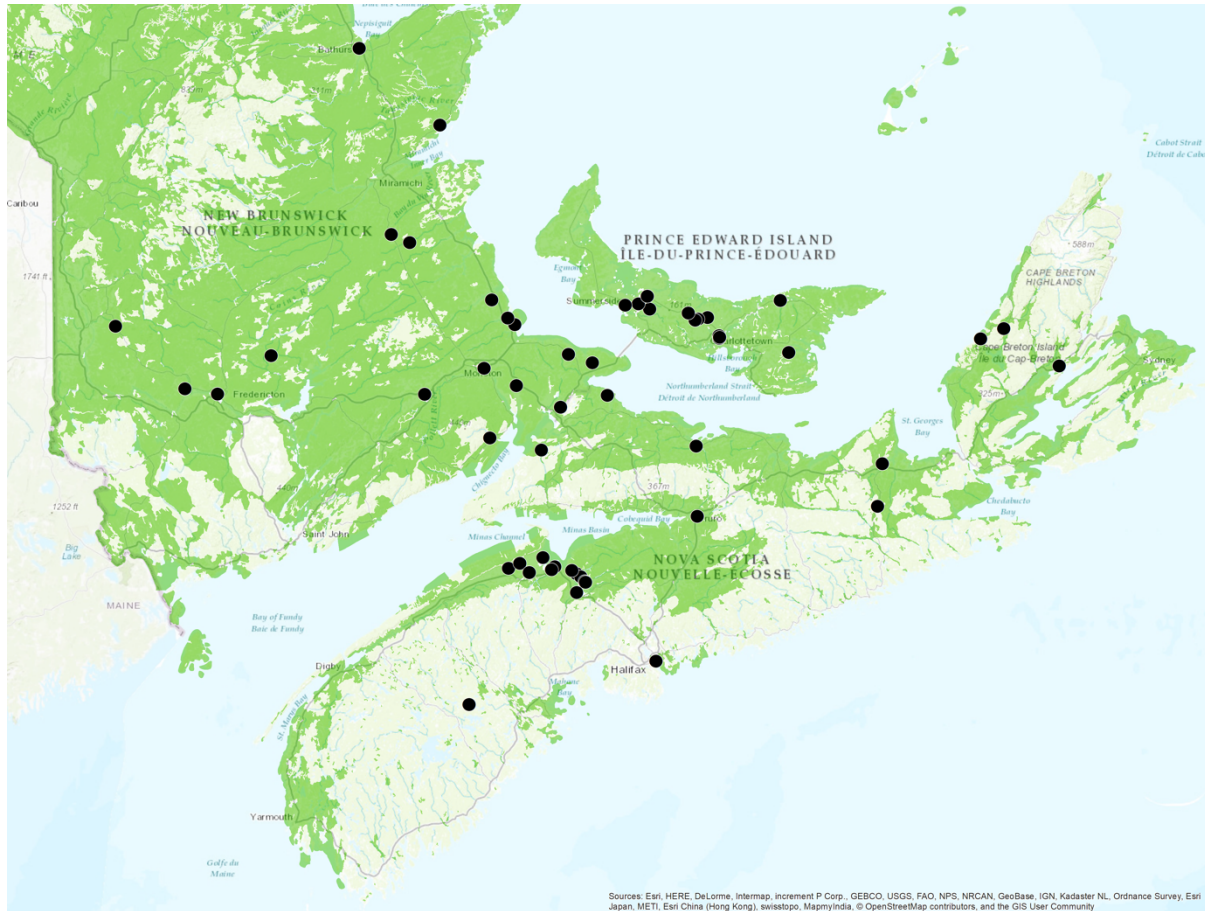


Figure 3.1 The Canadian Maritime provinces. Theoretically viable agricultural land is highlighted in shaded areas. Dots are interview locations (see chapter 4).

3.1 Agriculture in the Canadian Maritimes

3.1.1 *Agricultural practice in the Maritimes*

The economy of the Maritimes has historically been defined by agriculture—first in the subsistence farms of early settler-colonial activity, and more recently by industrial, export-oriented production (Beaulieu, 2015; Burge, 1987; McLaughlin, 1987; Wade & Robichaud, 2011). Farms across the region cultivate grain, fruit, and vegetables, as well as a significant proportion of livestock; there is also economically significant production of non-food items such as spruce (for Christmas trees) and mink (for fur) (Statistics Canada, 2019).

Middle-sized farms in the region have decreased in proportion in the past thirty years, while small and large farms have increased (see Figure 3.2); this is also a national pattern (Statistics Canada, 2017a). Meanwhile, the Maritimes also face a demographic challenge: much like the rest of Canada, the number of farmers is decreasing overall as their average age increases (Beaulieu, 2015; Statistics Canada, 2019). While the Maritimes show some increase in small farm numbers, the number of farms continues to decrease overall: the total number of farms in the region decreased by approximately 30% between 1996 and 2016, from 10,075 to 7,086 (Statistics Canada, 2017b).

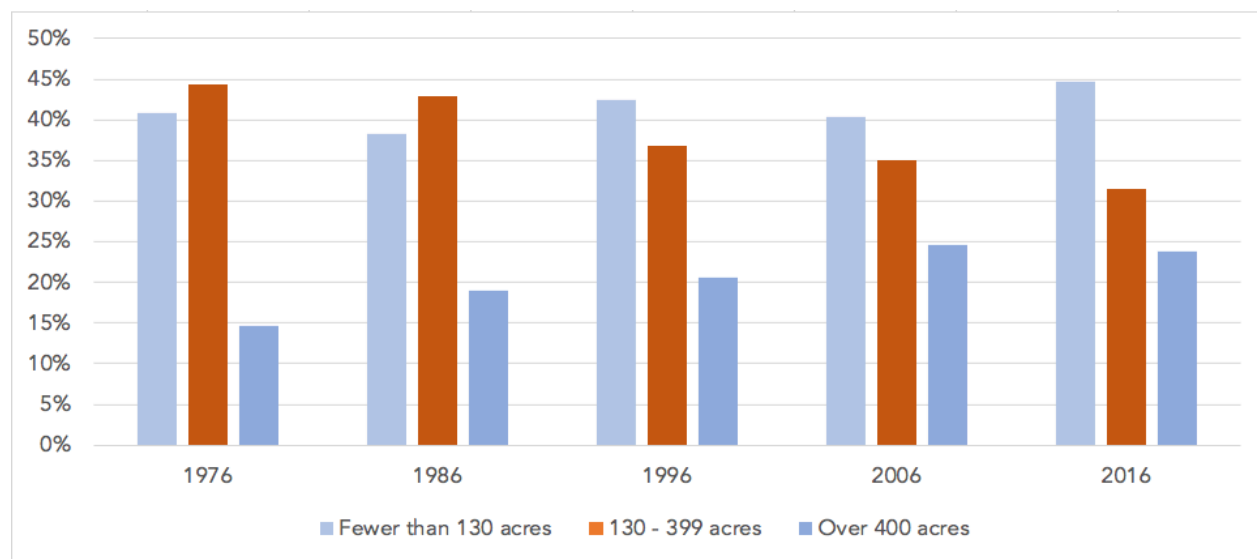


Figure 3.2 Proportion of total farms by size in the Maritime provinces, 1976-2016. (Statistics Canada, 2019)

Federal and provincial agricultural policies are primarily focused on the production of crops for export, and have consequently focused on larger-scale farms as a means of establishing that demand (Agriculture and Agri-Food Canada, 2020; Vanderlee et al., 2017; Wiebe et al., 2011).

Multinational corporations have a particular stronghold on Prince Edward Island, where a significant amount of potato production is sold directly for export (Murphy, 1987; Vanderlee et al., 2017).

3.1.2 Case study: small-scale vegetable producers

This thesis focuses on a sub-population of agricultural producers: small-scale vegetable farmers. The term “small-scale” is contested in the agricultural literatures, where scale can either refer to the land area used by a farm or to the level of income produced annually. For my purposes, I align my definition of “small-scale” with Statistics Canada, namely any operation of fewer than 130 acres (Statistics Canada, 2019). Within the Maritimes, and especially for vegetables, however, land use tends to be significantly smaller for vegetable production.



Figure 3.3 High tunnel typical of intensive growing in the Maritimes: here, multiple crops share season-extension infrastructure. Early summer squash grow on the left, while snap peas and herbs share beds on the right. Season extension allows for earlier plantings and harvests.

Small-scale producers are an interesting population by which to consider the impacts of climate change on the food system because of their relative isolation from political and institutional support, either in terms of growing practices or adaptation planning; and because their sale markets are highly networked. Because of the federal and provincial focus on supporting large-scale export markets, smaller-scale producers have largely tended to build their own niches to ensure points of sale (Soubry et al., 2020a). It is common for smaller farmers to sell exclusively through of direct marketing, whether that be selling at farmers' markets; directly selling to consumers through on-farm market stands or informal networks; or organising Community Supported Agriculture (CSA) schemes which take payment in advance in exchange for a set amount of food provided throughout the season (Canadian Organic Growers et al., 2016;

Farmers' Markets of Nova Scotia, 2013; Jellett, 2013).

Policies aimed at agricultural development, such as the Canadian Agricultural Policy and its predecessors, have followed a similar focus towards large-scale agricultural exports (Government of Canada, 2019b). Development opportunities are focused on the type of infrastructure a large-scale vegetable farm might have, including machinery and pesticide storage, crop insurance, and large-scale business development. As a result, uptake in programmes for on-farm infrastructure development tends to be lower among small-scale farmers, who feel the programmes are neither enough, nor well-suited for their purposes and too time-intensive to be worth applying for (Soubry, 2017c).

3.2 Food system vulnerability to climate change

Climate change has already produced observable impacts in the Maritimes (Bush et al., 2019; Savard et al., 2016). The food system has proven itself to be vulnerable to rapid environmental changes (Savard et al., 2016; Soubry, 2017b). I've already discussed the implications of climate change on food systems generally in Chapter 2, but will highlight the most significant risks to the food system of the Maritimes given current projections.



Figure 3.4 Small-scale farms often employ easily-moved polytunnels to cover crops and allow for earlier maturation and harvest. Unlike greenhouses, these tunnels are loosely anchored, and can therefore be moved many times in the same season.

3.2.1 On-farm risks

Climate impacts have affected, and will continue to affect, production patterns across the region. Qualitative assessments of the region have identified several areas of vulnerability on-farm; for a more thorough exploration of these risks, please see Soubry (Soubry, 2017b). Crop stress has increased due to a number of factors, including higher, sustained winds, and warmer temperatures, which dry out plants and reduce crop fertility (Hatfield & Takle, 2014); higher levels of drought; and extreme weather events (Savard et al., 2016). More intense hurricane and other extreme weather events across the regions' coasts present a high risk for on-farm infrastructure such as barns, greenhouses, and storage infrastructure, often causing crop loss if vital structures like greenhouse plastic need to be cut down during storms to save the undergirding structure (see Figure 3.4, above) (R. E. Schattman et al., 2018). Erratic precipitation has led to rain and snow coming in large events rather than at regular intervals; this can cause erosion in unprotected soils (in the case of rain) and significant stress in season-extension structures (in the case of snow) (Savard et al., 2016). Pests and diseases which were not previously common to the region have spread northward, increasing crop stress especially in vegetable monocultures (Jellett, 2013). Farmers have also noticed what they term a "seasonal shift" characterized by wetter, late springs and warmer, dry falls which extend into November (Soubry, 2017b). Finally, high-temperature days have increased in number over the average seasons, leading to concern over farm workers' continued capacity to work during the hottest hours of the day, which would lead to significant losses in productivity (see Figure 3.5, below). (Bush et al., 2019; IPCC, 2019a; Vasseur et al., 2008).



Figure 3.5 Small-scale crop production in the Maritimes often involves significant amounts of hand labour. Here, a worker draws soil around bean plants to hill them, increasing fertility and suppressing weeds. In such short, densely planted row inaccessible by tractors, the job is best done by hand.

While some studies have suggested that certain climate impacts may be beneficial to food production, the complex and nonlinear nature of impacts means that some potential benefits are often erased by negative consequences. A higher number of growing degree days may mean that new crops can be grown, yielding potential economic benefits (Arnold & Fenech, 2017). However, increased extreme weather events, combined with the “seasonal shift” described above, mean that unless the crops have previously been planted, no actual growing benefits can be accrued: temperatures may rise, but available daylight remains the same (IPCC, 2019a; Soubry, 2017b). Moreover, most of the crops which would benefit from higher temperatures can be considered “marginal” food crops, such as ginger, turmeric, and wine grapes (Savard et al., 2016). While significant investments have been made in the industries associated with growing

these crops (Scotia, 2008), critics have anecdotally pointed out that they have virtually no effect on food security.

3.2.2 Infrastructure-based risks

Climate vulnerabilities also exist for the broader food system, affecting systems for storage, distribution, and sale of food in the Maritimes. The most significant risk is to transportation infrastructure, which relies on a narrow network of highways and bridges to move food in and out of the provinces. This network is at significant risk from sea level rise: the Chignecto Isthmus, which is the only land bridge between New Brunswick and Nova Scotia, is a thin strip of land in part protected by two dykes which hold off the Bay of Fundy on one side and the Northumberland Strait on the other (Savard et al., 2016; Wade & Robichaud, 2011). In current conditions, the isthmus floods multiple times a year, cutting off transportation lines and creating economic losses of approximately \$CDN 50 million per day (Bush et al., 2019), as well as a mounting food security risk: analyses estimate that Nova Scotia's import-heavy food system would have supplies for about three days if it were cut off (Natural Resources Canada, 2016).

Additionally, rising temperatures will continue to place stress on cold-storage infrastructure, which is especially essential for meat and fruit production in the region (Macleod & Scott, 2010). Some major storage and processing areas are located in dykeland areas prone to flooding, and are vulnerable to complete shutdown in case of storm surges (Chouinard et al., 2008; Daigle, 2012).

It is also worth noting that while the Maritimes remain provinces which mostly import food, climate change will likely amplify food insecurity, especially for the rural poor and for

Indigenous populations. Eastern Canada's largest problems of food insecurity occur among Indigenous peoples, a situation worsened by the other social and individual health consequences of ongoing colonization by a settler state (Council of Canadian Academies, 2014; DeSchutter, 2012). Climate impacts, moreover, tend to fall disproportionately and most punishingly on the rural poor (Hallegatte et al., 2016). Current climate scenarios would lead to increased food insecurity, malnutrition, health problems, and death for vulnerable populations (DeSchutter, 2012).

3.2.3 Current adaptation planning

All three Maritime provinces have climate mitigation and adaptation plans which aim to respond to climate change (Government of New Brunswick, 2016; *An Act to Achieve Environmental Goals and Sustainable Prosperity*, 2019; PEI Department of Communities Land and Environment, 2018); at the time of writing, however, none of them address climate impacts on the food system. Current areas of action related to agriculture are primarily concerned with reducing greenhouse gas (GHG) emissions caused by machinery, fertilizer use, and tillage (Arnold & Fenech, 2017). This concern mirrors the Canadian Government's federal climate plan, the Pan-Canadian Framework on Clean Growth and Climate Change, which emphasizes agriculture's role in carbon capture, storage, and sequestration (Government of Canada, 2018). None of these areas, however, acknowledge that climate change may have a negative impact on the food system, or that any action needs to be taken in building resilience and adaptive capacity for the food system (Soubry, 2017c).

Critics of provincial and federal climate plans have noted that there are effectively no accountability processes or metrics to address provincial governments' adaptation targets (Auditors General of Canada, 2018; Mertins-Kirkwood, 2019). This means that those plans which do exist have no system to evaluate how effective their implementation is, and no higher authority to hold them to account. In 2018, the Auditors General of Canada noted that Nova Scotia, for example, had not reviewed its assessment of climate impacts since 2005; and that, in Prince Edward Island's climate plan, "the timeline, estimated financial costs, method for measuring results, and assignment of responsibility were not outlined" (Auditors General of Canada, 2018, p. 16). In New Brunswick, climate mitigation and adaptation efforts have been characterized as widely rhetorical rather than indicative of any substantial action (Mertins-Kirkwood, 2019). Other research has found that civil servants in the Maritimes, whether provincial or municipal, consistently misunderstand the mechanics of climate change and its associated risks in the region despite the information available to them; and that planning remains institutionally siloed, ensuring that risk information is not communicated across departments or governance levels (Fox & Daigle, 2012; Lieske et al., 2015; Philp & Cohen, 2019; Wade & Robichaud, 2011).

Farmers, moreover, have been reluctant to accept support from those government programmes which do exist, due to a long-standing mistrust of government policy (and, occasionally, a philosophical opposition to any notion of "subsidy") (Müller, 2008; Soubry, 2017c). Regardless of scale, farmers often hold independence as a high value, leaving them disinclined to accept any support from government (Stock & Forney, 2014). In the Maritimes, small-scale producers often find themselves ineligible for grants and support given that most grants assume a minimum size

of operations and cash flow commensurate with larger farms. This leads to a situation where even those programmes and grants which *do* exist to help support agricultural adaptation to climate change are not accessed by those they target (Soubry, 2017a). While previous research has found them adapting techniques and on-farm infrastructure, the opportunity to plan longer-term is stymied by a limited access to funding (Soubry, 2017a).

The resulting adaptation policy landscape in New Brunswick, Nova Scotia, and Prince Edward Island is one where small-scale farmers and other food system actors are largely unable to access broader adaptation plans and support services—whether because the plans are ill-suited to their purposes or because those plans simply do not exist. The food system therefore remains significantly vulnerable to the impacts of climate change. It will require concerted policy and grassroots action to safeguard.

I consider small-scale vegetable producers in the land-based food system of the Maritimes to be an excellent case study of how farmer knowledge interacts with adaptation policy, as well as the implications of sidelining this knowledge. Firstly, the area is already feeling the impacts of climate change, especially in terms of increased average temperatures and sea level rise; its farmers and food system actors have already implemented reactions to these changes, whether consciously planning for climate adaptation or not. Secondly, the region has largely the same policy outlook on food systems and climate change: none of the provincial governments consider the latter a threat to the former. This makes it easy to compare interviews across provincial contexts. It also makes it possible to examine a situation whereby farmers have largely been reacting outside of policy contexts, and where their knowledge has not been integrated into

adaptation policy. Finally, I have significant experience in the area and am a member of the community of producers, which allows me to understand the subtleties of food systems in the area and build on already-existing relationships to perform in-depth qualitative research (see below, section 4.1.4). This depth of insight would be impossible for me as a researcher anywhere else. I consider the ways in which it enriches the analysis presented in this thesis throughout the next chapter.

4. Methodology

In this chapter, I present an overview of the methodologies and theoretical frameworks I deployed to perform research for this thesis. The research papers in this thesis were developed using a mixed-methods framework; I use these methods in parallel, rather than sequentially, in order to answer my research questions. I outline collection and analysis methods for both primary data, which came from fieldwork, and secondary data, which relies on literature and already available datasets. I also consider the theoretical underpinnings of these methods, notably grounded theory methodology and the concept of relational accountability toward participants.

The methods presented here have informed each research paper to various extents. Each paper presents an in-depth discussion of its methodologies (see Chapters 5, 6, and 7). They build on the methods used in my Master's thesis (see Soubry, 2017a), which forms the groundwork for this doctoral thesis.

4.1 Primary data

In this section, I discuss the primary data that I generated and collected with research participants through fieldwork. I introduce the guiding principles of grounded theory methodology, then present how I generated and analyzed data through interviews and memos.

4.1.1 *Grounded theory methodology*

The data generation and analysis processes in this thesis are rooted in grounded theory methodology (GTM). GTM emerged in the 1960s as a response to positivist methodologies

which Glaser and Strauss considered blind to interpreted realities (Glaser & Strauss, 1967). It encourages researchers to build theory without imposing preconceived theoretical frameworks on the data (Birks & Mills, 2015; Charmaz, 2016; Glaser & Strauss, 1967; Mills et al., 2006; Urquhart, 2013, among others).

The power structures inherent to formal structured interviews can make participants reluctant to answer anything other than what they are directly asked (see, for example, E. Marino & Schweitzer, 2009). Researchers following GTM attempt to empower participants during data generation so that they allow their own experiences, concerns, concepts, and logics to guide the research process (Dunne, 2011). A researcher will read the available literature broadly prior to engaging in fieldwork, but will not create an explicit research agenda beyond initial guiding questions. They can thus go into fieldwork well-informed, but open to participants dictating what is important (Urquhart, 2013). The approach allows for the emergence of topics which might seem unrelated but are, in fact, crucial to understanding a question's context.

GTM is particularly appropriate to the qualitative research context of this thesis. Data generation is generally centred around semi-structured interviews, where an interviewer guides the subject towards certain areas of inquiry without holding the conversation to a strict question-and-answer structure. Previous research has noted that, in structured interviews about climate change, local knowledge holders often cleave to politicized dialogue, skewing responses towards those that confirm the researcher's perceived objectives (E. K. Marino, 2014; E. Marino & Schweitzer, 2009). One of my goals during fieldwork was to allow food system actors to dictate where conversations could go. In leaving interviews open, I accounted for the possibility of subjects for

which I had not prepared, gave autonomy to participants, and attempted to provide a space of trust.

GTM has evolved over the years into several divergent schools of thought. My own research specifically follows Charmaz (2006, 2016)'s constructivist stream of grounded theory, which differs from its predecessors by adopting a more reflexive stance towards the researcher's positionality. It situates research within specific historical and social conditions, acknowledging that researchers are people subject to the same social, political, and cultural forces as their participants (Mills et al., 2006). It calls on research to acknowledge the power dynamics at work in generating knowledge (Charmaz, 2006). The political nature of this approach dovetails with the ethical imperative for relational accountability that informs my work. I discuss these concepts below.

One criticism of data generation in GTM is that participants may lead researchers towards biased conclusions by guiding the discussion away from the original intent of the research. This is a weak criticism for three reasons. Firstly, GTM researchers rarely have a clearly stated research objective beyond that of discovering participants' perspectives: a specific goal would make it impossible to fully listen and let participants lead. Secondly, researchers in GTM who seek a generalized sense of experience will usually interview enough participants that coordination between them would be unlikely. Finally, the criticism assumes that the researcher is trying to be "objective", and that there are truths which can be "corrupted" by bad data. This is a false assumption: GTM is concerned with participants' perspectives and experiences and the collective narratives that emerge from them, not with any sense of objectivity. My own

understanding of my research is that it is driven by my own positionality and assumptions as well as those of the research participants (Charmaz, 2016). By collating and comparing experiences and perspectives, I aim to create not unimpeachable truth but useful theory. The benefits of GTM thus outweigh the possibility of any one participant attempting to skew a narrative (Urquhart, 2013).

4.1.2 Data generation

I collected and generated primary data through three principal avenues: semi-structured interviews, participant observation, and memoing.

4.1.2.1 Semi-structured interviews

After receiving clearance to proceed with fieldwork from the University of Oxford's Central University Research Ethics Committee, I interviewed small-scale producers; retailers and distributors; government workers; and civil society workers (see Table 4.1). Fieldwork for these interviews took place between May and August 2016 (n=40) and between December and March 2017-18 (n=25). The first period corresponds with data I collected originally for my M.Phil thesis (see Soubry, 2017a). I use those data in the analysis below, but do not duplicate any of the work or analysis from my M.Phil in the papers from this thesis. I received separate ethics clearance for each period of fieldwork (see Appendix 5).

Table 4.1 Breakdown of participants by type and region.

Type of participant	2016	2017-18	Total
Farmer	32	12	44
NB	8	8	16
NS	19	0	19
PEI	5	4	9
Retail/marketing	3	3	6
NB	0	2	2
NS	3	0	3
PEI	0	1	1
Government	3	7	10
NB	0	1	1
NS	3	4	7
PEI	0	2	2
Civil society²	2	3	5
NB	0	1	1
NS	1	1	2
PEI	1	1	2
Total	40	25	65

NB=New Brunswick; NS=Nova Scotia; PEI=Prince Edward Island

As I discussed in chapter 3, I chose to work with small-scale producers in part because of pre-established relationships which would allow for better access during interviews, and because of the diverse nature of small-scale agriculture in the region. Small-scale farmers are demographically and economically significant members of the agricultural community in the region: because of how the arable land base is distributed, most vegetable farms cultivate fewer than 140 acres (Statistics Canada, 2017b). Thanks to the region's varying terrain and soil quality, what is considered a large farm in the Maritimes would be small in other jurisdictions (Millward, 1999). The farmers I interviewed are therefore representative of the diversity of the region's vegetable producers. They remain a representative case of small-scale farmers, given that they

² Refers to NGOs or advocacy organizations within food systems.

receive relatively little state support and therefore have analogous positions to smallholders in multiple countries (Cohn et al., 2017).

Interviews took place in French or in English, depending on the participants' preference. As a member of the farming community in my case study area, I used personal connections to schedule initial interviews and access certain participants whom I considered key informants. To choose participants outside my personal contacts, I advertised the research project in newsletters from regional agriculture organizations. I also sent e-mails to members of regional farming organizations through a randomized, anonymized contact list generated by organization staff. Both forms of outreach led to an online form where participants could register their interest in participating (see Appendix 3). I also used snowball sampling techniques to identify potential farmer interviews. Snowballing was necessary for meeting farmers in the region, given that some producers choose not to register their operations and may therefore be untraceable in formal databases (Chromy, 2011). I also directly contacted government offices, purposely seeking out interviews with participants who held positions relevant to my research inquiry.

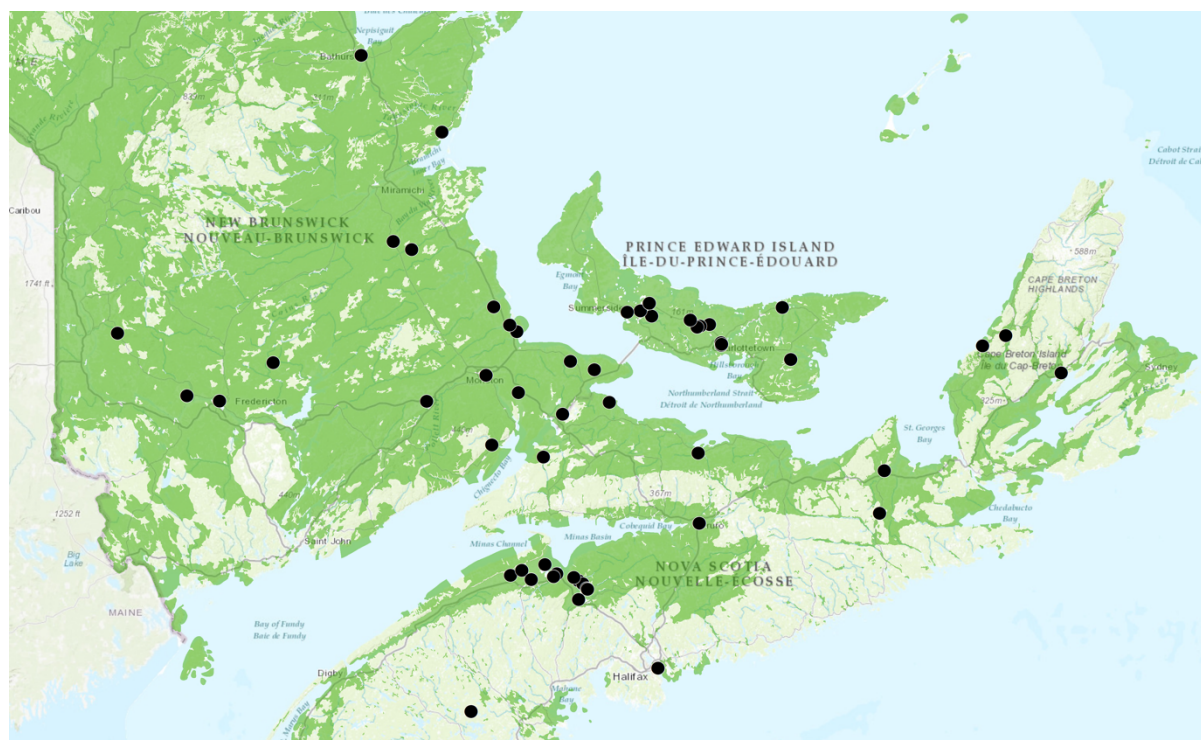


Figure 4.1 Respondents (black dots) in relation to agricultural land capability (shaded green).

Interviews took place across the Maritime provinces and were well-distributed when compared to the available agricultural land area (see Figure 4.1, above). They were semi-structured and lasted between thirty and sixty minutes.

Interviews covered the impacts of extreme weather and of climatic trends on food production; sources of governmental and community support; and other concerns that respondents considered relevant or important to discuss. An interview guide (included in Appendix 4) provided main points to be covered during the interview, with options depending on the type of actor I was interviewing. These guides were not intended to be a rigid set of questions, but rather points of inquiry from which conversations could emerge.

While this form of interviewing presents some challenges—notably, that they can deviate significantly from the initial subject; that, because of the heterogeneity of responses, they become difficult to compare directly between participants; and that the tenor of interviews necessarily changes as the fieldwork progresses; they offer significant advantages for research based in GTM (Birks & Mills, 2015). The possible deviations from a researcher’s proposed subject can suggest new avenues of inquiry, and avoids problems stemming from an overly rigid or mistargeted research design. Semi-structured interviews are therefore appropriate for a GTM-based study, which focuses on common themes rather than direct, factual comparability (Rapley, 2001).

Table 4.2 Sample questions from interviews (see Appendix 4 for full interview guide)

Question type	Sample questions
Preliminary questions	- Can you tell me more about how you practice agriculture? - (What is produced, on what acreage, what infrastructure, etc.) - Can you tell me a bit about the history of your farm?
Environmental change	- What practices are dependent on certain types of weather? - How do you cope when they change? - What do you know about how climate change is affecting and may affect [your region]? - Have you factored climate change into how you plan your farm? How so? - What infrastructure do you think is most vulnerable to change? - What are the factors you’re having difficulty predicting over the next ten to twenty years?
Government	- Are you receiving any support from the provincial/federal/municipal government in order to farm? - Where is that support coming from? What’s been your experience with farming support in your region? - Where do you think that support is going in the next ten to twenty years? What’s hardest to predict?

I encouraged participants to talk about whatever seemed most important to them, even if it did not immediately seem relevant. Most of the interviews were then transcribed verbatim for analysis. Some interviews were not transcribed, or only partially transcribed; in this case, I took detailed notes on the content of the recording. This occurred in cases where interviewees did not want to be quoted verbatim but agreed to be recorded for note-taking purposes; or when

significant portions of the interview went clearly off-topic (as when, in one instance, an interviewee required help with a lamb stuck in a fence, which generated twenty minutes of grunting noises). This only happened in three instances, and did not significantly hinder the analysis, though the analysis process was necessarily modified to fit the data (Ryan & Bernard, 2003).

4.1.2.2 Participant observation

I also generated data through participant observation, as interviews with farmers typically took place on-farm. I often proposed skilled labour in exchange for an interview, sometimes working alongside them as we spoke (see 4.1.4, *Relational Accountability*). I took notes while working, recording on a field microphone and thereafter writing memos (see below; see also Birks & Mills, 2015). Participant observation, including conversations with farmers and other actors, working on the land, and walks around the farm, began when I arrived and ended when I left. I made it clear to the participants that this would be the case; I told them that they could call out anything discussed as being off the record, or ask me not to discuss it in memos or research outputs.

Working alongside interview participants elicited crucial data that I would otherwise have missed. It allowed for the emergence of tacit knowledge tied to landscape, actions, and practices (Fikret Berkes, 2009; Curry & Kirwan, 2014; Julie Ingram, 2008). In designing this methodology, I drew inspiration from the concept of "landscape elicitation", in which the environmental context acts as a starting point for participants to talk about things they might not otherwise discuss (Barton, 2015; Sherren et al., 2016). Place is a potent stimulus for memory and

reflections, which can live outside any individual mind, and are called up through experience and interaction (Thornton, 2008). In the context of farm work, I could ask specific questions about why crops were planted or harvested a certain way; what constraints shaped land management decisions; and how weather and infrastructure impacted food production—all of which provided a grounded sense of a farmer’s actual experiences, and how they relate to perceptions and worldview. I could also notice the ways in which farmers performed certain tasks, their reaction to certain questions, and the state of their farm system in general.

Interviews with government officials, food retailers, and distributors were performed at their place of work. In those situations, I was interviewing participant at their place of work during their paid hours; they were compensated by their organization or institution for speaking with me, and I did not personally offer them compensation.

4.1.2.3 Memoing

In keeping with the GTM notion that “everything is data” (Birks & Mills, 2015), I generated memos throughout the fieldwork and analysis processes. These memos were unedited, often stream-of-consciousness reflections on the feelings I had felt during the interview: hunches I had, things an interview had made me think of, or anything else that felt like it needed to be said at the time. Often, they would take the form of recordings that I would make in the truck on the drive from the interview site back to my accommodation. Other times, I would take a moment to write notes, long-form reflections, or mind maps in a notebook before my thoughts wandered from the interview. When came the time to analyze data, I would often make memos in written form. As I transcribed or coded an interview and felt an idea or a connection crystallize, I would

stop and make notes about it, tying data with emergent theory in whatever messy form was needed at the time. Memos became more focused over time, sometimes emerging into full outlines of analysis sections for future papers (see Figure 4.2).

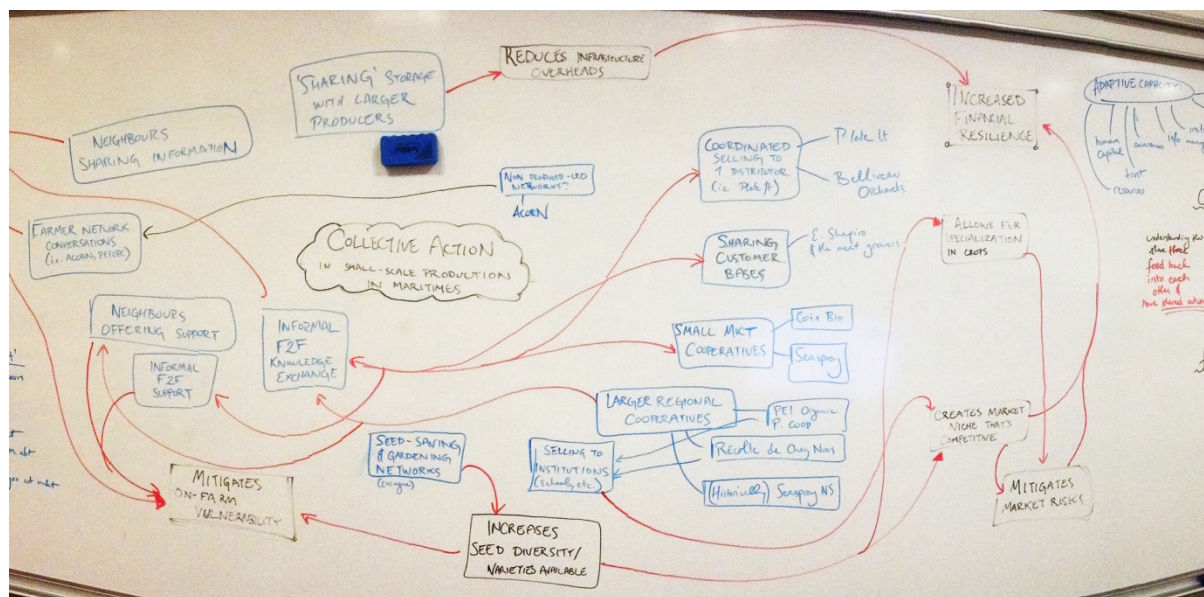


Figure 4.2 A memo about collective action performed in later analysis stages (already forming a paper).

4.1.3 Data analysis

I began analyzing data while in the midst of my fieldwork, even as I was interviewing new participants. The GTM analysis framework is built upon a principle of “constant comparison” between data and analyses: data collection processes are informed by the theory as it is being constructed (Birks & Mills, 2015; Suddaby, 2006). Using GTM thus allowed my data collection and data analysis to inform each other. Memos (discussed above) acted as the bridge between the two, allowing space for off-the-cuff analysis regarding how interviews related to other interactions or theory (Birks & Mills, 2015; Charmaz, 2006). A continuous stream of analysis informed theory generation, giving me space during fieldwork to reflect on which subject areas

to investigate next (Birks & Mills, 2015). Figure 4.3, below, gives a graphical explanation of the process.

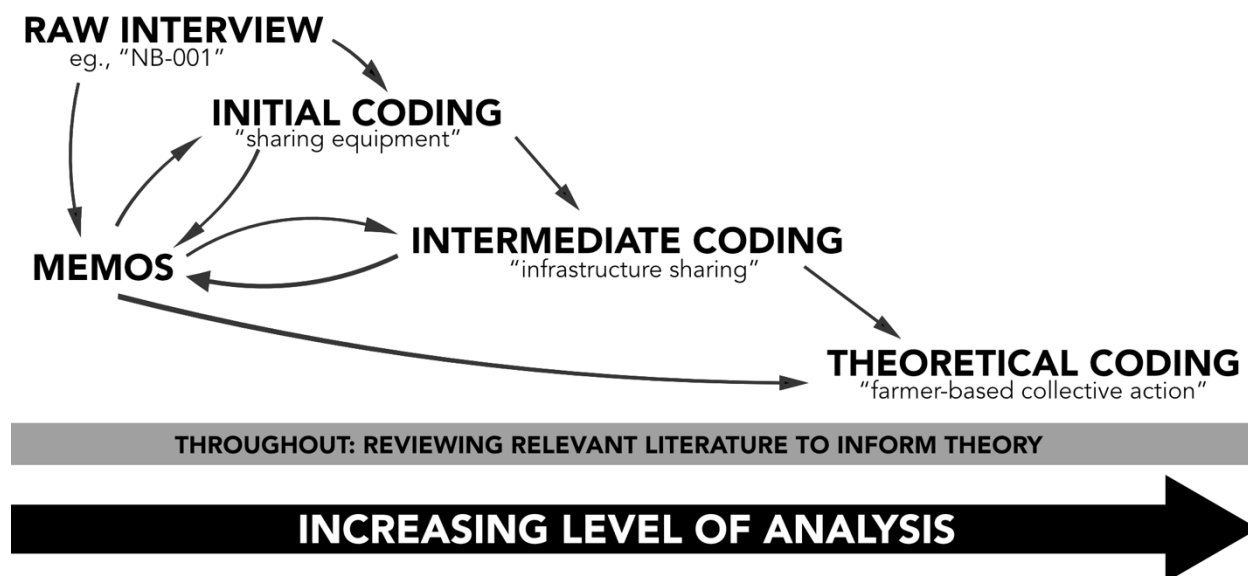


Figure 4.3 The grounded theory coding process. Each coding step involves memoing and review of literature, iteratively moving towards building theory.

Coding

Coding involves the close reading and thematic grouping of transcripts in order generate material for memos and theory (Charmaz, 2016; Glaser & Strauss, 1967; Mills et al., 2006).

After transcribing each interview, I would heavily code the text on a granular level using NVIVO 12 (QSR International, 2019), noting each idea as it emerged. Following the initial round of coding, I would return to the list and group thematically similar codes under a higher-level category, thereby creating a coding hierarchy. I refined these “intermediate” codes throughout

the process as new ideas emerged or took on different meanings. Figure 4.4, below, presents a sample of the coding hierarchy.



The screenshot shows a hierarchical tree structure in NVIVO 12. The root node is 'collective action' (37 files, 271 occurrences). It branches into 'farmer-based collective action' (29 files, 121 occurrences), 'farmer knowledge sharing' (14 files, 22 occurrences), 'farmers' organizations' (11 files, 14 occurrences), 'general support' (11 files, 16 occurrences), 'sharing infrastructure' (2 files, 4 occurrences), 'diversity of enterprise' (1 file, 1 occurrence), and 'farmers sharing customers' (1 file, 1 occurrence). Further sub-nodes include 'farmer experience' (1 file, 1 occurrence), 'conferences and workshops' (5 files, 6 occurrences), 'intergenerational support' (7 files, 11 occurrences), 'farmers selling collectively' (3 files, 4 occurrences), 'farmers sharing equipment' (2 files, 3 occurrences), and 'farmers sharing storage' (1 file, 1 occurrence).

▼ collective action	37	271
▼ farmer-based collective action	29	121
▼ farmer knowledge sharing	14	22
farmer experience	1	1
▼ farmers' organizations	11	14
conferences and workshops	5	6
▼ general support	11	16
intergenerational support	7	11
farmers selling collectively	3	4
▼ sharing infrastructure	2	4
farmers sharing equipment	2	3
farmers sharing storage	1	1
diversity of enterprise	1	1
farmers sharing customers	1	1

Figure 4.4 Screen capture from NVIVO 12 showing intermediate and granular-level coding for a single high-level code. Numbers indicate interview files containing the code and number of occurrences overall, respectively.

Theory emerged throughout the process by a recursive, iterative dialogue between codes, memos, and relevant literature from the field. As I built codes that triggered memories from fieldwork, I looked at memos I had written in the heat of the action; having created intermediate codes, I wrote memos about what they might mean for broader theory. The content of memos and interviews gave me insights into what theoretical literature I should explore next. As more substantive theory emerged, I created theoretical codes within the hierarchy, grouping intermediate codes so as to give them narrative coherence (Birks & Mills, 2015; Glaser & Strauss, 1967). Figure 4.3, above, gives a graphical overview of the method.

4.1.4 Relational accountability

Beyond the practicality of being able to interview someone literally in their field of work, working alongside participants was an important requirement of upholding relational accountability, a process on which I want to reflect here.

Relationships of colonialism and power are, in many ways, central—though not foregrounded—in this thesis. My research takes place on the unceded territory of the Mi'kmaq and Wolastoqiyik; it is complicit in colonial structures of land distribution and control (Cameron, 2012; Tuck, 2009; Tuck et al., 2014). It aims to recognize and question the pervasive nature of colonial dynamics within research structures, whether in climate science or qualitative research with local communities (see, for example, Escobar, 2012b; Hendrix, 2017). Though the papers I present here do not address it explicitly, my work exists within a broader movement that works to decolonize academic research (Castleden et al., 2012; Fairhead & Scoones, 2005; Schultz et al., 2018; Tuck & McKenzie, 2015), to support the work of Indigenous scholars and thinkers, and to make reflective and respectful space in settler scholarship for Indigenous methodologies.

As a theoretical tool, relational accountability helps to equalize power dynamics between the researcher, the subjects of their research, and the communities in which both interact. Wilson describes the ethical imperative that research “needs to be based in a community context (be relational) and has to demonstrate respect, reciprocity, and responsibility (be accountable as it is put into action)” (2008, p. 99). Relational accountability holds as its primary goal the recognition of relationships that govern communities. If its original context is tied to Indigenous communities, where relationships are explicitly highly valued in both research and day-to-day

life, its broader application extends across all relationships (Wilson, 2008). Research which upholds relational accountability must accurately reflect the relationships expressed by the participants, and its analysis processes must “reflect an understanding of the topic that is shared by researcher and participants alike” (Wilson, 2008, p. 101). Much like Charmaz (2006)’s constructivist GTM, it requires researchers to understand the political and social pressures acting upon them and the research participants, and to act with reciprocity, consideration, and respect. It establishes a relationship which understands the embodied and practical aspects of reconciliation (Tuck & McKenzie, 2015).

My connections to the farming community, my academic knowledge and status, and the research funding I received are all forms of power; they are also responsibilities. Relational accountability is a way of taking ownership of both; of trying to work with farmers to build good and helpful research. To uphold relational accountability, I gave work that was reciprocal to the knowledge I was offered. Often, people agreed to participate because they knew me or my old farm bosses, and trusted that I had the interests of the farming community at heart. They also knew that compensating them financially would not replace the farm work from which they were stepping away to talk. So I offered work, and tried to let the people I interviewed know that I cared and wanted to honour our relationship with each other and with the food systems in which we participate.

It is tempting to consider relational accountability as an additional limitation to research. In situations where the community acts as a gatekeeper for the research, and submits final approval, it could pressure a researcher only to publish what the community might approve (Castleden et

al., 2012). It reflects an evident affinity with the research population which some may perceive as bias. Proponents of relational accountability do not consider it in this way: rather, they consider it a corrective to methodology which has, for too long, ignored the human impact of extractive research on vulnerable and marginalized populations (Cameron, 2012; Castleden et al., 2012; Wilson, 2008). Whether one chooses to acknowledge it or not, research creates a relationship between parties; in the social sciences, this relationship has primarily been an extractive one (Grosfoguel, 2013). Choosing to acknowledge power dynamics and the responsibility researchers have to be accountable to relationships serves as an ethical guard against abuse.

4.2 Secondary data

4.2.1 Literature review

Data for the first paper of this thesis (see Chapter 5) were collected through a systematic literature review. I discuss the specifics of how the review was performed in the paper itself, but also wish to justify the method and its use in a social scientific context.

Systematic literature reviews (SLRs) are useful in answering specific questions about research knowledge and practice, especially in order to understand large volumes of information such as entire fields of research (Pittaway, 2011). They are designed to identify gaps and make recommendations in how to fill them by “bring[ing] together the evidence base on a particular theme in order to make credible policy, research or practical recommendations” (Pittaway, 2011, p. 217). While the method was initially developed in medical research, it has become common in social science literature, especially in areas seeking to make policy recommendations (Petticrew

& Roberts, 2006). Unlike narrative reviews, SLRs follow strict protocols so that they can be reproduced by other researchers (and thus be verifiable). Analysis is largely quantitative, in forms such as descriptive statistics or crosstabulation analysis, rather than thematic groupings—though some researchers, especially those covering fields in the social sciences, have successfully mixed methods (Hospes & Brons, 2016; Petticrew & Roberts, 2006; Pittaway, 2011; Schoenfeld, 2014).

Pittaway (2011) identifies a number of principles that SLRs tend to follow, including transparency (the research approach is freely available); clarity (the process is clearly laid out); focus (a clear research question); and synthesis (the review compares and contrasts to draw conclusions around the evidence base). The conclusions are based on reproducible results and analyses rather than opaque or idiosyncratic explorations of the literature, leading to a high degree of comparability between reviews.

This approach was useful for answering the research questions that Chapter 5 poses about the state of the field of farmer perceptions and climate change. To achieve this, I created categories such as location, type of farm, and whether certain factors were present in each study. I analysed trends of their emergence in papers over time through descriptive statistics and crosstabulation analysis. Though the review often deals with qualitative studies and offers largely qualitative conclusions, its methodology is rigorous and reproducible, and therefore provides much-needed, objective perspectives on a field that has so far been foggy and unbounded.

4.2.2 Thematic and discourse analysis

I use thematic coding and analysis in my third research paper (Chapter 7) to find relevant and common themes within datasets. I also borrow from the principles of discourse analysis in considering the use of specific terms. I give a more in-depth explanation of the methodological practice in the paper, but give some context and justification of its use here.

Thematic analysis is a practice of data reduction to highlight emergent themes throughout a data set (Ayres, 2012; Riessman, 2007). Through coding practices, data are segmented; categorized; summarized; and reconstructed in a way that captures the most important concepts in the set (Ayres, 2012). Analyzing the data set is an inductive process where data generates ideas for thematic codes, which are then compared to prior theory from outside the set and the data as a whole, such that “coding facilitates the development of themes, and the development of themes facilitates coding” (Ayres, 2012, p. 868).

Despite their surface-level similarities, there are significant differences between thematic analysis and grounded theory methodology. GTM analysis occurs simultaneously across different segments of data, which are often atomized through coding and observed in clumps; thematic analysis, on the other hand, tends to analyze documents sequentially, without constant comparison (Riessman, 2007). Whereas GTM analysis does not require the introduction of prior concepts, either through a literature review or other means (Glaser & Strauss, 1967), thematic analysis places some importance on having a background understanding of the subject being analyzed (Riessman, 2007). Finally, thematic analysis is primarily descriptive: it does not seek to create theory or uncover an essential structure. It nevertheless generates meaningful insights that

can be useful in policy recommendations and research, especially when attempting to understand the underlying themes of a given document, policy, or set of documents (Ayres, 2012; Riessman, 2007).

Thematic analysis proved useful when comparing government documents and farmer interviews along a single thematic point — that of resilience (see Chapter 7). The purpose of the comparison was not to generate theory, but to observe underlying patterns within the broader theoretical framework of resilience theory playing out in practice. In thematically analyzing the government documents, for example, I began by auto-coding any passages which used the word “resilience” or any associated stem words, and subsequently coded the themes that came up contextually around those passages. This kind of coding would not have been appropriate to GTM because of its premeditated research focus; in the case of thematic analysis, however, it was justified and necessary (Riessman, 2007). Thematic coding allowed me to note similar emerging themes while remaining focused on the initial purpose of the research.

Because I needed to consider a broad social context in analyzing specific text and discourse, I also employ aspects of sociological discourse analysis. Ruiz-Ruiz's notion of sociological discourse analysis (Ruiz & Ruiz Ruiz, 2009) considers three levels at which analysis takes place, often simultaneously: textual, where discourse exists as an object; contextual, where discourse is a situation or event; and sociological, which considers discourse from the point of view of information and social product. I employed this method to understand discourse around emergent themes such as resilience. By isolating relevant terms, I could discern their production as not

merely words spoken by actors, but concepts echoing across socioeconomic contexts and in specific ideological environments (Goulet, 2013; Ruiz & Ruiz Ruiz, 2009)

4.3 Conclusion

This chapter outlined the methods I used to gather both primary and secondary data for this thesis and its three research papers. These involved semi-structured interviews and memoing, which were informed by grounded theory methodology; systematic literature review; and thematic and discourse analysis. I also introduced the concept of relational accountability, which governs how I enact my relationship with my research participants.

I explore the insights generated by these research processes in the next three chapters.

5. Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007-2018

Bernard Soubry^{1*}, Kate Sherren², Thomas Thornton¹

Published in the *Journal of Rural Studies* (DOI: 10.1016/j.jrurstud.2019.09.005)

¹ Environmental Change Institute, School of Geography and the Environment, University of Oxford, Oxford OX1 3QY, UK

² School for Resource and Environmental Studies, Dalhousie University, Halifax, NS, B3H 4R2, Canada

* Corresponding author: bernard.soubry@ouce.ox.ac.uk, phone: +1 (438) 838-8218

Abstract

While there is broad agreement in theory that farmers' expertise should be integrated into discussions of land management and climate change adaptation in the food system, it is unknown how much research practice has integrated these recommendations. To gauge the state of the field, we reviewed and coded a sample set of papers (n=105) concerning farmers' perceptions of climate change. Crosstabulation analysis reveals that: 1) researching farmer "perception" of climate change seems to be more frequent in the Global South, as opposed to the North, where other terms are used; 2) farmers are rarely described within their social-ecological contexts, and often simply have their observations segmented and assessed for verification against historical data or quantitative measurements; and 3) the broader dynamics of research practice may perpetuate extractive and colonial patterns of exchange between the Global North and South. We find that farmers from the Global South are rarely described, but often evaluated in their perceptions. We conclude that, with some exceptions, the field does not substantively embrace farmers' perceptions as a contribution to adaptation discourse. We posit that the lack of in-depth qualitative methods in our sample may be correlated with the perception of farmers as passive and vulnerable, rather than viably adapting.

Key words

Farmers, perception, climate change, adaptation, land management, literature review

5.1 Introduction

Farmers are on the front lines of climate change and efforts to mitigate its negative impacts on food systems. While changes and shocks to global and regional food systems will affect all humans in some way, food producers are first to feel the blows. Increases in global average temperatures and the frequency of erratic or extreme weather events across regions make crop failures more likely (Chen et al., 2016; FAO, 2017; IPCC, 2014c; Liverman & Kapadia, 2010); these events may cause further land management crises through erosion, flooding, and drought, all of which may render food production more difficult or impossible (IPCC, 2014a). These impacts already affect producers' capacities to distribute and sell food, and will negatively affect global food security (FAO, 2016a; John Ingram et al., 2016; S. J. Vermeulen et al., 2012). Farmers' livelihoods are consequently at risk across the world: climate change will most likely increase net poverty, especially in rural areas where agricultural production is economically important (Hallegatte et al., 2016).

Food producers are neither helpless nor hapless before the impacts they face. Farmers are expert land managers in their own right, though their voices rarely appear in policy or management discussions beyond calls to support food producers. Historically, farmers' perspectives have been relegated to "informal" knowledge streams (Julie Ingram, 2008; Scoones & Thompson, 2009; Sherren & Darnhofer, 2018; Sumane et al., 2017). Every day, however, farmers are faced with complex and urgent multivariate problems: they need to consider the economic, environmental, and human resource implications in every agricultural decision they make (Chambers et al., 1989; Darnhofer et al., 2016; Scoones & Thompson, 2009). As close observers of the land and the food system, farmers are the "ultimate applied scientists" (Sherren & Darnhofer, 2018, p. 7),

for they live by their experimental success or failure. This expertise does not imply that all farmers are necessarily viably adapting to environmental, social, or economic changes and shocks; indeed, reviews of the state of food and agriculture highlight significant difficulties in this regard (FAO, 2016b; FAO et al., 2018). Rather, we underscore that farmers, due to the nature of their work and livelihoods, are the best interpreters of their needs and capacities within a given farm system; and that any intervention on behalf of a third party to aid adaptation may benefit from understanding their viewpoint and specific forms of knowledge.

In this respect, farmers are key constituents in the process of understanding both climate change impacts on food systems and how best to mitigate and adapt to these impacts. Firstly, including farmers allows for deep and complex institutional access to rural communities; due to the nature of their craft, farmers evolve in multi-actor networks which overlap formal and informal knowledge networks (Sumane et al., 2017). Considering farmer knowledge and perceptions allows for management-level institutions to connect with concerns, knowledge, and endogenous adaptation at a local and informal level. Secondly, farmers' tacit, embodied knowledge may provide crucial insight to local conditions, vulnerabilities, and opportunities to which higher-level institutions may not have access (Carolan, 2006; Lehébel-Péron et al., 2016). Local ecological knowledge is a recognized keystone of successfully managed socioecological systems (Fikret Berkes & Ross, 2013; Turner et al., 2008), and farming requires a deep, though often tacit, understanding of the biological and ecological processes and changes—something fundamentally inaccessible to anyone not working the land in the same way (Fikret Berkes, 2009; Turner et al., 2008). Finally, food producers and farm workers are often the first to be affected by climate impacts (FAO et al., 2018; Hallegatte et al., 2016), and therefore the first

livelihoods to be affected by higher-level adaptation policy; considering their needs, losses, and knowledge is therefore a matter of equity as much as adaptation (Turner et al., 2008).

Mirroring the calls which have been made in the anthropological, sociological, and conservation literatures to improve the integration of indigenous and local knowledges with scientific models in land management (Armitage et al., 2009; Bennett, 2016; Fikret Berkes & Ross, 2013; Raymond et al., 2010), recent cross-disciplinary scholarship has called for farmers' knowledges to be recognized as a valuable contribution to discussions around the adaptation of food and land management systems to climate change (F Berkes, 2007; CCAFS, 2016; FAO, 2016b; Lemmen et al., 2008; Nelson et al., 2007; Oliver et al., 2012; Raymond et al., 2010). Sumane et al. (2017), among others, have called for land management frameworks which allow farmers' knowledge to interact equally with that of land managers, researchers, and policymakers. Creating these frameworks requires what Carolan (2006) identifies as "interactional expertise": the capacity to interact in the space between valid, but different, frames of reference and epistemic contexts (Carolan, 2006; Chambers et al., 1989; Collins, 2004; Scoones & Thompson, 1994, 2009). There is increasing recognition that farmers' knowledge and management decisions, though often informal, are deeply informed, and therefore valuable additions to regional adaptation planning (Julie Ingram et al., 2010; Lois Wright Morton et al., 2017; Sumane et al., 2017).

Yet the integration of farmer knowledge into climate adaptation research and policy is not a simple task. It requires financial and institutional commitment; trust between research communities, management communities, and farmers; and time enough to develop both in their full social and ecological contexts. How well have the appreciation and integration of farmers'

knowledge filtered into research practice in the years following this call for more holistic management and research? After years of being sidelined, and at a pivotal moment in food systems and climate policy, are farmers' knowledge systems being undervalued in our efforts to understand and respond to climate change? To put it bluntly: are farmers being taken seriously?

To better understand the state of the field, and to consider whether dominant theories have filtered into research practice, we reviewed and analyzed a sample (n=105) of international, English-language publications from the past decade concerning farmer perceptions of climate change. Through careful reading, we answered a series of questions about the papers' contexts, authors, affiliations, and methods and coded more substantive issues such as agricultural systems and discourse around farmers' perceptions.

This paper does not aim to provide a comprehensive overview of the relationship between all farmers and a field of scientific research. Rather, we use a sample set of papers as a proxy for the field of climate change and farmer perceptions. By examining this domain, we try to tease out what may appear to be more generalizable relationships between farmers and research practitioners. We aim to inform food system adaptation projects, land management, and policymaking by highlighting possible gaps between dominant theories and the ways in which research is presently performed.

5.2 Farmers and perception in climate research

5.2.1 *Why talk about perception?*

The concept of “perception” is central to understanding and reacting to risks related to climate change. In the social sciences, the term is used to capture how we interpret reality and experience in order to discern—and inform our reaction to—form, behaviour, and action (Fetterman, 2008). The definition depends on the discipline using it, and is rarely uniform even then: in the conservation literature, for example, Bennett (2016) notes that the term is frequently used, but loosely defined depending on the situation.

Within the theoretical framework of climate adaptation, “perception” refers specifically to one’s relationship with climate-based risks: here, we base our definition of the concept in how it exists within the “solution space” outlined by the IPCC (2018a). Risk, according to the framework, considers the magnitude of the hazards involved; the vulnerability of actors and infrastructure; and the presence of assets or actors (social, ecological, or otherwise) in an affected area. One of the key components of risk is its *perception*: a series of “subjective judgement[s] [made] about [its] characteristics and severity” (IPCC, 2018a, p. 557). Risks, especially climate-related risks, must be assessed and managed in order to inform adaptation and mitigation processes. But the success of adaptation planning depends on how actors perceive and react to the risks involved (IPCC, 2018a).

Perception interacts with another increasingly-recognized tool that the IPCC identifies in its climate risk framework. Local knowledge, in the framework, encompasses “the understandings and skills developed by individuals and populations, specific to the places where they live”; it is “a key element of the social and cultural systems which influence observations of, and responses

to climate change”, influencing decision-making and governance in the short- and long terms (IPCC, 2018a, p. 553). In the food-climate nexus, then, whether adaptation succeeds or fails depends on both farmers’ knowledge and their perceptions of the risks involved. Knowledge and perception are intertwined and interactive facets of climate adaptation: while the former is the sum of understanding and past experiences, the latter is a knot of subjective judgements, reactions to specific events or processes (of which climate change may be only one).

For our purposes, we define farmers’ perceptions of climate change as subjective judgments which inform appropriate reactions, based on explicit and tacit knowledge about the characteristics and severity of risk. We focus our study on farmers’ perceptions in order to explore how farmers’ contributions are integrated into food and land adaptation to climate change—and, therefore, the way they evaluate and interact with risk and policy. Knowledge is essential to perception, but encompasses a vaster set of experiences and understandings (Collins, 2004; IPCC, 2014a; O’Connor, 2007); perception as we define it in the climate adaptation space provides a more focused node of inquiry. As we discuss below, we examine “perception” rather than “knowledge” to isolate the literature which considers the risks posed by climate change.

5.2.2 Considering the global North-South divide in climate research

One further reason to examine the state of the literature on farmers’ perceptions of climate change is to consider the potential differences in research conducted in the Global North and the Global South. We follow the *Oxford Bibliography of Literary and Critical Theory*’s definitions of Global North and South, though we recognize that the terms are contested (Mahler, 2018).

Research efforts in the Global South, especially in fields related to development, have often used the technologies of colonialism in order to achieve their aims (Escobar, 2012b). These technologies, as postcolonial scholars have noted, have created a dynamic of inferiority for local and indigenous knowledge-holders, who may begin to think of themselves as inferior and underdeveloped in the face of exogenous inquiries (Escobar, 2012c; Murphy, 1987). This may skew research results by creating dynamics which incite participants to craft answers which aim to please rather than reflect reality (E. Marino & Schweitzer, 2009). Research which proceeds through colonial structures has made uniform and systemic a highly diverse, rich set of cultures and knowledges through normalization, controlled knowledge, and increasingly bureaucratized societies (Escobar, 2012a; Grosfoguel, 2013).

This history must be borne in mind when examining local and indigenous interactions with climate change research. Recent scholarship has leant credence to the widespread but anecdotal understanding that, within climate research, scientists are more likely to produce work in or about the countries in which conditions make it easier to generate data, rather than the ones which are shouldering the most dramatic impacts of climate change. Hendrix (2017), for example, notes that English-language climate research in Africa tends to overwhelmingly take place in countries with previous British colonial history; strong civil liberties; and relative political stability. He also notes that such research usually employs macro-level methodologies which provide more general than local data. Consequently, research into adaptive capacity may be hindered by trying to understand phenomena which “can only be understood crudely from afar” (Hendrix, 2017, p. 145).

Exploring the methods and approaches used by researchers of farmer perceptions of climate change may lend insight into the ways in which this subset of the field interacts with the colonial legacy of North-South research.

5.3 Methods

5.3.1 Data collection

To obtain an initial sample to review, we searched the SCOPUS database for English-language papers published between 2007 and 2018 which contained the keywords “farmer”, “perception”, and “climate change”. We chose SCOPUS because it is well-established in literature reviews, though the search yielded similar results across various databases. By sampling within the past decade, we wanted to capture how farmers are presently treated in research practice, rather than to track the evolution of that treatment. We chose the keywords that yielded our sample after multiple searches with other options because they identified a simple, yet well-bounded corpus of concepts of a viable size for thorough analysis. Our other initial search strings included terms such as “knowledge” in addition to, or in place of, “perception”; “agriculture” rather than “farmer”; and “environmental change” rather than “climate change”.

Our final choice of terms introduces biases, as might be expected from any selective representation. It was made, however, to examine farmers’ perception of climate change within a framework of climate risk and adaptation. As we explain above, while “knowledge” of climate change can refer to the sum of understanding and past experiences with the phenomenon, “perception” narrows in on farmers’ subjective judgements and related decisions and is therefore inherently more closely connected to endogenous and planned adaptation measures. As a

concept, perception has parallels in other fields: Bennett (2016) notes the frequent occurrence of the term in conservation research, and suggests that, though often dismissed, perceptions are essential to evidence-based conservation. It was useful to use terms which were mirrored in the disciplines of conservation and land management, given that farmers interact with researchers in other contexts than climate change. We consider the various uses of the term “perception” across our sample in our discussion section below.

The choice also allowed us to maintain consistency and keep to a bounded area of research within a much larger subject area. For example, the same query including “knowledge” instead of “perception” yielded 3,625 papers, which suggests that there exists a significant but separate literature where farmers are framed as having knowledge about climate change rather than “perceiving” it first-hand. Our sample selection intentionally digs into the vein of work around perception in order to more effectively place boundaries on our exploration of the literature.

From the initial list of 189 papers, we surveyed abstracts and filtered our selection down to 105 papers. In order to make it into the final study set, papers needed to include research that:

- collected primary data from farmers through direct interactions (i.e., they could not exclusively collect farming data from a census, nor could they exclusively be concerned with agricultural policy, extension, or horticulture);
- discussed farmers’ relationships to climate change through observable phenomena, (e.g., extreme weather events, temperature increases, etc.); and
- had an empirical basis (i.e., they did not exclusively consider the theoretical implications of farmer perceptions of climate change).

5.3.2 *Analysis*

In reviewing each paper, we sought to answer the following questions:

- Where is the research taking place?
- Are authors who perform research in a region affiliated to a local institution?
- What kinds of methods were used in the research?
- How are farmers' production contexts described?
- How are farmer perceptions about climate change characterized?
- If a paper attempted to verify farmers' perceptions as observations against historical data, were farmers' perceptions accurate?

We reviewed and coded the papers according to the following categories:

Region of study. We inductively generated a set of regional clusters for the papers, assigning them to North America; Europe; Oceania; Asia; Sub-Saharan Africa; and South America and the Caribbean (see Table 5.1). The rationale behind the clustering was tied to geographic and economic similarities between the countries. Some regions (for example, North Africa) were not included because the sample we identified contained no papers concerning the region.

Within the analysis, the regions were clustered into the economic Global North (North America, Europe, and Oceania) and Global South (Asia, Sub-Saharan Africa, and South America and the Caribbean).

Table 5.1 Countries included in each region

Cluster	Region	Countries covered
Global North	North America	United States
	Europe	Italy, Malta, Mediterranean Region, United Kingdom
	Oceania	Australia
Global South	Asia	Bangladesh, China, India, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand
	Sub-Saharan Africa	Bénin, Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, South Africa, Swaziland [sic], Tanzania, Uganda, Zambia, Zimbabwe
	South America and the Caribbean	Argentina, Bolivia, Jamaica

Local institutional affiliation to the region. We classified papers based on whether their authors were affiliated with an institution that was local to the region (i.e., in the same country). We tracked affiliations separately for the lead author and for all other authors of the paper. We did this in order to explore the phenomenon of local authorship leadership.

Methods used in the research. We reviewed each paper for the methods used to collect data. We found that researchers used surveys; interviews; focus groups; historical climate and weather data; participatory rural appraisal techniques (PRAs); and participant observation techniques.

Types of farming production. We captured the types of agricultural production that were described in each paper, which included fruit; livestock; aquaculture; grain; dairy; “mixed production”, a description employed to suggest that many types of commodities were being produced, though not explicitly stated; and “not given”, meaning that the paper never referred to a specific type of production.

We only coded a paper's production type as "mixed production" if it used that phrase, or something similar, to describe the commodities; we did not include any examples the paper provided within our typology. This was due to the fact that, when papers described mixed production, they typically gave one or two examples, but not an exhaustive list, of a farm's outputs. Coding these examples would have led to an incomplete description. Moreover, we found that no paper within our sample described more than one singular type of production.

Discourse concerning farmer perceptions. It became apparent upon reviewing the literature sample that there exist multiple, overlapping discourses around farmers, perceptions, and climate change, and that papers frame farmers according to one or many of these discourses. We did not succeed in finding any existing typologies of perceptions in the literature analogous to the one which emerged in our analysis. Existing typologies of farmers' perceptions primarily focus on describing farm production (e.g. Nainggolan et al., 2013; Soini et al., 2012) or income streams on farms (Daloğlu et al., 2014; Guillem et al., 2012).

By identifying and grouping indicative thematic statements from each paper, we developed a typology to understand how farmers' agency is characterized. As we reviewed papers and undertook the initial stages of analysis, we grouped papers into emerging themes of farmer characterization. We iteratively reviewed and adjusted groupings as the analysis proceeded. We found that the discourse around farmers considers them "verifiable", "vulnerable", and/or "viably adapting"; these types are informed by how farmers have been perceived throughout the development and postcolonial literatures (FAO et al., 2018; Loboguerrero et al., 2018; Niles et

al., 2015; Sumane et al., 2017). Table 5.2 provides definitions of these terms, while Table 5.3 provides examples of their usage in our sample.

Table 5.2 Farmers' perceptions as characterized by reviewed articles

Type	Definition	Characteristics	Analogue in literature
Verifiable	Farmers may perceive changes, but these must be evaluated against historical climate data for the region in order to ascertain whether farmers are correct.	Focuses on empirical observations of change Uses historical climate data as an objective metric for verification	None found.
Vulnerable	Farmers may perceive changes, but are not able to successfully adapt to climate change on their own and need help from outside institutions.	Focuses on adaptation to change Makes recommendations for supporting farmers to reduce climate change vulnerabilities	The Intergovernmental Panel on Climate Change's definition of "vulnerability", which covers "the propensity or predisposition to being adversely affected" (IPCC, 2014b, p. 128)
Viably adapting	Farmers perceive changes in weather and climate and are endogenously adapting their practices based on these perceptions.	Considers farmers as local experts in adaptation Advocates collaboration between farmers and existing initiatives for viable climate change adaptation	Farmers as "ultimate applied researchers" (Kent & Sherren, 2017, p. 7) Definitions of self-organization and adaptability in farms (Darnhofer, 2014)

Table 5.3 Examples of discourse typology

Example	Verifiable	Vulnerable	Viably Adapting
Government and policy makers should support farmers to generate long-term and location-specific adaptation strategies. (Manandhar et al., 2011)			
To test farmers' perceptions of recent changes in climatic conditions, climate data for 1948–2013 were obtained from the Khulna Climate Station [...]. (Kabir et al., 2017, p. 2)			
Smallholder farmers continuously adapt to climate change using autonomous adaptation strategies [...]. (Tambo & Abdoulaye, 2013, p. 386)			
The high rainfall variability and rising temperatures observed in the meteorological records and supported by farmers' narratives pose a threat to agricultural productivity. Hence, agriculture development efforts need to prioritize interventions that will help [...]. (Mulenga et al., 2017)			
Farmers' perceptions of climate variation, risk and change are complex. They are keenly aware of variability [...] skilful seasonal forecasts [...] would help farmers take decisions. (Coe & Stern, 2011, p. 395)			

After coding each paper, we used the PivotTables software package on Microsoft Excel (Microsoft, 2018) to perform descriptive statistics and cross-tabulation analysis to understand the distributions of categories and relationships between them. The purpose of crosstabulation was to give an exploratory overview of the collected papers based how frequently these variables occurred together, rather than to perform statistical tests.

5.4 Results

5.4.1 *Study areas, author affiliations, and research methods*

We found that most of the papers in our sample concerned research performed in areas in the Global South (Table 5.4). Of the 105 papers surveyed, most engaged with farmers in Sub-Saharan Africa and in Asia. Following those two larger regions, the papers concerned Europe; North America; South America and the Caribbean; and Oceania (Table 5.4). Overall, 85% of papers reported on research performed in the Global South, while 15% did so for the Global North.

We found that lead authors were affiliated to a local institution in just over half of papers, though the distribution varied according to the region studied. Regions with the highest number of locally affiliated lead authors were, in descending order, North America; Europe; Asia; Oceania; and Sub-Saharan Africa. None of the papers from South America and the Caribbean had a lead author with a local affiliation. Lead authors were locally affiliated significantly more in the Global North than in the Global South (Table 5.4).

When we include authors in any position on the author list, the proportion of locally affiliated authors rise to 80% overall (Table 5.4). Local authors were most likely to be involved in research based in Europe and North America, then Asia, South America and the Caribbean, Sub-Saharan Africa, and Oceania. In the Global North, 94% of papers were written by local authors, versus 78% in the Global South.

Historical climate data was used more frequently than any other method, generally for verifying farmers' perceptions (Table 5.4). Surveys were used in 79% of papers; the majority of these were household sample surveys which were distributed across the region with an n ranging widely between 15 and 3300. They were followed in frequency by the use of focus groups, and semi-structured interviews. Participatory rural appraisal techniques (a group of tools and activities for community-led discussion including social mapping, resource mapping, and timelines; see Paul (2013)) emerged as a set of methods used less frequently, as did participant observation techniques. Counting the ways methods were used in combination with each other revealed that surveys and historical data were overwhelmingly used in combination above others. Following this combination was surveys, historical data, and focus groups; surveys, historical data, and interviews; surveys exclusively; and surveys, historical data, interviews, and focus groups. Other combinations occurred in 6% of papers or fewer.

Breaking research methods down by region yielded trends which suggest a Global North/South divide in methodology. Comparing farmer observations with historical climate or weather data was employed as a method less often in Europe and North America, than in Asia, Sub-Saharan Africa, and South America and the Caribbean. In the Global North, interviews were used more

commonly than in the Global South. Table 5.4 presents a more thorough comparison of Global North and South in the sample.

Table 5.4 North-South differences in climate change perceptions research

Region	NA (n=6)	EU (n=8)	OC (n=2)	GN (n=16)	AS (n=35)	SSA (n=49)	SAC (n=5)	GS (n=89)
Percentage of total number of papers	6	8	2	15	33	47	5	85
Authorship (%)								
Lead author is locally affiliated	100	75	50	81	69	37	0	47
Any author is locally affiliated	100	100	50	94	83	74	80	78
Methods (%)								
Survey	83	88	100	88	80	78	60	78
Historical data	67	38	100	56	91	86	100	89
Interview	33	25	100	38	29	27	20	27
Focus Group	33	13	0	19	43	31	60	37
PRA	0	13	0	1	9	6	0	6
Participant Observation	0	13	0	1	3	0	20	1
Type of production (%)								
Production described	17	50	50	38	20	16	60	20
"Mixed production" described	67	25	50	44	23	18	0	19
Production not described	17	25	0	19	57	65	40	61
Typology (%)								
Verifiable	0	38	100	31	83	71	60	48
Vulnerable	100	75	0	75	83	71	60	75
Viably adapting	33	25	0	25	40	41	40	40

Table legend:

NA	North America	AS	Asia
EU	Europe	SSA	Sub-Saharan Africa
OC	Oceania	SAC	South America and the Caribbean
GN	Global North (aggregated)	GS	Global South (aggregated)

5.4.2 *Farm production and farmer perceptions*

The most common type of production described by the papers in our sample was mixed farming, which was invoked in 23% of papers. We identified these via phrases such as “mixed farming, including poultry and beekeeping, is practiced” (Ayal & Filho, 2017); or “the two case study regions represent [...] mixed farming systems” (Tseganeh Kassie et al., 2013, p. 1116). Other

types of singular production occurred less frequently: in decreasing order, these were grains (11%); dairy (4%); fruit (3%); livestock (3%); and aquaculture (2%). In 54% of cases, the production type was coded as “not given”. Sub-Saharan Africa, Asia, and South America and the Caribbean were the three regions where production types went most frequently unmentioned, with production type not being given in 65%, 57%, and 40% of papers respectively. Production methods were not described in 61% of papers concerning the Global South, versus 19% of papers regarding the Global North (Table 5.4).

Many papers made use of historical climate or weather data in conjunction with other methods in order to ascertain whether the changes which farmers had perceived matched the meteorological record (84% of the 105 papers). In 8% of cases, authors concluded that farmers communicated observations which did not match the meteorological record. In 5% of the cases, farmers’ perceptions were deemed partially accurate in observing multiple phenomena. In 87% of these papers, farmers’ observations were consistent with historical weather or climate. Grouping areas for Global North and Global South showed a similar distribution: farmers’ observations were consistent with the climate record in 89% of cases in the Global North, and 87% of cases in the Global South.

Globally, papers characterized farmers most frequently according to the “vulnerable” discourse (75% of papers); next most common was “verifiable” (46%) and “viably adapting” (38%). This pattern did not differ in Asia, Europe, South America, and Sub-Saharan Africa (see Figure 5.1, below). The discourse distribution differed in North America, where all papers used a

“vulnerable” discourse, 33% used the “viably adapting” discourse, and none used a “verifiable” discourse. The two papers in the set concerning Oceania only employed a “verifiable” discourse.

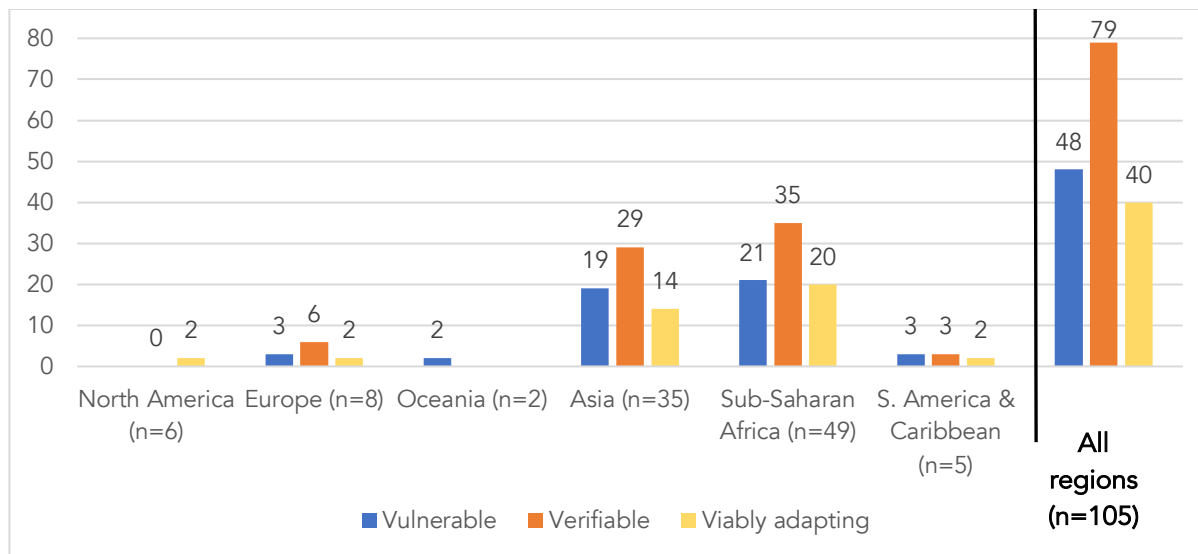


Figure 5.1 Discourse of farmers' perceptions by region

5.4.3 Defining “perception”

Given the importance of “perception” within our search string, we were surprised to find that papers rarely had a consistent or established definition of the term on which they were basing their analysis. Most papers did not define the term at all. Those papers which explicitly did suggest differing understandings. For example, Ayeri et al. (2012) considers farmers' perceptions as observations of weather and climate events which have been made over a period of time and which can then be applied to adaptation strategies. Baul et al., on the other hand, define perception as “the process of receiving information from the surrounding environment and transforming it into physiological awareness”(2013, p. 586). Other researchers suggest perceptions to be “practical knowledge rising from concrete situations” (Chérif et al., 2016, p. 6). Still others consider them inseparable from local knowledge (Gamble et al., 2010). In the paper set, farmers' perceptions could be affected by social and cultural factors (Varadan & Kumar, 2014);

or they could be entirely objective (perceiving that rainfall had increased or decreased, as in Ayeri et al., 2012). Even when papers did contain definitions, we found them to be significantly variable. We return to the implications of these heterogeneous definitions in our discussion below.

5.5 Discussion

We set out to understand the state of the field of research around farmers' perceptions of climate change. We wanted to clarify how the field considers farmers in comparison to the broader theoretical calls to consider farmers as expert contributors to environmental change management and adaptation discussions. Some of the patterns our research identifies may provide insights into the gap between theoretical standards and research practice, as well as productive avenues for future research.

5.5.1 *Why did most papers cover the Global South?*

Our results show that the Global South receives significantly more attention than the North in the literature on farmer perceptions of climate change. Table 5.4 (above) presents a comparison of aggregated statistics by region in the Global North and the Global South. It shows that our sample contains far more papers concerning regions in the Global South than regions in the Global North (85% vs 15%).

We were surprised to find the Global North so underrepresented in our sample, considering the volume of work which exists in the literature outside this study. In the United States alone, for example, significant lines of inquiry have been developed and consider the barriers to adaptation and mitigation for farmers (J. G. Arbuckle et al., 2015; Haden et al., 2012; Niles et al., 2016;

Roesch-McNally et al., 2017, 2018); farmer beliefs around climate change and conservation measures (J. G. Arbuckle et al., 2013; Gramig et al., 2013; McGuire et al., 2015); and farmer knowledge and perceptions of climate change (Niles et al., 2013; Prokopy et al., 2015).

The fact that our search yielded the results it did despite the existence of the above literature suggests interesting insights into the disciplinary use of the term “perceptions”. Our search query and its resulting pattern were repeated over multiple search engines, which indicates a low likelihood of a technical fluke; and, as we describe above, we considered the term “perception” carefully in order to match language with the established theoretical framework on climate risk and adaptation (IPCC, 2018a). Why the low representation of Global North-based literature in our search query, then?

Two potential explanations come to mind. Firstly, the literature in the Global North may not be focused on perceiving risk in the same way as the Global South: a non-systematic review of the literature on farmers and climate change available in the Global North shows more of an emphasis on how farmers characterize themselves, rather than on how they react to climate change. Terms such as “trust”, “belief”, and “intentions” are common in Global North-based literature outside our sample (J. G. G. Arbuckle et al., 2017; Kenny, 2011; L. W. Morton et al., 2017; Niles et al., 2013, 2016). This could signal an incompatibility with our chosen framework of risk perception, where considering whether climate change is “believable” is not as much in the foreground for farmers as the work of simply reacting to events.

Secondly and concomitantly, the fact that farmers in the Global South have generally suffered first, and more strongly, from climate impacts than those in the Global North might bias perceptions research towards the former region. Climate impacts on the food system have affected the Global South first, and will continue to affect its regions disproportionately (FAO et al., 2018; Hallegatte et al., 2016; IPCC, 2014a). The fact that literature on farmer perceptions of climate change is not as prevalent in the Global North could be influenced by the comparatively low occurrence of food security-threatening events in the region, as well as its generally high financial resilience and adaptive capacity (IPCC 2018).

The low incidence of papers on farmer perceptions of climate change from the Global North within our sample could thus indicate a divide between an ontological approach and a phenomenological approach to farmer perceptions of climate change. In the former, closely associated with the Global North, the literature concerns itself primarily with how farmers consider the nature (or ontology) of climate change. In the later, associated with the Global South, the literature looks at farmers' judgements of and reaction to events (the phenomenology) (Hall, 2016; Howard, 2013). Put crudely, the overabundance of the Global South in our paper sample may be due to the fact that farmers and researchers in the Global North still have the luxury of debating belief—for now.

5.5.2 The field does not yet understand its farmers

Surveying the literature suggests that while theory around farmer perceptions and climate change recognizes the importance of understanding farmers' social and ecological contexts, research practice more often contains itself to surface-level observations and description. Our results

suggest that the research field often lacks in-depth engagement with the social-ecological systems in which farmers are evolving. We argue that this limits researchers' depth of understanding of farmers' resilience to climate change.

Methodologically, surveys dominated research practice in our sample: a large majority of papers used large-scale sample surveys (79% of occurrences), with 78% of papers concerning the Global South using this method. Moreover, farmers' operations were rarely described. In discussing farmers' perceptions of climate change, the papers in our sample identified farmers' types of production less than half the time: the majority of papers were coded as "not given" (54%), and almost a quarter described "mixed production" of commodities (23%). In terms of clarity and context regarding the commodities produced or a farm's production techniques, "mixed production" does not provide specifics. The Food and Agriculture Organization of the United Nations defines "mixed production" as "farming involving crops, livestock and/or trees" (FAO, 2018)—a definition so vast it might as well be referred to as "farming".

Why do surveys take primacy in our sample, and why are farmers so vaguely defined by researchers? It is surprising that, in considering farmer perceptions of climate change, researchers so infrequently use methods that need longer-term qualitative, ethnographic, or otherwise highly descriptive study. Other fields which have considered the interactions of local and indigenous knowledge with climate science have placed much more importance on understanding socio-cultural contexts (see, for example, Baul & McDonald, 2015; Cunsolo Willox et al., 2013; Ford et al., 2016). What are the reasons and potential limitations which might drive authors away from such methodology?

One possible answer is that many of the papers about the Global South were lead by authors from the Global North, a condition which might have lead researchers to adapt their methods to work around funding or capacity limitations. Completing a research project from afar does not necessarily influence the quality of the research it produces; that said, it imposes certain constraints on the process. Funding and time constraints on researchers may limit periods and types of data collection; such limitations can influence the choice of methods towards those that can be deployed to collect data rapidly or even remotely. Data collection on the ground may require translators and research assistants, who add a layer of cultural context to disentangle, as well as further costs. These financial and logistical burdens might disincentivize researchers from conducting deep qualitative interviews, participant observation, in-depth rural appraisals, or other personnel-heavy techniques.

Moreover, working at a distance can make it preferable to use methods which are effective at gathering a broad swath of quantifiable and comparable observations (frost date changes, for example) across a population. They can also be performed consistently by multiple research assistants, eliminating the need for a lead researcher to be present. In doing so, however, they may only capture a snapshot rather than represent the full breadth of farmers' perceptions, much less a farm's management decisions (Darnhofer, 2014). Researching closer to home makes it easier to experiment with data collection and may facilitate more frequent, if not longer, periods of meaningful interaction with farmers.

Has the distance in the field between practitioners and research sites affected the way farmers have been engaged, discussed, and (in some cases) their perceptions evaluated in the literature? We cannot make inferences as to the nature of each individual research project. When we look at the sample as a whole, though, the correlation seems stark, as does the lack of substantive participatory engagement with farmers.

Such broad, rather than deep, description of farmers' practices and perceptions may limit researchers' analysis of climate resilience on farms and in food systems. Discussions in the resilience literature have noted that "underestimating" farmers—either by disregarding practices, or not counting them at all—can negatively impact the quality and breadth of research (Jellett, 2013; Mauro et al., 2009; Sumane et al., 2017; UNCTAD, 2013). Historically, agricultural and land management literatures have privileged quantitative natural science studies, often to the detriment of the social sciences—including, but not limited to, qualitative social sciences (Darnhofer, 2014; Kent & Sherren, 2017; Palsson et al., 2013; Sherren & Darnhofer, 2018). Yet, as Darnhofer (2014) notes, models which attempt to quantify farm resilience must necessarily make a series of simplifying assumptions. They are often unable to capture the relational dynamics of resilience-building on- and off-farm. Quantitative methods are essential in farm systems adaptation research, but relying on them exclusively necessarily obscures insights which could be brought to light by other methodologies. By using qualitative methods less frequently, researchers may remove critical context which would otherwise provide useful information for policy recommendations (Adams & Sandbrook, 2013; Bennett, 2016).

Resilience to climate change requires not only the capacity to notice changes in trends and to adapt one's practices, but also to note what underpins those changes: the relationships and social capital, organizational infrastructure, and culture of support built over the years between farmers and communities (Adger, 2003; Adger, Barnett, et al., 2012; J. Glover, 2012; Nelson et al., 2007). Those relationships, and the work and knowledge required to build them, are the basis of farmers' expertise in both production and adaptation (Carolan, 2006; Raymond et al., 2010; Sumane et al., 2017). They are key to understanding how farmers might react to extreme events or climate trends; to evaluating their vulnerability; and to understanding how successfully they are adapting (Darnhofer et al., 2016; John Ingram, Andersson, et al., 2010; Mauro et al., 2009). There exists significant amounts of work across fields which build on these relationships between local knowledge and climate change (see, for example, Audefroy et al., 2017; Egeru, 2012; Future Agricultures Consortium, 2011; Nakashima et al., 2012; B. M. Smith et al., 2017); while they do not explicitly use the term "perceptions", their insights may prove essential to filling such a gap in discourse.

5.5.3 The colonial undertones of the North/South divide

Our results also point to larger political and socio-economic dynamics which might have led this field of research—one among many—to focus on the Global South from the vantage point of the North. Critical research has brought to light that colonial dynamics remain embedded in academic practice: they shape funding bodies' research priorities and geographies of funding, and hence researchers' field-siting and methodological choices (Agrawal, 1995; Escobar, 2012b; Soler et al., 2018; Sumane et al., 2017; Wilson, 2008). We see these dynamics reflected in the work concerning farmer perceptions of climate change.

Despite largely concerning the Global South, most of the research projects within our sample were led from the Global North: in the former, only 47% of papers had lead authors who were affiliated with a local institution. We also found that farmers in the Global South are rarely described, but often evaluated: although farmers' production techniques were only described in 20% of papers, their observations were often verified (88% of papers). This higher level of attention towards whether farmer perceptions are "correct" is also reflected in the discourses we counted: the sample we filtered through our typology of farmers' agency suggests that the field considers farmers in the Global South as vulnerable (75% of papers) and as verifiable (48%) more so than it does viably adapting (40%). Our analysis suggests that farmers are perceived by researchers as passive subjects to climate impacts rather than as agents in a larger system.

The above data suggest that the theoretical understanding of farmers as experts and the practice of treating them are taking place in separate arenas of the literature. While the field is, at one level, engaging with farmers and their vulnerability to climate change, our analysis suggests that a significant amount of research capacity is still being expended in determining whether farmers are "correct" in their perceptions of changes. Interestingly, our results also show that farmers in the Global South are, in the majority of cases, accurate in their observations, which supports the call for them to be considered as experts. Where farmers were evaluated against historical data, 87% of papers found them to be correct. Certainly, good research requires verifiability; but academics, scientists, and researchers are also capable of error and bias, especially in considering climate impacts on local areas.

The dynamics we describe—a tendency to view farmers, especially in the Global South, as the passive subjects of climate impacts; and a strong research focus on verifying whether their observations are correct rather than describing their context and perceptions—echo dynamics which have, in other fora, been criticized as systemically colonial and exploitative. As we mentioned above, Escobar (2012b) has criticized Global North-South relationships for being extractive. Grosfoguel, furthermore, has argued that academic knowledge structures were designed to be, and have remained, Eurocentric, where Western males from the Global North produce the canon of thought to which the rest of the world is subjected: this becomes “commonsensical”, he writes, “because [these dynamics] are a reflection of the normalized racist/sexist epistemic structures of knowledge of the modern/colonial world” (Grosfoguel, 2013). These criticisms illuminate how self-beneficial it might be for colonial systems to perpetuate the image of farmers in the Global South as passive, vulnerable, and simple: the less farmers can participate in research as equals, the more researchers have the opportunity to perform research on them (Hendrix, 2017; Soler et al., 2018).

We do not suggest that any author of any paper in our sample had any intention other than to perform good research; yet no one is exempt from the political and social structures in which they operate. Broadly speaking, the papers in our sample follow the patterns that postcolonial scholars criticize. Why do farmers in the Global North *know* about climate change, while those in the Global South merely *perceive* it? Why are farmers who live in the Global South more likely to have their observations verified by researchers from the Global North (Table 5.4)? Why are most people who write about farmer perceptions of climate change in the Global South actually from the Global North?

The term “perception” itself may unintentionally cleave to discourse which intellectually discriminates against farmers and sidelines the Global South. The term “perception”, as it is variously employed by papers in our set, often wildly deviates from the relationship to risk that the IPCC, and adaptation theory in general, employ to define it. We noted above that few of the papers chose to define perception; those that did offered varied definitions, few of which were compatible. This implies that either perception may not be critically considered by most of the studies in the field, or that there is a fallacious assumption that a unified definition does exist. Viewed broadly, and divorced from its relationship to risk and knowledge, it can appear as a shorthand for observations judged untrustworthy or not sufficiently scientific for academic standards. It may be worth considering whether the term “perception” is truly, given its vagueness, what is meant.

5.5.4 Implications for future research

Based on our findings, we have two principal recommendations. First, there is a clear need to invest more time and capacity into long-term qualitative methodology in attempting to understand farmers’ perceptions of climate change. Because the sample we analyzed heavily relies on quantitative forms of data collection—a situation possibly created partly by institutional dynamics and partly by practical considerations, among other factors—it fails to acknowledge crucial contextual information from farmers which could inform climate and adaptation research and policy, or at the very least provide an improved background for understanding farmers’ observations. Interviews, focus groups, and participatory methodologies were less represented in the paper set we reviewed. Including these in research on climate change has yielded interesting

and useful results for farmers and researchers alike (e.g. Mapfumo et al., 2013; Sautier et al., 2017), and exploring their methods in other case studies is desirable. Participatory work in general can allow researchers and participants to “ground” their knowledge in place, enabling meaningful dialogue which eschews the more typical power dynamics of extractive research (Ashwood et al., 2014).

Using more qualitative methods will require research projects in which primary investigators spend more time in the region and develop long-term relationships with on-the-ground research collaborators. Echoing Sherren and Darnhofer’s call for more focused qualitative social science in rangeland research (2018), we argue that qualitative methodologies must become more accepted tools in understanding farmer perceptions of climate change. Institutions, both those funding and carrying out research, should work assiduously to ensure that research projects take place responsibly and under reasonable timelines; journals and research publications which might not otherwise be open to deeper, lengthier qualitative pieces, should broaden the definition of what is considered an acceptable scientific publication. We do not suggest that quantitative and model-based studies have not been, nor will continue to be, useful to understanding the relationships between farmers and climate change; rather, we note the imbalance which must be redressed. When we consider the knowledge which integrated research in other disciplines has contributed to climate adaptation discourse, these reforms seem urgent and necessary.

Secondly, the concept of perceptions of climate change needs to integrate a shared understanding between adaptation theory and the study of farmer knowledge in order to lead to productive discussions across regions. Bennett (2016) notes that the social sciences have historically

displayed a looser grasp of “perception” in a research context, particularly within conservation; altering the research agenda to change this is desirable. Primarily, we find that the field needs to distinguish between understanding perceptions as subjective evaluations of climate-related risk, and perceptions as observations to be evaluated. We suggest that research with the latter focus is unnecessary to the broader project of climate change adaptation. Papers which second-guess whether agriculturalists can accurately gauge changes in weather and climate undermine the broader research agenda of climate change adaptation across the food system by relegating experts to a provisional role. When considered in such a light, farmers are no longer “professional specialists in survival” (Chambers et al., 1989, p. 3); they are simply problems to be solved (Sherren & Darnhofer, 2018).

Instead, adopting a definition closer to the one understood by climate adaptation theory—summarized by the IPCC as a judgement on about the potential severity of impacts, informed by knowledge as well as beliefs (IPCC, 2014d)—would allow separate strands of research to be reunited. Framing research to embrace this definition would help better encapsulate and integrate farmers’ observations, long-term knowledge, and agency. It would also guide research towards a fuller understanding of the history and surroundings that inform both how farmers observe climate change and how they can adapt to it. Understanding that farmers’ perceptions are couched in their knowledge and social-ecological contexts will allow the field to focus on why farmers react the way they do—and perhaps let farmers have more of a say in how they are supported.

5.6 Conclusions

We reviewed and coded a sample set of papers (n=105) concerning farmers' perceptions of climate change, and found that 1) researching farmer "perception" of climate change seems to be more frequent in the Global South, as opposed to the North, where other terms are used; 2) farmers are rarely described within their social-ecological contexts, and often simply have their observations segmented and assessed for verification against historical data or quantitative measurements; and 3) the research field may perpetuate extractive and colonial patterns of exchange between the Global North and South.

Our study speaks to the urgent challenge of including farmers in adaptation discussions concerning the food system. Current climate projections concerning food systems imply that, no matter how much mitigation action might be achieved in the future, adaptation is necessary if damage to the food supply—and to food producers' livelihoods—is to be contained (FAO et al., 2018; IPCC, 2014d). Farmers will likely bear the brunt of the task, as they will need to adapt to any social, economic, or political interventions which might be decided at a higher level as well as the direct environmental shocks that befall their farms. It is imperative, then, that any discussion of the adaptation of food systems include the needs and capabilities of farmers, who shoulder both the burden of adaptation and suffer the consequences of poor or non-inclusive institutional planning. Any research which informs both the larger scientific and policy discussions at higher levels must be held to the same standard of inclusion.

There remain several points for further exploration based on our results. The first is the literature which lies beyond "perception"; while we limited our sample to the term for the sake of consistency and feasibility, there should be further assaying of the literature on farmer

knowledge and climate change, as well as other related fields, in order to broaden our understanding of the state of research practice. In addition, more statistical analysis could explore the correlations between methods used and types of perception documented, and to track citations within papers to understand the theoretical orientations to perception held by various research groups.

Meanwhile, our analysis shows that while researchers in multiple fields are engaging with farmers' perceptions of climate change, they consider farmers from an untenably narrow perspective. There also remains an imbalance between the Global North and the Global South in how farmers are considered. Papers often use methods which elide rather than elucidate farmers' sociocultural contexts and agricultural practices. Researchers' discourse around perceptions is spread widely between vulnerability, verifiability, and viable adaptation, rather than beginning from an understanding that farmers are capable experts. Despite repeated calls across the literature for farmers to be considered as experts, whose knowledge is a valuable contribution to the food systems adaptation literature, there remains a gap between theory and research practice. Integrating more substantive qualitative methods in farmer perception research, as well as integrating concepts of perception into risk management and climate adaptation, will help farmers' voices and knowledge be better reflected in the whole of the research field.

It is not enough for papers to call for research practice to be enacted; research must be restructured to allow for a more inclusive community of knowledges to interact and inform each other. The responsibility for adaptation of the food system to climate change rests not solely on the shoulders of farmers, or of policy makers, or researchers—but on all who interact in the food

system. Research communities should welcome all forms of expertise and experience and help each other build the intellectual infrastructure to effectively integrate them. Food, of all things, is not an exclusive topic.

Acknowledgements

Thanks to the team at *Community Forests International*, which provided essential desk and thinking space in the early days of this analysis. Thanks also to the anonymous reviewers whose insights greatly helped the paper in its first drafts. BS is supported by the Rhodes Trust (UK) and the Pierre Elliott Trudeau Foundation (Canada).

6. Farming Along Desire Lines: Collective Action and Food Systems Adaptation to Climate Change

Bernard Soubry^{1*}, Kate Sherren², Thomas F. Thornton¹

Published in *People and Nature* (DOI: 10.1002/pan3.10075)

¹ Environmental Change Institute, School of Geography and the Environment, University of Oxford, Oxford OX1 3QY, UK

² School for Resource and Environmental Studies, Dalhousie University, Halifax, NS, B3H 4R2, Canada

* Corresponding author: bernard.soubry@ouce.ox.ac.uk, phone: +1 (438) 838-8218

Abstract

1. We examine collective action in the food system of the Canadian Maritimes to determine its effect on the resilience and adaptive capacity of food producers, distributors, retailers, and governance institutions.
2. Our data suggest that beyond their immediate benefits for their participants, expressions of collective action generate higher-level impacts which often translate into drivers of adaptive capacity.
3. Drawing on a metaphor from urban design, we suggest that collective action should be considered a *desire line* for food systems adaptation: rather than building adaptation strategies based on top-down design, collective action emerges from farmers' needs and capacities to build financial resilience, enhance human and social capital, and strengthen institutional agency within the system.

Key words

climate adaptation, food systems, collective action, farmers, Canada, desire lines

6.1 Introduction

Are there ever any shortcuts in food systems adaptation? One wishes there were, but the complexity of the global food system resists quick fixes. Rising average temperatures; uncertain, or intensified precipitation; and more frequent extreme-weather events will lead to crop failures and loss of nutrition (FAO et al., 2018; IPCC, 2014d). The increasing vulnerability of transportation and storage infrastructure will affect distribution and supply chains (Ericksen et al., 2009; S. J. Vermeulen et al., 2012). The nature of the global market suggests that the

financial and physical hardships caused by climate impacts will primarily fall upon rural populations, especially food producers (Hallegatte et al., 2016). If it is to succeed at all, climate adaptation planning needs to match the complexity of the problems it faces, reaching across scales (Adger, 2003; Adger et al., 2005) and centres of power (Ostrom, 2008). Rather than exclusively focusing on specific risks and their mitigation, it must also bolster adaptive capacity—the “ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (IPCC, 2018a, p. 541)—to account for unpredictable shocks and unaccounted drivers of change (Adger et al., 2011; Brooks & Adger, 2005).

Part of the difficulty in finding solutions to the wicked problem of climate change lies in the nature of institutions, which—as the means through which transactions are made predictable—are resilient for better or for worse (Dovers & Hezri, 2010). Institutions in climate adaptation are a paradox: while they provide an alternative to an entirely chaotic reshaping of the world, they also make us “‘prisoners of history’, [given that] institutions typically embody past understanding and imperatives, not present or future ones” (Dovers & Hezri, 2010, p. 212). The challenge of climate adaptation is therefore also the challenge of institutional change. Berkes (2009) points out the importance of networks and “bridging organizations”, which provide a space multiple types of knowledge to interact and coordinate so as to co-manage and ultimately transform institutions. As organizations, they “respond to opportunities, serve as catalysts and facilitators between different levels of governance, and across resource and knowledge systems” (Fikret Berkes, 2009, p. 1695). How do these elements, necessary as they are to adequate climate adaptation, manifest on the ground?

Urban design and planning describe a common phenomenon that may be helpful to understanding adaptation. In cities, tracks often appear where people repeatedly leave city-imposed sidewalks behind in order to navigate more efficiently. These repeated paths are called *desire lines*: communally-generated vectors which solve the problem of getting from one point to another while nimbly ignoring ineffective structures (N. Smith & Walters, 2018). Similarly to institutions, they become “behavioural grooves where many people tread” (Sherren, 2009). They are socially generated; they react constructively to poor planning; and they are sufficiently obvious to be followed by others (Nichols, 2014).



Figure 6.1 Desire line, Brighton, UK (Hulme, 2013).

Desire lines remind us of the collective nature of adaptation, which is just as important in solving the problem of climate change as it is in solving how to get home on time. In systems-level adaptation, collective action is an essential vector to communicate information and technology

(Meinzen-Dick et al., 2010); bridge compromise between political levels (DeMarrais & Earle, 2017); allow for local experimentation and social learning (Atkinson et al., 2017; Christmann et al., 2015; Rodima-Taylor et al., 2011); and strengthen the capacity for effective decision-making (Adger, 2003; Nelson et al., 2007).

Food systems adaptation policy has generally been implemented with a top-down approach, rarely considering the importance of collective action. Literature in the area has mainly focused on modelling studies, to the detriment of observational and experimental research (Porter et al., 2017). Some literature has raised the importance of collective action in farm-level adaptation (Andersson & Gabrielsson, 2012; Leclère et al., 2013; van Bers et al., 2016); however, its methodologies have tended towards revealing more mechanistic, individual aspects of adaptation, focusing on crop yields and production systems (Darnhofer, Bellon, et al., 2010). Crucially, research initiatives have failed to bring farmers to the table in order to develop solutions, despite a growing consensus in the literature that producers' expert knowledge should be leveraged (Kent & Sherren, 2017; Soubry, 2017c; Soubry et al., 2020b; Sumane et al., 2017). Doing so leaves a gap in understanding the relationships between farms, farmers, and other areas of the food system such as distribution and sales (Darnhofer et al., 2016; Porreca, 2010; Wynne-Jones, 2017). Top-down methods may be more efficient at delivering policy, but they risk presuming the needs of parties and creating the unattainable expectation that such policy will single-handedly solve the problem of adaptation. (Ostrom, 2010b).

Collective action and desire lines may follow the same path: both react to an imposed environment with tacit knowledge adapted to local conditions. Both provide emergent and

endogenous solutions independent of what could be elaborated exclusively from theory. And both may be useful in bringing to light the role of collaboration in creating robust, adaptable land-based food systems.

In this paper, we examine how collective action, climate change, and food systems interact by asking: How does collective action emerge in land-based food systems? How does it affect these systems' resilience and adaptive capacity? And how can it contribute to the broader goal of successful climate change adaptation? Our research aims to build on the emergent understanding of how collective action affects food systems adaptation and to inform decision-making at the regional and federal levels in Canada. It may be that building policy goals in accordance with collective action is one path to building resilience in the food system at the regional scale.

6.2 Methods

6.2.1 Research area: the Maritime provinces of Canada

The Canadian Maritime provinces of New Brunswick, Nova Scotia, and Prince Edward Island (hereafter referred to as “the Maritimes”) have historically seen their economies defined by agriculture (Beaulieu, 2015), though these have diversified in recent decades. A trend towards farm agglomeration has decreased the number of mid-sized farms, leaving distributions of farm sizes centered around small and large farms (see Fig. 6.2). Consequently, and helped in part by a Canadian focus on agricultural exports (Statistics Canada, 2017a), farms have developed market niches based on their scale, with small farms selling more locally and intersecting less frequently with large-scale grocery and export-related sales. We focused primarily on small-scale vegetable production.

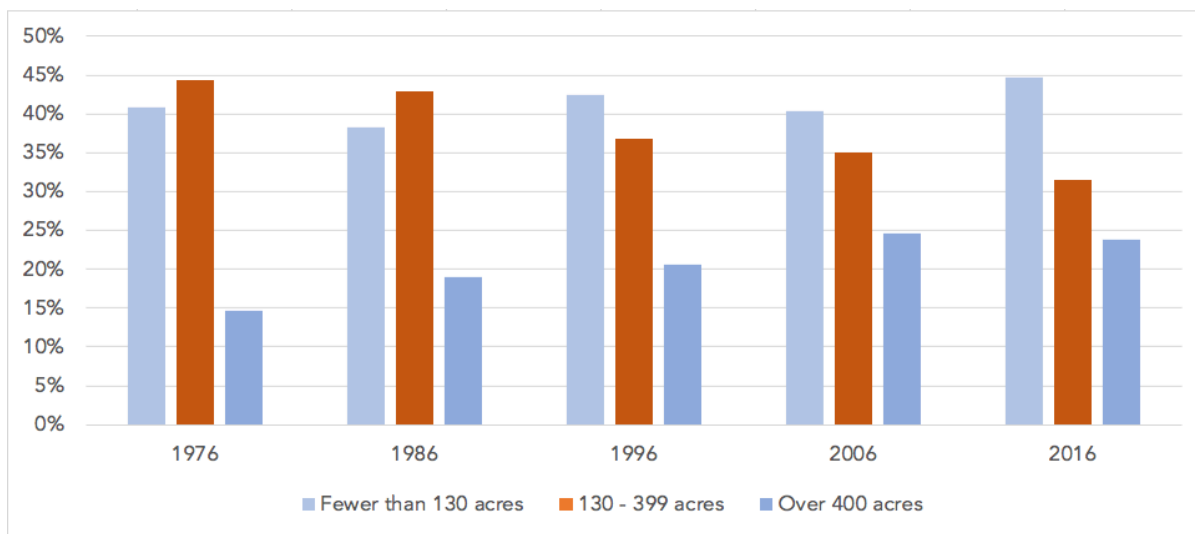


Figure 6.2 Proportion of total farms by size in the Maritime provinces, 1976-2016. (Statistics Canada 2019)

Climate change is projected to have largely negative impacts for the region's food system.

Though models do show projected gains in crop production due to increased availability of heat units, they also highlight higher rates of crop failures and disruptions in production, distribution, and consumption due to sea level rise; more frequent extreme weather events; and shifting pest populations and diseases (Arnold & Fenech, 2017; Rapaport et al., 2017; Savard et al., 2016).

Farmers report events and trends which suggest that the above have already affected the land-based food system in the region (Soubry, 2017c).

Provincial governments' climate action plans leave significant gaps in food systems adaptation planning and implementation. Areas of action related to agriculture are primarily concerned with reducing greenhouse gas (GHG) emissions caused by machinery, fertilizer use, and tillage (NB Govt, 2013; PEI Department of Communities Land and Environment, 2018; Scotia, 2009).

Critics have accused certain government agriculture and land planners at the municipal and

regional levels of consistently misunderstanding the mechanics of climate change and the risks associated with its impacts in the region despite the information available to them (Fox & Daigle, 2012; Lieske et al., 2015; Wade & Robichaud, 2011). There exist few accountability processes or metrics to assess provincial governments' adaptation targets, which allows plans to be made without a system for evaluating their effectiveness (Auditors General of Canada, 2018). Finally, small-scale farmers in the Maritimes have a narrow relationship with government, either due to their ineligibility for support which is largely targeted at large-scale agriculture (Soubry, 2017c) or a desire for independence and mistrust of government subsidy (Stock et al., 2014; Stock & Forney, 2014).

Reluctant though some may be to engage with government, farmers in the region have a history of cooperation and collective action in responding to economic and social disruptions (Burge, 1987; Coghlan & Brydon-Miller, 2014). The National Farmers' Union, formed in the 1960s and active in New Brunswick and Prince Edward Island, is a farmer-led organization which has catalyzed collective responses to the industrialization of vegetable production (Burge, 1987; Desmarais & Wittman, 2014; McLaughlin, 1987; National Farmers Union, 2014). Nova Scotia, meanwhile, saw the rise of Antigonish Movement in the 1930s, which created a number of agricultural cooperatives to respond to rural economic decline (Coady, 1939); other provincial initiatives claim the movement as part of their ideological roots (Coghlan & Brydon-Miller, 2014; Macaulay, 2001; Macinnes, 1978; Sacouman, 1977). All three Maritime provinces also have organizations member to the Canadian Federation of Agriculture: the Nova Scotia Federation of Agriculture, New Brunswick's Agricultural Alliance, and the Prince Edward Island

Federation of Agriculture (Canadian Federation of Agriculture, 2019). The Maritimes are therefore an interesting place to examine the capacity of collective action to generate change.

6.3 Data Collection and Analysis

6.3.1 *Grounded Theory Methodology*

We designed our research project according to constructivist grounded theory methodology (GTM) (Birks & Mills, 2015; Charmaz, 2016; Glaser & Strauss, 1967). GTM aims to allow researchers to build theory without requiring preconceived theoretical frameworks to be imposed upon research (Birks & Mills, 2015; Glaser & Strauss, 1967). Within this frame, researchers are encouraged to structure data generation so that participants' experiences and concerns guide the research process (Dunne, 2011). We received clearance to proceed with interviews from the University of Oxford's Central University Research Ethics Committee.

6.3.2 *Data Collection and Analysis*

Between 2016 and 2018, we conducted long-form interviews with small-scale farmers; retailers; government officials; and civil society actors across the Maritimes (n=60). Interviews took place in French or in English, depending on which language was preferred. Interviewees were selected through advertisements in regional agricultural organization newsletters, as well as through random, anonymous sampling of farmer organization databases. Both led to an online form where participants could register their interest. We also directly contacted government offices and sought out interviews with relevant people. Additionally, snowball sampling techniques were particularly useful for meeting farmers in the region, given that some producers choose not

to register their operations and are therefore untraceable in formal databases (see Chromy, 2011). The respondents were distributed across agricultural land in the region (see Fig. 6.3).

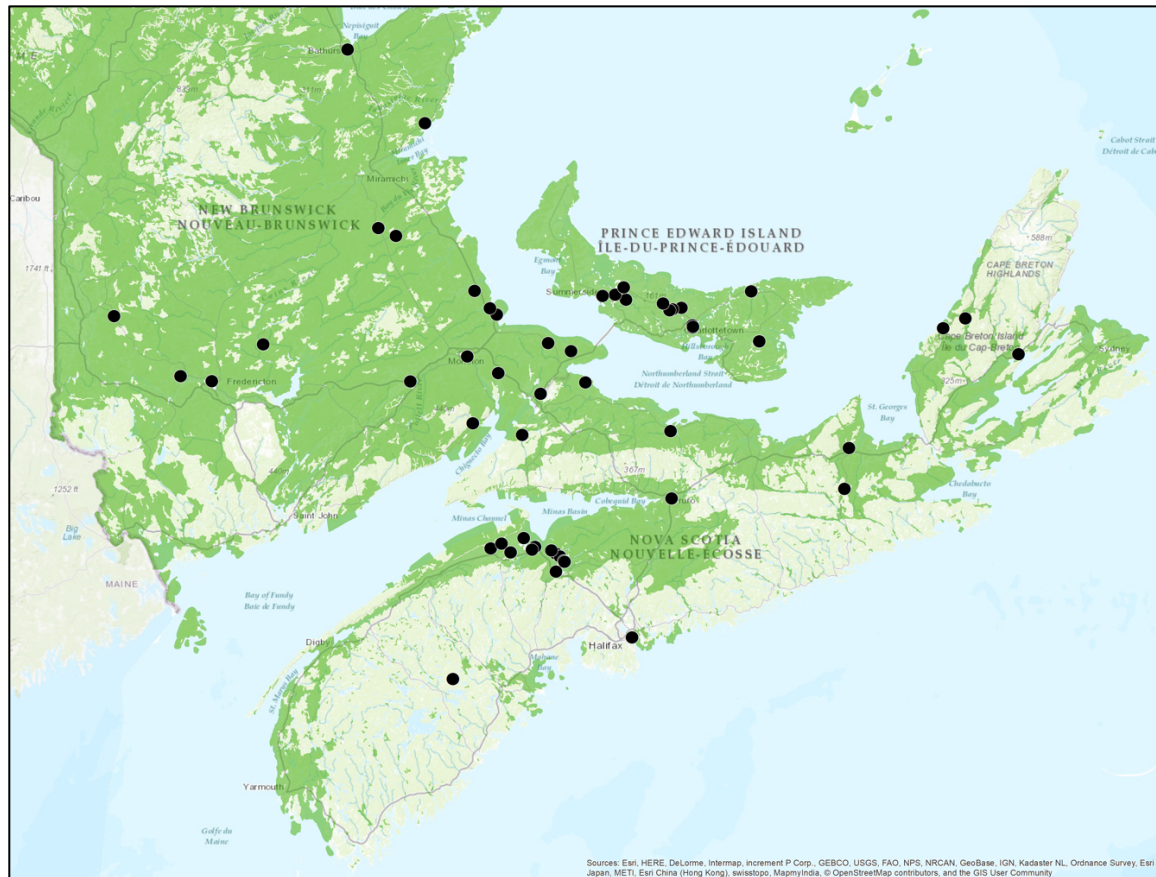


Figure 6.3. Respondents in relation to agricultural land capability. The shaded area represents available arable land in the region; dots are interview sites. Our interviews do not span the whole region of study, but are representative of the areas available for farming.

We primarily targeted small-scale vegetable producers as part of our sample. In framing our research, we hoped to capture a sample population where farmers sell within similar market streams, work under similar production stresses, and have similar response capacities. Small-scale agriculture in the region is primarily vegetable-based (Statistics Canada, 2017a); vegetable producers are more likely to belong to same-scale retail or distribution associations. BS, the lead author of this paper, was a farm worker and manager in the region between 2013-2016, and has a

close relationship with the small-scale vegetable production community in the region. This connection enabled a more trusting researcher-participant relationship and allowed for conversations which might otherwise have been more reserved. For these reasons, small-scale production is a suitable and justifiable research population for the type of data generation which we wished to elicit: working with larger-scale producers would have required either an unsustainable amount of time to gain the same amount of trust, or else the use of quantitative research methods which, while descriptive, would have led to a less subtle interpretation of actors' relationships (Darnhofer, 2014). We also recognize that the question of what "small-scale" represents is contentious, given that definitions vary both in size and metric (Bronson et al., 2019; Cohn et al., 2017; van Vliet et al., 2015). The largest area of active production we considered was 150 acres, which fits within the distribution of smaller farms in the region.

Ethics for the study were approved by the University of Oxford's Central University Research Ethics Committee. When participants were first approached and communicated interest in being interviewed, they were presented with a written consent form which informed them of the potential risks of the research and assured them that their interviews would be anonymized. In situations when participants were unable to provide written consent, verbal consent was recorded.

We conducted semi-structured interviews (n=60) during the spring and summer of 2016, as well as during the winter of 2017; interviews typically lasted an hour. Table 1 provides a breakdown of the types of actors we interviewed in each province.

Table 6.1 Interview respondents by region

	New Brunswick	Nova Scotia	Prince Edward Island
Farmers	11	19	9
Retail/Distributor	2	4	1
Government	2	5	3
NGO	0	2	2
Total	15	30	15

Interviews with farmers covered the perceived impacts of environmental changes on crops and farm infrastructure; the adaptation of production methods or business plans; support received or given from farmers, government agencies, and other food system actors; and any other concerns the farmer considered important. Interviews with retailers and distributors involved describing the state of food distribution in the region; environmental or other risks to distribution; forms of support given or received by farmers or other distributors; and other concerns. Interviews with government officials also considered the impacts of environmental changes on the food system. They covered a department's relationship with farmers and farmer organizations; programmes and support which were offered to promote adaptation; and future plans for relationship-building and adaptation. On farms, we also undertook participant observation: most interviews took place in the context of a day's work on the farm, and the researcher performing the interview often worked side-by-side with the farmer while talking, recording on a field microphone. This exchange of work for information was essential to us in maintaining a sense of relational accountability (Wilson, 2008) between farmers and researchers. Work time is irreplaceable during the growing season: by providing skilled help, we meant to justly compensate farmers for their expertise and build a relationship of mutual respect and utility.

After a period where participants could add additional comments or clarifications to their transcribed interview, we coded transcripts inductively according to constructivist GTM and noted emerging themes for analysis. This followed an inductive process, moving from axial coding of initial ideas to theoretical coding of a typology of collective action. Each round of coding proceeded from specific items to more general themes to potential theory (Birks & Mills, 2015; Urquhart, 2013), thereby building theory that was based entirely on interview participants' experiences rather than through existing literature (Suddaby, 2006). From the initial set of codes, we highlighted forms of collective action which clustered around common themes and generated a typology of collective action for the region. Collective action within the interview material could be classified into three sections: community-based, farmer-based, and market-based (see Table 6.2). Where examples are useful, and to convey local voices and expertise, we present transcripts from interviews below.

Table 6.2. Categories of collective action

Category of collective action	Definition and examples
Community-based	Included local groups; community or regional agriculture organizations not governed by farmers; non-farming neighbours and community members lending support and knowledge
Farmer-based	Farmers sharing infrastructure and informal peer-to-peer support; agriculture organizations governed by farmers
Market-based	Formal and informal marketing co-operatives; farmers' markets; food hubs and other distribution actors

6.4 Results

Participants volunteered multiple categories of collective action that impacted both their individual farms and their relationship with other areas of the food system such as food distribution, storage, and sales. A summary of these expressions is available in Table 6.3.

6.4.1 *Types of collective action*

We grouped expressions of collective action according to emerging categories and found that collective action in the region is rooted in surrounding communities; on farms; and within the markets where food is distributed and sold.

6.4.1.1 *Community-based*

Community-based collective action refers to actions or institutions organized by non-farmer community members which support small-scale vegetable production in the Maritimes. Many of these are informal associations, bound by support from neighbours and community. Farmers seek out advice and knowledge about local climate and soil conditions by community members from older generations. They also benefit from close neighbourly contact, receiving help in other specialized tasks such as veterinary medicine or farm tool repairs:

A family friend is our large animal vet, and we go over and watch hockey at their house, you know. Anytime anyone is sick or injured on a weekend I can call them and say, I've got this in my fridge, is this what I should be using? Or he'll come out in the middle of the night if we need him. [...] He gives really great advice in terms of livestock.

Farmer, New Brunswick (NB-013)

A lot of our knowledge on the historical climate trends or weather events has come from other people that we are asking those questions to. Our first-hand experience is really limited, still, and the two growing seasons that we've had here have been very different from each other.

Farmer, Nova Scotia (NS-024)

One informal expression of community-based collective action was a regional seed-breeding group which seeks to isolate locally adapted, resilient seed varieties for collective use, and therefore indirectly support small-scale agriculture.

Participants also noted the importance of community-led agriculture organizations, which aim to bridge gaps in government support for agriculture. These organizations often liaise with governance institutions such as Departments of Agriculture and extension agents on behalf of farmers.

The government has a great information package—I shouldn't say it's great; it's good. I think it needs another element. It tells you [that the agriculture industry is there] are there, but it doesn't necessarily tell you how to get into [it].

Q: So it provides information that still makes it necessary for an organization like SPADE [the Sunrise Partnership for Agricultural Development and Education, New Brunswick] to exist.

A: SPADE [helps] link the organizations that are doing that. There are 5 or 6 organizations that are all tackling little parts of that how to become a farmer chain, but there are still gaps.

Farmer, New Brunswick (NB-013)

6.4.1.2 Farm-based

Farm-based collective action emerges through formal and informal interactions between farmers which aim to support on-farm production, financial resilience, and knowledge in the community.

Respondents described some formal, regional, farmer-led non-governmental organizations that aim to build community between farmers and advocate on their behalf to government:

As a general farm voice, you have the Agricultural Alliance, the NFU [National Farmers' Union]. And government has been pretty receptive because [...]

they're] strong associations now compared to maybe how it was 10, 15 years ago. So the government will listen.

Government worker, New Brunswick (NB-011)

Networks within the farming community provide support on farms and between farmers by sharing knowledge about useful practices and techniques.

It's hard during the season, but in the winter, [farmers in the region] always try to get together and talk about what systems have been working or not, what the problems are. [Others are] very helpful for that kind of discussion too. I've definitely found the community here to be helpful and welcoming.

Farmer, Nova Scotia (NS-019)

Farmers also share infrastructure such as equipment and storage space; this pooling of resources helps reduce overhead costs on individual farms. These collaborations also make it possible to use certain types of equipment which would otherwise have been too expensive or complicated to be worth the investment, given the comparatively low volume of production for small farms.

We don't have a round baler, so we pay someone to come in and do our baling. We didn't used to have a hay-mower, we now share one with the neighbor [...]. We find it cheaper than having our own baler [...] We don't have to own all this equipment, [...] we couldn't justify owning it for the small volumes that we're doing. Those are efficiencies that we have.

Farmer, Nova Scotia (NS-013)

For smaller-scale producers in the Maritimes, the demand for product occasionally outweighs the capacity to supply it. Some farmers spoke about sending customers to other small farmers in the region, rather than turning potential buyers away entirely, in order to keep the demand in the region.

Often the biggest issue is that we don't have enough of what people want. [...] Usually people around here are really good at saying, I don't have any piglets, go talk to this person. We'll pass around our customers to other people.

Farmer, New Brunswick (NB-013)

6.4.1.3 Market-based collective action

Market-based collective action refers to actions taken by farmers, distributors, and retailers to improve or stabilize their market streams. These include forming formal or informal co-operatives; creating or gaining control of farmers' markets; and creating collaborative distribution hubs (also known as food hubs). They are distinct from community- or farm-based collective action in that they specifically focus on increasing income or financial stability for those involved.

Formal market-based collective action is principally organized around marketing co-operatives, which are led by farmers and aim to pool resources, improve farms' profitability, and better manage the market for local producers. Co-operatives are often highly diversified: the largest regional co-op in our sample was formed as a horticultural co-op but has now expanded to include farmer's market, as well as controlling several advertising streams for the region.

Informal co-operatives, on the other hand, exist as non-incorporated alliances of farmers who work together at market, selling collaboratively to increase their table presence and attract more customers than they would alone.

Farmers spoke of the financial and social benefits that co-operatives have provided for their farms. They found that going to market as a co-op is financially beneficial to everyone involved:

it creates a “catch-all” market for surplus produce and frees up capacity by reducing the time each farmer had to spend at market.

Last year, at [the market], we would just have brought strawberries. We would have made [...] \$1200 last year. But we decided to bring vegetables and all, and officially integrated that cooperation by incorporating as a co-operative with three other farms, what did it bring us? \$5000 in vegetables plus \$1200, \$1300 in strawberries. That's a substantial gain for a first year. And it happened without us really planning for it. We hadn't planned with going to [that market] in mind.

Farmer, New Brunswick (NB-001)

Participants also identified co-ops as opportunities for cross-scale collaboration. One mid-scale apple producer took on packaging responsibilities for a number of smaller-scale producers, allowing apples to be sold to regional grocery stores which would otherwise have been out of the reach of small-scale producers:

One of the producers [...] said, we're ready to take the risk and be the aggregator, so they invested in a packing line. [...] [the producer] takes everybody's apples in the region and is able to offer Sobey's [a grocery store chain in the region] the price and the quantity that they need for their market. [...] [A smaller orchard] sells its apples to [the larger orchard], which bags them and sells them to Sobey's. Which means that those two [could collaborate]—[the smaller orchard] said, the [financial burden of the] packing line doesn't interest us, but it [is] a service [we] need. With the co-operative that makes sure that networking is strong and that those kinds of people can get together... the co-operative didn't do anything except just be there.

Co-operative executive director, New Brunswick (NB-010)

Co-operatives also create a network of producers and distributors who can share knowledge and provide support in times of need.

Because of my [health concerns], I have been relieved of market duty. This is another benefit of the Co-op, that we help each other out if somebody is having a bad year—the co-op can kind of come together to be there [and support them

financially or with extra labour] . And then hopefully next year I can be more organised and do my bit.

Farmer, New Brunswick (NB-005)

Opportunities have emerged for provincial governments to collaborate directly with co-operatives in the Maritimes: in one particularly successful instance, the government of New Brunswick took over a programme offered by a regional co-operative whereby farmers had hired a pest specialist to inspect members' orchards, making the service available to all fruit growers in the area.

I know that at the Ministry of Agriculture, the co-op is well-seen, and often used as an example, a source of inspiration for their own programmes, officially or no [...] [The government] was like, [the pest specialist service is one] we want to offer, and the co-op said, OK, take it. We don't need to run it to survive. The objective is for farms to keep going.

Co-operative executive director, New Brunswick (NB-010)

Other forms of market-based collective action include the creation and control of farmers' markets, whether through co-ops or other means; building distribution networks which work exclusively within the small-scale production niche; and the creation of food hubs, which aggregate produce from local or regional farmers for regional sale. All of these multi-scale institutions were perceived as providing additional security in sales for producers by creating a diversity of markets which might accept produce with a higher degree of flexibility than contracts to commercial sellers.

Back in the day, where they would do apple co-ops [...] there is a reason why they did that: because in masses, they were able to compete together with larger companies [...]. I think that, as market farms, rather than competing with one another, working collaboratively, [...] still having your own kind of thing, but

together—I think we can actually go further forward faster and meet a demand [more easily].

Farmer, Prince Edward Island (PEI-005)

Table 6.3. Categories and expressions of collective action

Category	Expression	Definition and examples
Community-based	Community food advocacy groups	Organizations which engage food policy at the local and community levels and dialogue with policymakers and government
	Seed-saving groups	Community groups breeding and producing locally adaptive and resilient varieties
	Community or regional agriculture organizations	Organizations led by non-farmers which work with producers to develop marketing, promote peer-to-peer knowledge sharing, facilitate infrastructure sharing, and provide access to government support
	Neighbour and community support	People who are physically proximate to farms and who form networks of practical support (helping with large farm tasks; specialist services such as electrical work; etc.)
	Knowledge-sharing from neighbours	Neighbours around farms who provide local historical knowledge of climate conditions, soil conditions, etc.
Farm-based	Peer-to-peer knowledge sharing	Farmers sharing knowledge amongst themselves re: practices, new technologies, etc.
	Customer-sharing	Farmers redirecting customers to other small producers if demand exceeds supply
	Equipment/infrastructure sharing	Farmers sharing equipment or infrastructure (e.g., storage) with each other to avoid additional costs
	Farming organizations	Farmer-governed organizations which lobby government with a unified political voice, and provide a support network for beginning farmers
Market-based	Formal co-operatives	Regional co-operatives made up of farmers which provide multiple support streams, including marketing; advertising; extension; etc.
	Informal co-operatives	Individual farms which have formal or informal collective selling agreements, exchange information and infrastructure, and provide support in times of need
	Farmers' markets	Farmers who come together to independently start markets in communities, with the objective to create niche markets for products
	Distribution-based collaboration	Food hubs, which aggregate produce from multiple farms and redistribute to food-impovertished areas

6.4.2 *Impacts of collective action*

Many participants suggested that collective action provides systemic benefits beyond the support of individual farm operations.

Co-operatives, collaborative selling, and sharing customers all contribute to the creation and maintenance of niches in the market—subsets of the market especially suited to small-scale producers. As well as facilitating a stable space in the market, niches encourage producers to collaborate in distribution and to unite politically in the face of a globalized food system.

In the big scheme of providing food, you have to find your own small place. And you can't change things, because [your strength comes from] how you decide where you fit.

Farmer, New Brunswick (NB-002)

Participants noted that networks, peer support, and regional agricultural organizations help build communal knowledge and reduce on-farm overhead costs by generating possible collaborations between farmers. Farmers highlighted the importance of building knowledge in the community to disseminate ideas and help innovate farm practices, given the lack of capacity of some government departments to provide agricultural extension support. In particular, farmers noted that these relationships increased the diversity of crops and infrastructure on farms, as well as in the number of markets they accessed for produce sales. Infrastructure changes allow producers to build efficiencies into the farm system. Sharing knowledge, equipment, and storage infrastructure reduces individual farm overhead costs. Selling at multiple markets, meanwhile, provides a financial safety net in case of economic shocks.

I want to diversify markets because that's more resilient, safer, and more stable, but that takes time and that takes energy. So then you go back to the co-op model.

We kind of get the best of both worlds. [...] Diversity of markets means that if something goes under, something goes wrong, [...], then you have other markets to fall back on.

Farmer, New Brunswick (NB-005)

Cooperation also gave a more general hope for success, no matter what future emerges. As the same farmer succinctly put it:

If we can do that—if we can find like-minded people who share vision and [...] work together in whatever capacity [we] can, then I think we can kind of get through almost anything.

Farmer, New Brunswick (NB-005)

6.4.3 Relating collective action to climate resilience

Participants described ways in which the systems-level impacts of collective action may help farms and the broader food system increase their capacity to adapt to climate change. They drew connections between financial adaptability and a farm's capacity to respond to future shocks, including those brought on by climate change.

For me, building a financially viable business that has flexibility in it is also part of that because then I can grow and shrink as I have to. I don't know how [the future] will play out. I feel like I have to keep that flexibility. And I think that's part of mitigating for climate change too.

Farmer, Nova Scotia (NS-019)

For some, maintaining financial resilience is an important facet of sustaining relative independence in a future where government funding may not be as accessible.

Even as we need more support from government, I think that maybe there's going to be less just because the pot is going to be shrinking and it's going to be spent

more in terms of disaster response. Part of resilience for a farm means having a certain amount of economic independence.

Farmer, Nova Scotia (NS-016)

Participants were also quick to point out the importance of a supportive network of practitioners and community members in mitigating risk, increasing collective knowledge in the farming community, and providing help in a crisis. They noted that co-operatives and other organizations are a useful source of human and social capital.

Having a supportive community is key to helping you get through any kind of crisis that you're going to face on the farm.

Farmer, Nova Scotia (NS-019)

I think that, for me, in any change, whether it be climate change, or in markets, in society [...] one of the most important things is that people can get together to face challenges that those changes bring. The role of the [co-op] in those situations is important, because it's like the glue that keeps people together to go further, to take the next step... [The co-op] is the gel that keeps all those small-scale players independent, but in collaboration.

Co-operative executive director, New Brunswick (NB-010)

Many forms of collective action in the region also interact with governance institutions. Regional organizations, community advocacy groups, and farmers' organizations were all mentioned as important advocates for farmers with governments. Farmers often suggested that the time-intensive nature of their work prevents them from engaging in extensive government consultation; collaborative organizations were reported as useful because they let farmers share concerns and present a united voice on issues without requiring farmers' constant presence.

Participants mentioned that certain ideas or projects which had originated in collective action settings were taken on by government once they had proven viable:

[The distribution hub] first [...] started around a roundtable discussion, back in January 2017 where there was government, there was [a major caterer] at the table, there were farmers, there was [...] a diverse mix of [community food organizations], the Farmers' Union; they were all at the table and they said [...] they needed something to connect the dots for logistics, for distribution, for aggregation, for storage. So [our organization] was developed, and funding was secured in August from [the larger cooperative in southeastern New Brunswick and the provincial government].

Co-operative executive director, New Brunswick (NB-016)

6.5 Discussion

We set out to examine how collective action emerges in land-based food systems, how it affects the resilience of food system actors, and how it can contribute to the broader goals of climate change adaptation for the food system. Our data suggests that collective action can emerge from seemingly heterogenous groups in the food system due to the existence of a community of shared concern, and build adaptive capacity and resilience in both individual farms and the food system more generally.

6.5.1 *Heterogenous groups, shared concerns*

The actors who participated in our study come from heterogenous backgrounds, and the collective action we noted emerges from three overlapping but separate areas—farms, communities, and markets. Their interests are varied and sometimes contradictory. Farmers, for example, want to sell at as high a price as feasible, while retailers and distributors want to buy at lower prices. Following Olson (1971)'s initial expression of collective action theory would suggest that such a group might find it difficult for actors to coordinate in order to serve

everybody's interests; this "group size paradox" remains a central strain of collective action theory (Pecorino, 2015).

Our results go counter to the logic of classical collective action theory: farmers across the Maritimes are coordinating with distributors in order to maintain a share of the market. Meanwhile, consumers and civil society are collaborating with farmers in order to ensure succession of the profession and access to a specific quality and sourcing of food, rather than simply accepting lower food prices from a global marketplace. What motivates food system actors to lay aside self-interest for the sake of a common goal?

One explanation may lie in the existence of a community of shared concern for agricultural resilience in the Maritime food system. Pelling (2011) develops the concept of *shadow community* as a natural, informal unit of adaptive action which unites actors with shared concerns and values. These communities transcend formal organizational boundaries; they are based in trust, shared concern, and ongoing engagement. Our study's participants often spoke of being united against larger forces—in some cases, climate change; in other cases, globalized market forces. They share both financial interests (maintaining solvency) and non-economic concerns (continuing to farm at the same scale, using certain practices). They ascribe value to spaces where they can speak informally with their peers. Moreover, many of the forms of collective action in which they participate are informal, and require mutual trust and reciprocity in order to be maintained. Anecdotally, it is clear to us—as former farm workers and embedded regional researchers—that the Maritime farming community is as well-connected as it may be geographically disparate: reputation, trust, and a shared sense of community are essential to the

maintenance of knowledge and aid networks among producers, retailers, and other food system actors. During data collection, some farmers and even government officials were initially reluctant to participate in an interview until the researcher had explained that they had previously worked for half a decade as a farm worker and had roots in the farming community across the Maritimes region. Without the close social networks to support them, adaptive processes in the region would be difficult, if not impossible.

The fact that co-operatives, knowledge sharing, and producer support all aim to build resilience in the food system speaks to the social nature of community resilience. It resonates with the suggestion within resilience theory that both social-ecological systems and social psychology are at work in self-organizing for strong community resilience (Fikret Berkes & Ross, 2013).

Following Darnhofer et al. (2016), our data also suggests that resilience in the land-based food system is built on the relationships which connect individuals, institutions, and ecological systems, rather than exclusively on mechanistic understandings of farm components such as soil health or irrigation infrastructure. Our insights lend weight to Ostrom (2000, 2010a)'s response to classical collective action theory: individuals *can* be willing to coordinate and achieve the benefits of collective action so long as there exists a sufficient platform of reputation, trust, and reciprocity. Though the actors in our participant sample are diverse, they all value the local small-farm based food system's continued existence; thus, the unifying driver of collective action.

6.5.2 How does collective action affect food system actors?

Our data show immediate benefits of collective action for small-scale producers and distributors, as well as higher-level impacts which map closely onto the drivers of resilience and adaptive capacity to regional environmental change.

Fig. 6.4 represents the flow of impacts and interactions between different forms of collective action in the Maritime food system described here. Producers noted that collective action is often immediately beneficial to them: for example, sharing infrastructure can reduce overhead costs on-farm and increase sales, which improves a farm's financial stability. Having spaces where farmers can confer, such as regional farming organization meetings, creates a supportive community through which farmers can exchange knowledge; provide support; and vent frustrations. These spaces become communities of practice, exchange, and regulation which can help individual farms and farmers during a crisis.

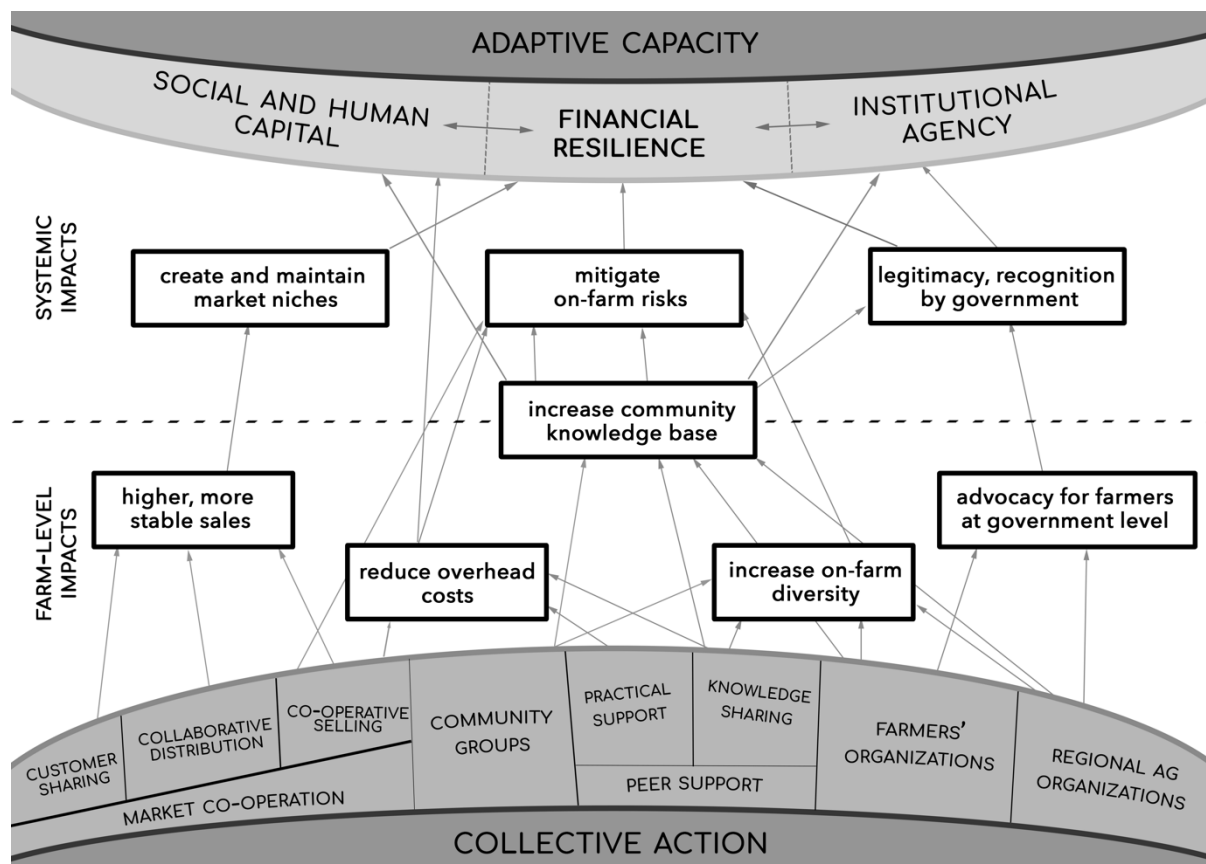


Figure 6.4 Collective action can build adaptive capacity in the food system

These effects are beneficial, but they also point to more sustained and complex impacts. In the case of the Maritime food system, the immediate impacts of collective action (higher sales for farmers; increased diversity; a unified voice for farmers at a provincial, regional, or federal level) directly affect food system processes—namely, the creation and stabilization of market niches; mitigation of on-farm risks and vulnerability; recognition and legitimacy in the eyes of government; and a strengthened community of knowledge and practice.

How do these structures mitigate climate-related risks for the food system? The cumulative impacts of collective action in the Maritimes' land-based food system map closely onto the established drivers of adaptive capacity that are required for successful resilience to climate

shocks and adaptation to climate change. Adaptive capacity in systems relies on social, human, and financial capital (Adger, 2003; Christmann et al., 2015; C. J. Paul et al., 2016), as well as sufficient institutional agency between actors and governance structures (Adger et al., 2011; Clapp & Scott, 2018; Delaney et al., 2014; van Bers et al., 2016). Social and human capital in the region are built and maintained through socialized learning, informal discussions, and networks of reciprocity and trust (Adger, 2003; Wynne-Jones, 2017), as well as by creating spaces for deliberation and organization. The latter is facilitated by co-operatives and food hubs: while neither types of organization we interviewed specifically identified as “bridging organizations”, they fulfill similar functions as those explored by Berkes (2009) in that they provide spaces for otherwise disparate actors to evolve within institutional structures. Financial resilience for small-scale producers in the Maritimes emerges because shared markets and stabilized niches buffer enterprises from larger global forces, and because farmer networks create opportunities to reduce overhead costs and outsource otherwise expensive distribution networks—a finding which reinforces the social nature of financial resilience as well as its economic basis (McManus et al., 2012). Institutional agency, meanwhile, comes out of the initial community of shared concern (Pelling 2011) around the livelihoods and culture of farmers, distributors, and civil society in a small-scale land-based food system in the Maritimes; solidifies into formal or informal institutions such as regional co-operatives; and creates the possibility for dialogue between provincial governance and a heterogeneous group of producers and distributors where none was before.

Collective action in the Maritimes land-based food system may act as a “meta-driver” of adaptive capacity to climate change: although none of the actions we noted stem from direct or

exclusive concerns about the impacts of climatic instability, their communal and cumulative impacts create the kinds of conditions which will enable the system to adapt to a variety of shocks. Though farmers are concerned about the impacts of climate change, these worries can fade into the background when more pressing destabilizing factors emerge: international markets, supply chains, and labour and succession issues remain urgent and take up a farmer's capacity to plan ahead. Collective action as we document it provides an avenue to address a variety of shocks; farmers can choose to buy into collective action for economic purposes and find benefits that ultimately help them shrug off climate shocks. The multi-purpose nature of collective action is its strength : adaptation, after all, is more likely to fail if it is limited to singular objectives such as mitigating impacts on production, rather than if it attempts to generate resilience and adaptive capacity across a system (IPCC, 2014d).

6.5.3 Policy implications of collective action

As we noted above, there are already concerns about top-down adaptation policy for agriculture, whether in the Maritimes or elsewhere (Ayer, 1997; Ostrom, 2010b; Soubry, 2017c). Creating food adaptation policy in Canada typically involves a period of consultation where farmers and other food systems actors are asked to provide opinions, which are synthesized into policy recommendations (House of Commons of Canada, 2018; Senate of Canada, 2018). Yet these processes can often be biased towards those who have the time, inclination, and financial capacity to act as witnesses. Governments have a tendency of accepting suggestions at a surface level while maintaining the status quo—in the case of Canada, a neoliberally-minded, export-based market economy—in agriculture and food systems rather than moving towards any radical or even necessary changes (Beilin et al., 2012; Laforge et al., 2017).

Farmers can be reluctant to adopt suggestions from governments they mistrust or apply for grants that add to their administrative burdens (Soubry, 2017c; Stock & Forney, 2014). Laforge et al. point out that government processes often “reinforce unequal power relations by restricting (containing), often through the direct enforcement of limitations through regulations, or diluting (co-opting) emerging grassroots alternatives through technologies of governmentality” (2017, p. 674). Co-opting can be particularly damaging to collective action when governments support programmes which pursue dominant trajectories rather than more transformative approaches (Laforge et al., 2017). Moreover, governments are notoriously, dangerously slow to action, considering the rate at which impacts of climate change are affecting livelihoods (IPCC, 2014d). Waiting for top-down adaptation policy to be filtered through the levels of governance, industry, and local implementation maximizes climate risks for everyone involved, especially vulnerable populations such as rural workers (Hallegatte et al., 2016; Ostrom, 2014). Considering the present paucity of adaptation policy in the Maritimes, how can collective action play into the creation of successful adaptation strategies for the food system?

We could consider expressions of collective action from farmers and food system actors as endogenous adaptation techniques, or *desire lines*, for food systems adaptation. Desire lines, we mentioned above, emerge out of a reaction to an imposed environment: they are the “manifestation of a common will”, a straightforward path through a landscape otherwise difficult to penetrate. In their most successful cases, the adaptation is adopted by planners and designers: mud paths are paved, clearing the way for a greater number of (satisfied) users (see Fig. 4). The concept need not be restricted to architecture and urban planning: Smith and Walters suggest that

“expanding [the concept] from its current limited scope is a useful tool for imagining how dominant forms of exclusion and social control in public spaces might be resisted” (N. Smith & Walters, 2018).



Figure 6.5. Ohio State University walkways adapted from desire paths (Reddit, 2019)

Under what conditions do desire lines morph into collection action and, ultimately, policy response? Perhaps the most straightforward path requires a clear need from the grassroots to be met with open attention from institutions. In one particularly successful example discussed above (section 6.4.1.3), the provincial government took on a pest management programme which had originally been created a farmer marketing co-operative to reduce specialist costs. This adoption was able to occur because it was mutually beneficial to both parties: on the farmers’ side, the

service was clearly needed, useful, and government adoption freed up the co-operative's capacity; on the government side, there was no need to worry whether the programme would be adopted by producers, and no effort to be spent creating and testing the service. The collective design of the programme sidestepped the potential problem of government co-opting a service.

Collective action—much like an ideal form of good adaptation policy—emerges because it is needed; is adopted because a shared community of concern is willing to support it; and is sustained because it is effective. In contrast to the high-risk approach of top-down adaptation, and following Thorn et al. (2015) and Mersha et al. (Mersha & van Laerhoven, 2018), we suggest framing collective action as a desire line which reveals already successful, effective, and accepted endogenous adaptation. Building adaptation policy with the innate needs and expertise of practitioners as a starting point, rather than with top-down guidance, could help create programmes which are immediately effective; enhance the adoption of any initiatives promoted towards farmers; and free up capacity in both the production community and in governance institutions to consider longer-term goals. This path has been taken up in other disciplines and fora, which have highlighted that supporting existing autonomous adaptation can be effective first-order policy when compared to top-down or planned adaptation (Ford, 2008; Pearce et al., 2015; Thornton & Manasfi, 2011). By following the desire lines of collective action rather than the planned path of policy, food system actors are already sending clear signals to policymakers about their needs and what methods might be most effective to address them; what remains is perhaps to develop the capacity of policymakers to take note.

We do not mean to suggest that collective action is a panacea to ineffective adaptation policy, nor that it is sufficient in all situations. Here, we describe how food system actors can support each other in short-term situations and urgent problems; but how can local-level collective action react when faced with the much larger project of transforming a food system into one which can adapt to climate change? Inevitably, there are limits to what collective action can achieve.

Collective work is not always constructive; social capital, for example, can occasionally contribute to conflict or conservatism within groups by identifying “leader” organizations at the expense of other sub-groups (Bauermeister, 2016; Crespo et al., 2014; C. J. Paul et al., 2016).

In the context of climate change, it may be that collective action is one effective, important, tool in a broader ecosystem of adaptation governance. Ostrom describes these polycentric systems in the context of climate change as “multiple governing authorities at differing scales rather than a monocentric unit” (Ostrom, 2010b). Participants in a polycentric system can use the localized knowledge and experience of collective action to mobilize significant resources from larger institutions, allowing investments to be directed towards knowledge-sharing, innovation, and resource mobilization (Ostrom, 2010b, 2010a). Collective action in the region may only be truly effective when paired with broader institutional support, lending a polycentric dimension to food systems adaptation to climate change.

Though there is a clear place for government to show initiative in supporting some endogenous adaptation practices which have emerged through collective action, we should remember that many of the actions have emerged from informal communities, and often in response to government failures. Further research may illuminate the place of governance institutions in

supporting informal action. What is the place of government in recognizing collective action if that action emerges in spite of a governing body? How can governing institutions support climate adaptation without accidentally or intentionally co-opting or corrupting collective action to their own agendas, as Laforge et al. (2017) point out?

6.6 Conclusion

We set out to understand how collective action emerges in the land-based food system, how it affects food systems actors, and whether it can contribute to the broader goal of food systems adaptation to climate change, especially in a policy leadership vacuum. We found that collective action in the Maritime provinces of Eastern Canada emerges along three dimensions: communities, farms, and markets. The participants we interviewed described the individual benefits of collective action processes in the region as well as their cumulative, more complex effects on the food system's stability. Our case study suggests that collective action emerges through heterogeneous communities of shared concern, and that it can help build adaptive capacity and resilience in land-based food systems.

We propose that sustained expressions of collective action be considered as desire lines for successful food systems adaptation policy: they act as signals indicating a useful, communally generated strategy to respond to multiple stressors. Considering that much adaptation policy remains top-down—a high-risk strategy—collective action can present systems which are already enthusiastically adopted by their participants; are necessarily effective at multiple levels; and reach across industries and concerns to solve challenges not solely related to climate change. Our results support government policymakers who seek to support food systems adaptation

through policy that is both highly effective and adopted by practitioners. The research also deepens inquiries in food systems and adaptation research concerning the effectiveness of collective action in building sustainable climate adaptation practices.

Acknowledgements

Deep gratitude to all the participants who volunteered their precious time, expertise, and kindness to this research. Thanks to the Mi'kmaq and Maliseet nations, on whose unceded territory the *Climate Resilience on Maritime Farms* project takes place. Thanks as well to the friends at Community Forests International and the McGill Land and Food Lab, who provided companionship and workspace; and to Günther Grill and Penny Beames, for the GIS help. Thanks to the Rhodes Trust (UK) and the Pierre Elliott Trudeau Foundation (Canada) for their unwavering support of BS.

7. "You keep using that word...": Disjointed definitions of resilience in food systems adaptation

Bernard Soubry^{1*}, Kate Sherren²

Under review by *Land Use Policy*

¹ Environmental Change Institute, School of Geography and the Environment, University of Oxford, Oxford OX1 3QY, UK

² School for Resource and Environmental Studies, Dalhousie University, Halifax, NS, B3H 4R2, Canada

* Corresponding author: bernard.soubry@ouce.ox.ac.uk, phone: +1 (438) 838-8218

Abstract

What does resilience mean when it's applied to adapting the food system to climate change? The term is a "boundary object": it has multiple definitions which do not necessarily correspond. While this slippery state can serve to unite different actors, it can also be co-opted by government to twist transformative adaptation into maintaining the status quo. We compared the definitions of resilience between two datasets: the conclusions and responses to the Canadian government's recent inquiries into climate change and agriculture, and semi-structured interviews with small-scale farmers in the Canadian Maritimes (n=37). The differences between the two suggest that government institutions may be creating policy which perpetuates *status quo* industrial agriculture without acknowledging farmers' differing conceptions of climate resilience for the food system. The findings highlight the need for the definition of resilience in climate and agriculture policy to be problematized. It corroborates the calls in adaptation theory for resilience to be understood as a normative term rather than a politically neutral one; and for broader inclusion of concerned stakeholders in consultations.

Key words

climate change, adaptation, agriculture, food systems, farmer knowledge, resilience, policy

7.1 Introduction

It should not be controversial to suggest that the word "resilience" is overused to the point of confusion. In policy and research discussions related to climate change, it is variously applied to

social, economic, and environmental systems (Crate, 2011; L. Olsson et al., 2015; Tadaki et al., 2017). Governments aim to increase it; communities need it to survive; no one really seems to understand what it requires. At times, one feels like Inigo Montoya, one of the heroes of *The Princess Bride* (Reiner, 1987), who memorably says to the villain Vizzini about his use of "inconceivable": "You keep using that word. I do not think it means what you think it means."

The temptation to quote the line is there—perhaps less light-heartedly—in considering political responses to food systems adaptation to climate change. Governments are under increasing public pressure to collaborate with local knowledge-holders and other institutions to increase the "resilience" of the agriculture and food sectors, which provide economic security and basic food security (FAO et al., 2018; UNFCCC, 2017). The impacts of climate change on the food system are evident, destructive, and projected to worsen (FAO et al., 2018; IPCC, 2014d): even in the financially secure Global North, climate change is projected to negatively impact food supply (Hallegatte et al., 2016). Those most at risk are often already marginalized, including indigenous communities, racialized communities, and the rural poor (IPCC, 2019a). "Resilience" has thus become a key word in policy responses to climate adaptation both regionally and internationally (FAO et al., 2018; IISD Reporting Services, 2019; UNFCCC, 2017).

Despite its enthusiastic adoption, adaptation researchers have long warned about abuses of "resilience" as a term in policy discourse. Because it covers so much theoretical ground, it is an excellent example of a *boundary object*: it can be defined differently by parties, yet serve to unite disparate opinions around common values or goals (Brand & Jax, 2007). If this state can be helpful to diplomacy and policymaking, it also risks diluting definitions of resilience such that

the term is effectively useless. When discourse veers from genuinely useful distinctions and separations, "resilience" can be co-opted for maladaptive political means and thus hamper the effectiveness of genuine attempts to mitigate damage (Brown, 2011; Lindenmayer & Fischer, 2007; Moser et al., 2019; Pizzo, 2015). Similar terms, such as "ecosystem services", have taken on entirely different meanings as they are adopted by other fields, diluting the initial definition to eventually represent an amalgam of past status-quo conceptualizations (Wieland et al., 2016; Winthrop, 2014).

In Canada, one recent governmental response to such pressure has been to solicit advice on climate change and agriculture from two committees: the House of Commons Committee on Agriculture and Agri-Food (hereafter known as the "AGRI Committee") and the Senate Committee on Agriculture and Forestry (hereafter known as the "AGFO Committee"). The committees worked between 2017-2018, interviewing solicited experts on climate change and agriculture (House of Commons of Canada, 2018; Senate of Canada, 2018). The committees' reports and the responses which the Canadian government submitted to those reports are, to date, the only publicly available Canadian federal policy documents concerning climate change and agriculture.

We were invited to participate in the Senate deliberations in 2017 due to previous work on climate change and food systems in Canada (Soubry, 2017c; Standing Senate Committee on Agriculture and Forestry, 2017). In participating in the committee hearings, we were surprised by how often the concept of "resilience" was invoked with seemingly no common definition. We wondered whether the definitions of resilience we heard during the hearings, and read in the

subsequent reports, were aligned with those of the people these hearings would most affect: Canadian farmers.

If government defines "resilience" one way and farmers another, the misalignment could cause significant problems for successful food systems adaptation in Canada. In Canada as through most of the world, farmers have been typically vulnerable to shocks, yet ignored by governments focused on growth over livelihoods (Cohn et al., 2017; Hallegatte et al., 2016; McLaughlin, 1987; Murphy, 1987). National and international government efforts have often been criticized for co-opting grassroots initiatives, furthering a more industrial trade and foreign policy agenda (Beilin et al., 2012; Holtslander, 2015). If government initiatives on "resilience" initiate definitional backsliding—whether politically motivated or for more banal, bureaucratic reasons—then the livelihoods of more vulnerable farmers, and of rural economies at large, might suffer maladaptation to climate change, leading to economic and livelihood risks (Brown, 2011; Meerow et al., 2016; Nakashima et al., 2012).

Does resilience as defined by Canadian policymakers mean the same thing for Canadian farmers? Does it provide opportunities for flexibility and necessary transformation in the face of climate change? Or do policymakers just keep using that word, even though it does not mean what they think it means?

With the above in mind, we considered the ways in which resilience is defined, implicitly and explicitly, in four documents: the reports from the House of Standing Committee on Agriculture and Food and the Senate Standing Committee on Agriculture and Forestry, as well as their

respective responses from the Canadian government. We compared these to an analysis of the resilience discourse from a set of semi-structured interviews conducted with small-scale farmers in the Canadian Maritime provinces across 2016-2018. In analyzing the datasets, we asked the following questions:

- How do Canadian policymakers define “resilience”, both implicitly and explicitly?
- How do farmers define the concept of “resilience” in relation to the farm and food systems?
- What gaps exist between government and farmer discourse about the food system’s resilience to climate change?
- What are the broader implications of these gaps or synchronies for how policy and farmers can work together to deploy mutually beneficial responses to climate change?

By asking these questions, we want to interrogate a dynamic which has emerged at international, national, and regional levels whereby policies developed for the sake of actors in the food system may not actually reflect these actors’ perspectives (Beilin et al., 2012; Brown, 2011; Laforge et al., 2017; Sumane et al., 2017). Successful adaptation policies must include the views of those most affected by the impacts of climate change and the policies we develop to respond to them (Armitage et al., 2009; Berbés-Blázquez et al., 2016). If policies that aim to build resilience fail to reflect these priorities, the boundary objects meant to unite disparate voices simply becomes a boundary, cutting off useful—and utterly necessary—dialogue.

7.2 Resilience as a boundary object in agriculture and climate change

Resilience is widespread as a concept in discussions of adapting the food system to climate change, even though its definition is amorphous (Brand & Jax, 2007; L. Olsson et al., 2015). The

Intergovernmental Panel on Climate Change (IPCC) defines it as “the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation” (IPCC, 2018a). This definition makes clear, if nothing else, the tension between more conservative and more transformational modes of resilience theory. On the one hand, resilience is about maintaining the essential function of a system; on the other, it facilitates change and transformation. Scott (2013) helpfully typologizes these two goals as “equilibrium resilience” and “evolutionary resilience”.

The discourse around resilience in farm and food systems dances between these two poles. Global food systems research has largely maintained an “equilibrium” understanding of resilience: the IPCC’s synthesis of food systems research, for example, mostly focuses on crop production models, rather than on social or food system-level analysis (Porter et al., 2017). Critics of the approach point out that looking at crop production as a measure of resilience implies a desire to maintain food production rather than actually understand the dynamics of the food system (Darnhofer et al., 2016). They note that adaptation and resilience theory have clarified that social processes, capital, and relationships are key determinants of successful adaptation to climate change (Adger et al., 2005; Adger, Barnett, et al., 2012; Tompkins & Adger, 2005): merely continuing to grow corn will not ensure food security or sovereignty, for example (Taylor, 2018).

Proponents of an alternative definition have pointed out that farmers and food system actors are involved in so many social, political, and economic systems that a “stable-state” status quo is

impossible. Understanding resilience as transformational and dynamic, on the other hand, reveals adaptive and collaborative networks which can transform policy and practice into rural realities (Fikret Berkes & Ross, 2013; M. Scott, 2013). On a farm level, it also allows for flexible, qualitative approaches to formulating management decisions. Resilience from this perspective is deeply relational: it is the ever-changing sum of the relationships between the land and its ecosystems, rural and urban infrastructure, food producers, distributors, retailers, and consumers (Darnhofer, 2014). It is necessarily place-based as a result (Brown et al., 2019).

The tension between these two ways of imagining resilience, a term which itself comes from physics by way of the natural sciences (M. Scott, 2013), is characteristic of the boundary object the term has become. A *boundary object* is a “term that facilitates communication across disciplinary borders by creating shared vocabulary although the understanding of the parties would differ regarding the precise meaning of the term in question” (Brand & Jax, 2007).

Boundary objects can be powerful communication tools: they create shared vocabulary across disciplinary borders by maintaining space where the precise meaning remains slippery (Brown, 2014; Thorén & Olsson, 2017). This kind of slipperiness is essential to create collaborations that would otherwise not have emerged between parties who would likely not otherwise agree.

But using a term without clarifying what it means can be confusing, if not dangerous. Under the guise of seeming objectivity, boundary objects can mask normative definitions, not to mention conflicts and power dynamics (Popke et al., 2016). What is resilient for some may be undesirable to many. A state may preserve a destructive or oppressive status quo at a time when transformation is another option (McManus et al., 2012). The persistence of some boundary

objects has led some to characterize them as *panchrestons*: an “explanation or theory [...] made to fit all cases, being used in such a variety of ways as to become meaningless” (Lindenmayer & Fischer, 2007). Brand and Jax (2007) point out that the specific meaning of the term “resilience” is increasingly unclear; that it is used ambiguously, with diverging definitions; that its original definition is about to vanish; and that resilience is increasingly considered as a *perspective* rather than a *concept*. The resulting dynamic can lead to unproductive debates that draw energy from urgent mobilization. In climate policy, for example, some have suggested that leaving the definition of resilience up for discussion may be getting in the way of actual climate mitigation efforts (Meerow et al., 2016; Moser et al., 2019).

A climate policy that wants resilience as a stable state and one that understands resilience as transformative will have different goals. Farmers and governments may have similar values on a surface level, but the ways in which these values are attained will have consequences across economies and in vulnerable peoples' livelihoods (Beilin et al., 2012). It is essential, therefore, to question the position of resilience as a boundary object in climate adaptation policy for farms and food systems.

7.3 Methods

We engaged with two separate sets of data in our analysis. The first is a series of interviews conducted between 2016-2018 with small-scale farmers in Canada. The second is a set of grey literature comprising reports by the Canadian Senate and House of Commons on climate change and agriculture, as well as the Canadian Government's response to these reports, which together

form the only publicly available policy from the Government of Canada on climate change and agriculture.

Our research agenda emerged spontaneously from having been invited to present our findings on small-scale agriculture and climate change in the region in a government context. Rather than planning a course of research ahead of time, we were surprised and curious, as we engaged in the policy process, to observe differences between policy and practice, and set out to investigate these. As such, the dataset we use to explore farmer definitions of resilience was not originally intended to inquire about these definitions. We intend this analysis to be preliminary and exploratory; we think that, even though the population of farmers it encompasses is restricted, it nevertheless uncovers questions and trends worth understanding, and which may reflect broader trends in national and international discussions of resilience, climate change, and food systems adaptation.

7.3.1 Small-scale farmers and food system actors

Over 2016-2018, we conducted long-form interviews with 38 small-scale farmers across the Eastern provinces of New Brunswick, Nova Scotia, and Prince Edward Island (hereafter “the Canadian Maritimes”, or “the Maritimes”).

The Canadian Maritimes have historically seen their economies defined by agriculture (Beaulieu, 2015), though these have diversified in recent decades. A trend towards farm agglomeration has decreased the number of mid-sized farms, defined here as cultivating between 50-160 hectares, while the number of smaller farms and larger farms have increased since the 1970s. Small-scale

farmers are demographically and economically significant members of the agricultural community in the region: because of how the arable land base is distributed, a significant number of vegetable farms cultivates fewer than 50 hectares (Statistics Canada, 2017b). Though not all farmers in the Maritimes operate at a small scale, those we interviewed capture a representative slice of the geographic and climatic diversity of the region. While no regional analyses exist regarding the growth of small farms, anecdotal evidence suggests that it could be due to the increased availability of markets and a resurgence in small-farm support from urban dwellers. While this classification is suitable for the Maritimes, thanks to its varying terrain and soil quality, what is considered a large farm here would be small in other jurisdictions (Millward, 1999).

Of the farmers we interviewed, the large majority were either certified organic or self-identified their production as aligning with organic standards and principles. We selected participants through advertisements in regional agricultural organization newsletters, which led to an online form where people could register their interest in participating. We also identified them through snowball sampling. Snowballing was particularly useful for meeting farmers in the region, as some producers choose not to register their operations and are therefore untraceable in formal databases (see Chromy, 2011). The respondents were distributed across agricultural land in the region (see Figure 7.1). The lead author also had existing relationships with the farming community in the region, having worked as a farm apprentice and manager across the region for several years; these relationships provided access which would not otherwise have been easily granted by farmers.

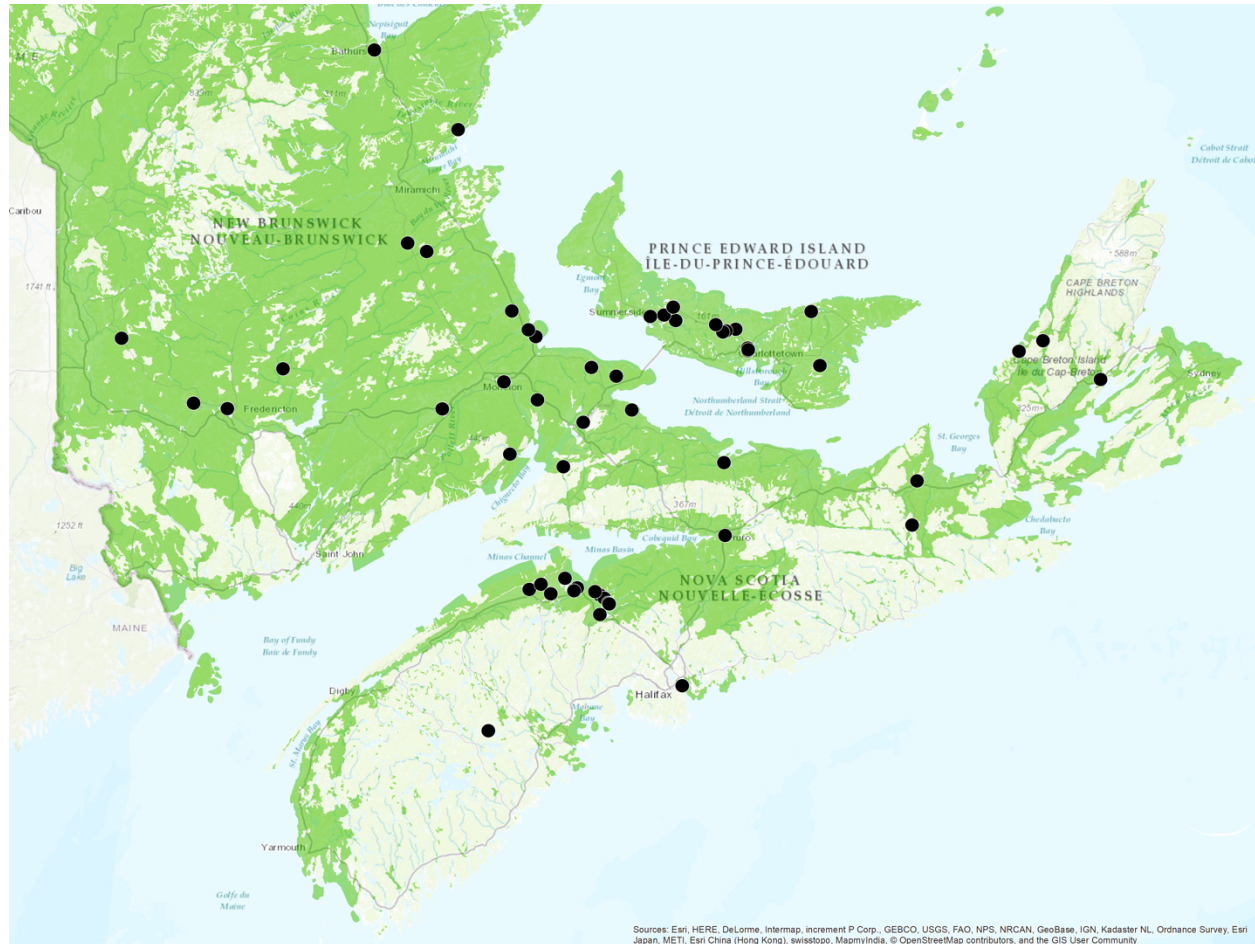


Figure 7.1 Interviewee locations relative to agricultural land distribution (shaded)

In finding participants, we specifically focused on small-scale vegetable producers in the region. The farmers we interviewed were principally growing a diversified group of vegetables, including but not limited to tomatoes and other nightshades, greens, crucifers, potatoes, and carrots; grew according to organic standards, whether certified or not; and managed the farm themselves, sometimes aided by a few employees. As such, their markets tend to be purely regional, if not local; their relationships with government are narrow, and they are largely overlooked in policy; and they exist within a tightly-knit group of other producers. Nevertheless, they are often promoted in regional tourism and in provincial policy as archetypes of agriculture in the region (Farmers' Markets of Nova Scotia, 2013; Jellett, 2013; PEI Govt, 2017).

We performed interviews between May-August 2016 and December-March 2017-18. They were semi-structured; took place in French and in English, depending on the participant's preference; and were largely participant-led in terms of research scope, following the principles of grounded theory methodology (GTM) (Birks & Mills, 2015). Interviews generally lasted between 30 and 60 minutes; they were recorded and then transcribed for analysis.

Though we had prepared an interview guide, we allowed participants to guide the discussion with their own concerns about the future and the difficulties of managing a farm rather than upholding any pre-determined notions (Urquhart, 2013). The content of the interview guide is more fully described in Soubry et al. (2020a), but interviews with farmers (n=38) covered the perceived impacts of environmental changes on crops and farm infrastructure; the adaptation of production methods or business plans; definitions of sustainability, adaptation, and resilience; support received or given from farmers, government agencies, and other food system actors; and any other concerns, whether climate-related or not, which the farmer considered important.

Having transcribed the interviews, we then auto-coded them using NVivo 12 (QSR International, 2019), highlighting passages for further analysis wherever the term “resilience” or any of its stemmed words (ie. “resilient”) appeared. We performed thematic analysis on the auto-coded passages about resilience to understand the subjects and themes most closely connected with the concept of resilience. This followed an inductive process, moving from axial coding of initial ideas to theoretical coding of a typology of resilience definitions. Each round of coding proceeded from specific items to more general themes to potential theory (Birks & Mills, 2015;

Urquhart, 2013), thereby building theory that was based entirely on interview participants' experiences rather than through existing literature (Suddaby, 2006).

7.3.2 Canadian climate policy documentation

To examine Canadian government policy on agriculture and climate change, we first selected documents which would make up a comprehensive dataset on Canadian climate policy regarding agriculture. This was more difficult than expected. Canadian climate and food policy are separately governed by guiding documents from different departments, such as the *Pan-Canadian Framework on Clean Growth and Climate Action* (Government of Canada, 2018), and the recent *Food Policy for Canada* (Government of Canada, 2019c). Neither of these major public policy documents directly reference the interaction of climate impacts with the food system. We thus chose the respective reports from the House of Commons and the Senate on their study of climate impacts on the agriculture, agri-food, and forestry industries, as well as the respective government responses to those recent reports.

Though the hearings were performed by the members of the AGRI and AGFO committees, the reports for each committee were drafted by the clerks of each committee with the assistance of analysts from the Canadian Library of Parliament. Two analysts from the Library of Parliament, Corentin Bialais and Alison Clegg, were involved in the writing of both committee reports. This suggests cohesion in government discourse around agriculture and climate change; though the dataset we chose cannot be considered official policy in the same way as, say, the *Food Policy for Canada*, they are nevertheless forms of proto-policy, influencing the government's future response in a cohesive manner (Tourangeau & Sherren, 2019).

The AGRI Committee and the AGFO Committee were given similar mandates to study the potential impacts and adaptation opportunities of climate change on agriculture, including “measures for the adaptability and resilience of the agriculture, agri-food and forestry sectors” (Senate of Canada, 2018) and “help[ing] Canada’s agriculture and agri-food sector build resilience to climate change” (House of Commons of Canada, 2018). They completed their work in December and May 2018, respectively; and received an official response from the Government of Canada in early 2019. Each committee interviewed a number of witnesses who identified themselves as: farmers; representatives from farming organizations; representatives from the agricultural industry; academics; and representatives from provincial or federal governments. Reports were based on these interviews, as well as on briefs submitted by witnesses.

Significantly more actors participated in the AGFO committee's inquiry than the AGRI committee's work (189 interventions vs 37). Counting the affiliation of each participant reveals that the majority of interventions came from the agri-food industry (32%); then farming organizations and academia; then government; then other organizations, followed by a single intervention by an independent farmer. Table 7.1 provides more detail as to intervener affiliation.

Table 7.1 Interventions by type of affiliation

	Farmer	Farmers' organization	Industry	Academia	Government	Other	Total
AGFO	0	39	61	44	37	8	189
AGRI	1	14	11	7	2	2	37
Total	1	53	72	51	39	10	226
%	0%	23%	32%	23%	17%	4%	100%

We used NVivo 12 (QSR International, 2019) to auto-code each document for the word “resilience” or any of its stemmed words, isolating relevant passages for further analysis. From there, we performed thematic analysis on the auto-coded passages, identifying themes most closely connected with the concept of resilience. We then grouped relevant codes together into meta-codes that indicated thematic groupings.

7.3.3 Thematic analysis: comparison

The purpose of thematic analysis is to understand similar and disparate themes, even though actors, due to different contexts, might have used different language; in this way, “data that have been decontextualized through coding retain their connection to their sources” (Ayres, 2012). We compared the emergent themes of each dataset, isolating the areas of convergence and divergence around resilience discourse in each, iteratively returning to the text as necessary to understand the relevant context and provide points for comparison.

7.4 Results

We found both implicit and explicit definitions of resilience in each data set. In each section below, we present the larger thematic groupings which emerged across each. We include a section of what we term “guiding themes”: conceptual terms which emerged in both data sets

and which describe desirable (pre)conditions of a resilient state. We present relevant passages from the data sets where appropriate to give context.

Because our interviews were semi-structured, not every interviewee was asked the same question; as such, we do not present quantitative data on responses. In thematic analysis informed by grounded theory, it is common practice to draw on threads which emerge from across interviews, participant observation, and memoing; results draw on interviews, but also on uncounted (or -countable) interactions during fieldwork. The analysis of these data is therefore entangled in the researcher's subjective experience (Charmaz, 2016). Terms related to quantity below thus refer to rough proportions of those with whom particular issues were tackled: for instance, “many” indicates a majority of farmers, while “some” means a still-widespread idea embraced by less than a majority.

7.4.1 Farmer interviews

7.4.1.1 Resilient markets and finances

In considering markets and finances, many farmers pointed out that a “resilient farm” requires *financial* resilience—that is, farms must remain economically viable:

(Q: What is a resilient farm?) A: I think economics is number 1. [...] I always talk about, stop talking about sustainability until we talk about economic sustainability. Because if it's not economically sustainable, I don't want to have a discussion with you. (NS-011)³

³ Interviews are anonymized and presented with codes associated with the province of origin and the order of interview. NS-011 is the eleventh interview in Nova Scotia. NB = New Brunswick; PEI = Prince Edward Island. In addition, interviews conducted in French have been translated for consistency and clarity, and have indicators marked with an asterisk (*).

A resilient farm system is one that is able to stay in business and stay productive in the face of all these problems that to some extent are already here, and that are expected to get worse. (NS-016)

Farmers' desires for financial resilience are often expressed through, among other things, diversification of market streams, which can ensure that there are other points of sale for products—and, simultaneously, that no one buyer can control the market.

*For me, the word resilience goes on a lot of fronts, but I think we can learn a lot from the Brussels sprouts era [1970s]. Everyone got into production, there was one buyer, when the contract fell, the whole regional economy fell apart. (NB-001)**

In some instances, maintaining income involves the diversification of revenue streams: producers have found alternatives to direct sales at market, providing a welcome financial buffer if there are difficulties in sales.

*We do try to diversify other ways, like with the U-Pick and direct sales, it's starting to represent like a good 15% of annual revenue, which isn't negligible. We're investing more and more, too, in value-added products, so wine and cider and juice. Which means that if there are problems with apple sales revenues there are at least sources of revenue that can help the business stay afloat. (NB-011)**

7.4.1.2 Collaboration for healthy, resilient communities

Many of the farmers we interviewed directly connected the resilience of their own farm to the social and economic health of their surrounding rural communities. Farms exist within a local and regional economic system, and farmers consider their participation in the broader economic system essential to their livelihood and to the viability of the farm system.

For most, collaboration is essential to successful production. This manifests through the presence of formal or informal marketing cooperatives, which create networks to share ideas as well as mobilize support in times of difficulty.

This is one of the beauties of the co-op, is resilience. [...] The co-op [...] is us getting together and helping each other [...] we want to create businesses, viable businesses, and we want to have fun. [...] Generally working together is how we're going to manage it. (NB-005)

Beyond cooperation between farmers, many of the participants highlighted the importance of healthy rural economies to their own resilience – whether in ensuring succession for their own farms, or in building the community infrastructure necessary to rural life.

That's why it's good to have farms in the country – because then you have people! Right? That came out in the social capital report [published by the GPI Atlantic institute (see J. Scott & Colman, 2008)]- if you don't have farms, you don't have volunteer fire departments, because you don't have people in the community during the day, you don't have people there that can just deal with all the things that come up in a community. (NS-001)

Farmers thus link the economic benefit of farms existing and collaborating nearby to one another with social resilience: the presence of farms is integral to the social fabric of rural communities.

7.4.1.3 Diverse, multifunctional farm systems

When discussing the resilience of individual farm systems, one of the overarching concerns for farmers was having viable, flexible infrastructure that can withstand shocks from weather without becoming a financial burden.

The biggest stressor in agriculture is finances, so that's where you have to be resilient. And very careful how you spend money, and where you spend it, and when you do spend it try to get... through building a building, build a building that'll do a whole bunch of jobs for you, not just one. (NS-013)

An underpinning factor in the farm ecosystem's infrastructure is soil health, which determines both the ability to continue producing food; to prevent erosion; and to preserve biodiversity and "aliveness" in ecosystems. Farmers stressed the need to preserve the health of soil and its microbiome as both a condition of a proxy for a farm's resilience.

I want [the soil life] to be very very alive and vital. [...] if you are trying to ferment vegetables that are from soil that isn't alive, it won't work. And I think that makes us resilient. (NS-001)

The notion of resilience also came up for producers in the diversity of crops produced: producers associated resilience with the production of multiple crops, rather than focusing on monocultures of cash crops, given that a single crop failure's risk would be distributed rather than concentrated. This was particularly useful for producers who could not afford crop insurance.

[With diversified production] you're doing a lot of different stuff and so you have a bad year if the lettuce doesn't do well, well the tomatoes might do well. So that is your insurance as well. (NB-005)

Finally, some producers associated resilience with self-sufficiency in the farm system: by reducing their need for external input, farmers reduce overhead costs and dependence on producers of organic or synthetic fertilizer.

In the overall picture [sustainable farming is] not taking everything out and not putting it back, and actually building the soils as you go. Not taking away but building on. (NS-013)

7.4.1.4 Guiding themes: diversity, flexibility, long-term vision

Several concepts came up in association with resilience which reflected the more general values farmers in the dataset associated with resilience. As previously discussed, diversity—whether in crop production or market stream—is an indicator of resilience for many producers. Producers

also highlighted the importance of building adaptive capacity and flexibility into planning and production systems.

We need to be more and more flexible, maybe, with how we approach our planning and our planting and everything that flows on from it. (NS-024)

Q: What's the value of diversification for you?

*A: Resilience, for me. (NB-001)**

Producers emphasized long-term planning as a factor for building farm resilience, whether in considering succession plans, the broader economic health of the community, or increasing farm system efficiencies to reduce costs by, for example, investing in renewable energy sources.

We think a lot about resilience even for when we get older. We're always thinking about [when] we are old people, how we want things to be, and so some of those things are really into that. So when we're older, maybe we would have a reduced income, and then it would be nicer for us not to have to have large electricity bills. (NS-006)

7.4.2 Canadian climate and food policy discourse

Documents in our policy-related dataset focused on institutions and farm systems, and were guided by largely economic themes.

7.4.2.1 Institutions

Government documents, especially government responses to the AGRI and AGFO committee reports, closely associated the term “resilience” with higher-level government policy documents such as the Pan-Canadian Framework on Clean Growth and Climate Change and the Canadian Agricultural Partnership.

The Government [...] is taking action through the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), building resilience to the impacts of climate change, and enabling clean growth and jobs through investments in technology, innovation, and infrastructure. The Canadian Agricultural Partnership (the Partnership) is the primary mechanism to help the agriculture sector contribute to the goals of the PCF [...]. (Government response to AGRI committee)⁴

More specifically, government discourse highlighted the importance of institutional links to ensure that knowledge could be transferred from government or university research to producers. These usually take the form of calls for "strengthened", "clearer", or "faster" knowledge transfer "platforms" or "pathways"—though the form of these is not made explicit.

AAFC has also put in place dedicated knowledge and technology transfer officers in research stations across the country to ensure clearer and faster pathways for AAFC—generated knowledge to reach the agriculture sector. (Government response to AGFO committee)

To build greater resilience, witnesses would like to see strengthened knowledge-sharing approaches that build trust and collaboration between researchers and producers, as well as between producers and consumers. (AGRI)

7.4.2.2 Farm system

Documents also consider the ways in which farm system practices could be altered through the use of beneficial or climate-resilient practices, without necessarily defining either.

As noted in the Report, the agriculture and forest sectors have a solid track record in using beneficial management practices (BMPs), being innovative and adopting new technologies to improve sustainability, strengthen resilience, and reduce their respective carbon footprints. (Government response to AGFO committee)

⁴ For clarity and concision, we refer to the AGRI committee's report (House of Commons of Canada, 2018), the AGFO committee's report (Senate of Canada, 2018), and the government response to each committee report (Government of Canada, 2019d; Minister of Agriculture and Agri-Food, 2019) without citing them each time.

The Committee recommends that the Government of Canada encourage new and established farmers to buy into best climate-resilient practices, equipment and technology that will increase agricultural efficiency, long-term resilience and sustainability. (Government response to AGRI committee)

Both reports highlight the importance of preserving and maintaining biodiversity as a part of building resilience. For instance,

Protecting or maintaining biodiversity was highlighted as important for resilience – in both forests and agriculture – by several witnesses. [...] Another witness explained that mature, biodiverse ecosystems have greater insurance, or resilience, against environmental shocks, so they should be protected and developed. (AGFO)

Soil management is another repeated topic in relation to resilience, with a special emphasis placed upon raising levels of soil carbon and organic matter as an indication for the capacity to hold onto nutrients. Soil health is linked to profitability in that it reduces the need for inputs, and therefore a farm's financial overhead.

Soil carbon provides multiple economic benefits to both producers and society. Producers recognize that soil health contributes to profitability and sustainability by lowering input requirements, enhancing the resilience of crops to periods of low rainfall, protecting their soil from erosion and compaction, and reducing nutrient runoff. (Government response to AGRI committee)

The documents also associated the development of diverse crop cultivars which can resist climate-related pressures with increased resilience.

Crop varieties resilient to evolving growing conditions, such as new and increased pest and disease pressures and more variable temperature and soil moisture, are an important way the sector can adapt to climate change. (Government response to AGRI committee)

7.4.2.3 Guiding themes

Several terms were closely associated with “resilience” throughout the committee reports and the government responses. Of these, the notion of growth came up most frequently as a necessary pathway for the industry into which resilience must be fitted.

The Government would like to thank the members of the Committee, and the witnesses who appeared before it [...] for proposing steps that the Government can take to ensure a continued and sustainable growth in these sectors while they adapt to changing climatic conditions. (Government response to AGFO committee)

The Government recognizes the vital importance of a resilient agriculture and agri-food sector that is able to adapt to climate change, and continue to grow sustainably. (Government response to AGRI committee)

Resilience was often associated with market competitiveness in the agriculture and agri-food industries, often discussed hand-in-hand with adaptation. The documents suggest that support for adaptation will be needed in order to continue with the industry's primary goal of advancing the sector in both market share and technology.

In addition, the Canadian Agricultural Strategic Priorities Program is designed to help the agriculture and agri-food sector seize new opportunities, respond to new and emerging issues, and pilot solutions to adapt to climate change and remain competitive. (Government response to AGFO committee)

As climate change intensifies, continued support from researchers, industry, and government will be instrumental in helping farmers boost their resilience and adapt to the environmental, economic and social challenges. Such challenges include the need to continually increase sustainability, compete in international markets, foster public trust, and comply with new standards and requirements. (AGRI)

The documents frequently discussed innovation in association with practices and the development of new technologies. These are coupled with the broader strategies of sustainability, mitigation, and adaptation, though they are not—as discussed above—clearly defined.

As noted in the Report, the agriculture and forest sectors have a solid track record in using beneficial management practices (BMPs), being innovative and

adopting new technologies to improve sustainability, strengthen resilience, and reduce their respective carbon footprints. (Government response to AGFO committee)

Finally, the concept of resilience was closely associated with that of sustainability.

As noted earlier, many agricultural producers are already adapting to climate change, and in doing so, are taking measures towards sustainability that will build the long-term resilience of their operations. (AGFO)

Many producers and retailers are taking measures that increase both the efficiency and the sustainability of their operations, thus enhancing competitiveness and building resilience. (AGRI)

7.5 Discussion

In *The Princess Bride*, the villain's misuse of big words is funny: supposedly a reflection of his superior intellect, it ends up being his undoing when he is later defeated in a "Battle of Wits" (Reiner, 1987). In the case of resilience, however, the misused word is more than an obstacle to rescuing a princess: explicitly or no, it defines and directs adaptation policy. Not exactly a walk through the Fire Swamp, perhaps, but certainly a situation which requires further scrutiny.

Our initial objective was to compare the implicit and explicit understandings of resilience between a subset of small-scale farmers in Eastern Canada and the present Canadian government policy on agriculture and climate change. We find that government policy and farmers largely focus on different areas of the food system in defining resilience; and that the greatest gap between definitions lies in how they understand the purpose of resilience. We subsequently argue that the presence of resilience as a boundary object in climate adaptation discourse around agriculture creates an opportunity for institutions such as the Canadian government to co-opt a potentially transformational concept for their own purposes and, consequently, miss an opportunity to build inclusive, informed food systems adaptation policy.

7.5.1 Diverging definitions of resilience for food systems

Our data show that government policy and farmer knowledge focus on different areas of the food system when they consider resilience as a concept, which leads to largely different frameworks for its purpose and mechanisms. Farmers frequently mention the importance of a broader rural community and economy to their work; government policy frequently ties resilience to farmers' relationships with official institutions. Farmers associate resilience with the diversification of both market revenue streams and commodities; government policy associates it with international market competitiveness and innovation. Farmers speak of adaptability and flexibility in their farm systems; government policy repeatedly ties resilience to growth (qualified as “clean” or “sustainable”).

Our results therefore indicate that while both farmers and government policy consider resilience a meaningful term in their practice, the term rarely holds a common definition, corroborating its nature as a boundary object (Brand & Jax, 2007; Pizzo, 2015). Figure 7.2 summarizes our findings, highlighting themes which emerged around the term “resilience” in both datasets and themes which were exclusively covered by one group.

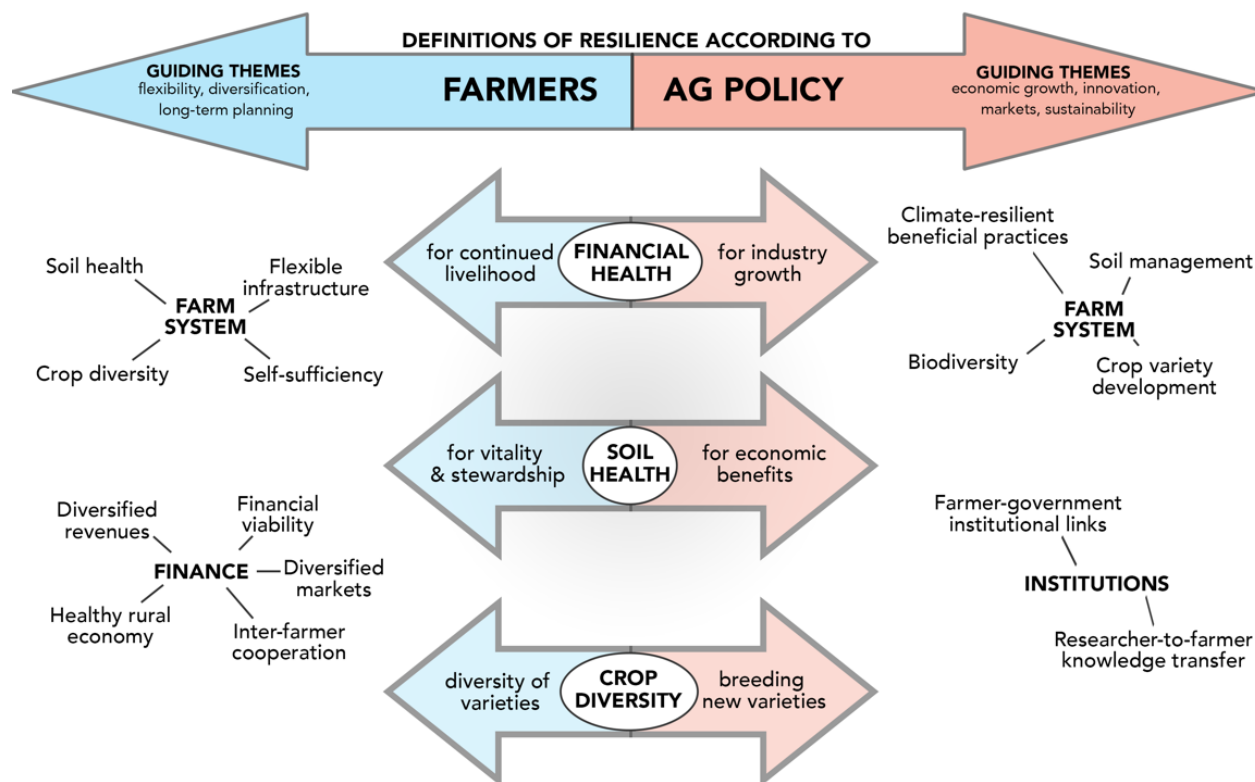


Figure 7.2 Diverging definitions of resilience between farmers and agricultural policy

Even in areas of seeming confluence (the middle of Figure 7.2), the thematic similarities only exist at the surface level. Financial resilience, soil health, and economic growth appear as themes in both coded datasets, but for different purposes. Farmers aim for a financially resilient state by reducing their dependency on external funding and co-operating with other producers, while government policy generally cites the Canadian government's own financial programming, which aims to increase industry growth through conditional grants or loans to farmers (Government of Canada, 2019a). Government policies also explicitly promote economic growth in the Canadian agricultural industry to build resilience, whereas farmers limit their concerns to financial stability for their own livelihoods and those of the communities around them, even if specific commodity mixes shift. Similarly, both datasets take up soil health as an indicator of

resilience in the farm system; but whereas the farmers we interviewed spoke of “vitality and alive-ness” and stewarding the land to continue producing, government policy refers to soil health’s “multiple economic benefits” (House of Commons of Canada, 2018), as well as its contribution in reducing greenhouse gas emissions in the agriculture industry.

The differences we have noted so far suggest a more fundamental rift in how both datasets, as proxies of particular discourses, consider the ultimate purpose of resilience. Teasing apart the difference in each group’s underlying motivation for resilience requires us to ask, following Meerow et al. (2016): what is resilience, anyway?

7.5.2 *Why be resilient?*

The category of “guiding themes” in our findings points to underlying and diverging assumptions about resilience between datasets. In analyzing them, our goal is not to establish who is defining resilience *correctly*, as the lexical flexibility is a challenge that many grapple with. Nor do we assume that any party is using the term disingenuously. Rather, we want to highlight the fact of the misfit and draw from it the implications for climate policy, however... inconceivable.

Our findings suggest that farmers frame the purpose of resilience as one where the farm can continue producing, with the necessary conditions for production being community health, economic interdependence, and long-term adaptive capacity. This is similar to Adger et al. (2012) and Strauss and Darnhofer (2015)'s suggestion that adaptation and resilience are necessarily social, and require social capital for initiatives to be successfully delivered. The

farmers we interviewed implied that resilience emerges from building and maintaining relationships in the food and social systems around them; in practicing values, rather than specific techniques. Diversification is a common technique in both market and farm management to maintain financial and farm system resilience; it requires collaboration and interdependence between other farmers and food system actors. Farmers spoke of forming market co-operatives, reducing overhead costs by sharing equipment, and participating in a healthy rural economy as forms of long-term resilience-building. By building a community of people around them who care about the future of both the farm and the area, and reducing financial and material dependence on outside networks or markets, farmers were able to think about their livelihoods in old age, of the future of the farm, and of the long-term land stewardship required by farm ecosystems.

Government policy documents, on the other hand, reveal guiding themes of economic growth within the agriculture industry, competitiveness, and innovation within the industry to suit the purpose. Discussions of resilience are frequently paired with the notion of “sustainable” or “clean” economic growth, and often mention how particular practices will help farmers remain competitive and innovative in a global market. From the perspective of government policy, practices which build resilience also help achieve industry competitiveness and profitability: building soil health or adopting new technologies serves the broader framework of continued crop production. Resilience in this framework relies on individual farmer responsibility – first, to choose “climate-resilient” or “beneficial” farm management practices; then, to apply for the right help from government institutions (Bjørkhaug et al., 2012; van Bers et al., 2016). The metric for and purpose of resilience are tied to how much is produced and sold; whether a farm maintains

profitability; and whether the industry as a whole can sustain economic growth (Müller, 2008; Nally, 2015). Criticism of the approach has pointed out that this framework is a particularly poor fit for small farms, given their reduced institutional agency and capacity to apply for grants (Burge, 1987; Radel et al., 2018; Soubry, 2017c; C. Sova et al., 2015). Policymakers' focus on such an approach suggests that they may have larger-scale agriculture in mind when considering climate change.

This difference in the underlying frameworks of resilience cleaves closely with the theoretical divide in resilience theory we discussed earlier: farmers' frameworks seem to tend towards “evolutionary” resilience, while government policy is decidedly more “equilibrium”-based (M. Scott, 2013). For farmers, as for much of the “evolutionary” side of resilience spectrum, resilience is a potentially transformative *process* that is inherently relational. Our dataset shows that farmers are clearly conscious of their social, economic, and political contexts in which their farms operate and the way in which these affect reactions to shocks or changes; their approach requires developing a multiplicity of relationship and approaches, networks of support, and system redundancies. For them, resilience is “not [a] fixed asset but [emerges] from the dynamics of enacted relations” (Darnhofer et al., 2016, 3; see also Brown, 2014; Carr, 2019). Resilience at the farm level requires an understanding of community dynamics, regional and national markets, and long-term climate trends as much as of soil health or production techniques. Its situated, relational nature allows it to be transformative: because their objective is to maintain a livelihood, farmers in our dataset were willing to form alternative market arrangements to build financial resilience. As such, farmers' understanding of resilience is closely tied to more transformational strains of adaptation theory, which stress that resilience is

both highly localized and situational (Adger et al., 2009; Darnhofer, 2014; Nelson et al., 2007) as well as dependent upon shared communities of practice (Matyas & Pelling, 2014; Pelling, 2011). It invokes a capacity to change rapidly to respond to perceived or received shocks, often through collective action (van Bers et al., 2016).

Canadian policy on climate change and agriculture, on the other hand, seems to consider resilience as a series of *outcomes* across individual farms (Darnhofer, Fairweather, et al., 2010). Committee documentation and their government responses focus on individual management practices and farm systems. They hold no mention of existing relationships between farmers, farmers' associations, or the broader social infrastructure of a rural community. Financial resilience in government institutions focuses on repayment for damages to crops or infrastructure or building infrastructure to maintain or grow production. The government policy view is consistent with much of food systems governance, which has centralized relationships of knowledge exchange and power towards governance sources (Hospes & Brons, 2016), typically “fixat[ing] on independent action and solutions as a means of achieving social change” (van Bers et al., 2016, p. 36). It is also consistent with more conservative forms of resilience theory, which emphasize a return to “business as usual” after shocks, as well as short-term responses to crises (Hospes & Brons, 2016; M. Scott, 2013).

Why are these conceptions of resilience so disparate? One indicative reason for the gap may well be the nature of the interventions during consultations. Small farmers were rarely consulted by the government inquiries. Only 23% of the interventions were made by farming organizations, with the rest coming from the agri-food industry, academia, and government (see

Table 7.1). One of the consequences of the format of committee hearings is that farmers need to engage with government on its own terms rather than theirs; most farmers, therefore, mobilize through farming and industry organizations, which may equalize or generalize positions (Tourangeau et al., 2019). Most of the participants in both committees were lobbyists or bureaucrats. Moreover, the government documents in our set are reflections and filters of what policymakers considered relevant during hearings; views outside preconceived notions of resilience may have been dismissed as incoherent with current policy. The result is a process which seems to largely listen from its own field of discourse rather than from multiple, potentially contradictory points of view. What does this lack of alignment imply for climate policy related to agriculture and the food system?

7.5.3 Implications for climate and food policy

If the presence of “resilience” as a boundary object in climate adaptation theory can be frustrating, we would argue that its unexamined presence in government policy could be dangerous. Its use enables government institutions to perpetuate an entrenched economic agenda rather than necessary transformation. This agenda, in turn, can silence or co-opt transformative initiatives from farmers, ultimately creating climate and food policy which leads to maladaptation (Beilin et al., 2012; Soubry et al., 2020b; Taylor, 2018).

Boundary objects are a double-edged sword: though they allow multiple groups to talk about a problem—in this case, resilience in the food system—they also often allow more powerful actors to impose preconceived values on them to perpetuate a status quo. The ways in which the consultations on Canadian food and climate policy aim to bolster resilience are remarkably close

to the Canadian government's existing economic and climate policies. Both focus on maintaining "clean" economic growth (Government of Canada, 2018); both emphasize high-technology, "innovation"-focused solutions to systemic problems (Government of Canada, 2019b). This has the consequence of filtering out other, human-based solutions which may be based in different forms of labour and skill, decentering solutions from the rural communities they must affect to the factories which produce technological advances (Tourangeau & Sherren, 2019). Government discourse does not appear to take into account global analyses of food systems policy, which argue that a significant shift in agricultural practice and funding is necessary to both mitigate emissions and successfully adapt (Berbés-Blázquez et al., 2016; IPCC, 2014d; UNCTAD, 2013). Nor does it consider frameworks which criticize economic growth and innovation as contradictory to building wealth and wellness in nations and in global trade, particularly for the rural poor and marginalized (Jackson, 2010; Raworth, 2017). Finally, they clearly do not reflect the views of small-scale farmers, which form a significant part of Canada's farming population, particularly in the Maritimes, and whose relational perspective has been documented internationally as well as in this paper (Darnhofer et al., 2016; Soubry et al., 2020b). Considering that the report conclusions closely reference existing government policies and recommend no more radical transformation of policy than investing more money into existing programmes, readers might be forgiven for thinking that the Canadian government had made up its mind on what its conclusions would be long before consultations took place.

By not considering resilience with a critical eye, the conclusions from the consultation merely reaffirm economic and political status quo. Critics of Canadian agriculture policy have noted its capacity to neutralize initiatives which break the neoliberal paradigm of high production outputs

by containing or co-opting farmer actions, noting that governments frequently limit transformational change by steering consultative processes into modest, incremental reforms (Clapp & Isakson, 2018; Laforge et al., 2017; Mauro et al., 2009). Laforge et al. (2017), for example, report a case study where a “buy local” campaign in Manitoba was initially pitched as a way to promote smallholder producers during increased public demand for local food. Initially, small-scale farmers were heavily involved in decision-making. As it became clear that those groups which could provide matching funding would hold most control over the campaign, however, smaller farmers were marginalized in discussions. The campaign failed to significantly benefit those it supposedly intended to help: instead, it celebrated all products *processed* in the region—including Coca-Cola beverages. Thus, in the case study as in other case of co-opted grassroots efforts, “funding, support and extension programs [bolster] actors who already [hold] power in the dominant system (e.g. corporate retailers) to benefit from local food systems” (2017, p. 675). Canada is not unique in this regard. Current global agricultural policy often klaxons an agenda of radical change while actually pushing for imitation of present practice and incremental change (Beilin et al., 2012).

In the policy-making process, this dynamic necessarily results in policy which presents itself as new while pushing for business-as-usual—notably through large industrial trade partnerships and a focus on exports rather than on food security and regional economic health. Its implementation hinges on the presence of “resilience” as a boundary object in climate and food policy. Co-opting a perspective requires an object on which government policy can pivot, and which allows all parties to think that their issue is being adequately addressed. Because resilience is a boundary object, it can be implicitly treated as a politically neutral term (Thorén & Olsson, 2017); by that

logic, a government which considers “resilience” to climate change in agriculture would be assumed to have the same framework as anyone else who might bring up the term, including farmers, and arguing for policy which “builds resilience” can be misperceived as a common, well-outlined, agreed-upon process.

For climate and food policy, the result is a space where institutions—in this case, the Canadian government—miss a significant opportunity to embrace relational understanding of resilience espoused by farmers and leverage it to create better, more inclusive policy. Resilience is not a neutral, unified term: it inevitably reflects the underlying political assumptions of the parties which use it (Brand & Jax, 2007; Davidson, 2010; L. Olsson et al., 2015). Its vague definition in discourse ignores the inherently discursive nature of the concept, flattening invisible power imbalances in the public eye (Carr, 2019; McGreavy, 2016). Yet its ambiguity is still an excellent opportunity to build inclusive climate adaptation policy, which must reconcile industrial objectives with the needs of actors in the food system. Taking care to reflect farmers' perspectives would lead to policies with better buy-in from agricultural communities, increased trust, and more successful adaptation across the food system overall.

By championing a climate adaptation policy for the food system which reflects neoliberal interests rather than stakeholder realities, policies are likely to become maladaptive. If the boundary object stands unaddressed, the likely outcome is a series of policies which are inaccessible to smallholders, or otherwise too entrenched in bureaucracy to make a meaningful difference. In the Maritimes, where we conducted our case study, current policies and opportunities for funding are often rejected by farmers who find them ill-suited to their situation.

Farmers may consider them impractical bureaucratic burdens, unsuitable for their purposes. The result is that small-scale producers, who are often among the most vulnerable to climate change (Hallegatte et al., 2016), become institutionally bereft. Though collective action has been shown to build adaptive capacity in such situations (Soubry et al., 2020a), it remains that climate adaptation policies which intend to build resilience but do not take into account the geographic, economic, and social contexts of their intended targets are rarely as effective as those that do (Rahman & Hickey, 2019). Our findings resonate with other research that has found that government programmes which champion a productivist model of growth undermine alternative forms of production—and, consequently, resilience to climate change (Andrée et al., 2018, 2019; Laforge et al., 2017)

Farms of different sizes will likely have different relationships with ecological, economic, and political systems, which means that their framing of “resilience” will be different as well. This study has focused principally on small-scale vegetable growers in order to set reasonable bounds on our data collection. Future research should investigate the differences and similarities in how resilience is conceptualized across scales. Clapp and Scott (2018) have argued that there are competing discourses of sustainable food production across scales, where larger-scale discourse centers around technology and economic efficiency, while small-scale discourse talks about ecological and energy efficiency. How might entanglement in a global supply chain, as well as extensive, industrialized methods of production, affect large-scale farmers’ understanding of resilience—or their sympathy toward policy concerned with preserving that industrialized model?

One distinction to bear in mind in such research is that no matter their entanglements, large-scale agriculture is not large-scale agribusiness: that is to say, farming in step with large-scale methods may safeguard against the precarious nature of farming as a livelihood. Critics have warned against confusing large-scale farmers from the industry in which they evolve: doing so obscures the presence of multinational corporations and other business actors who largely dictate the terms of engagement in the market, as well as the precarity of many farmers involved (Clapp & Isakson, 2018; Jansen, 2015; Stock et al., 2014). Preserving farmers' voices as distinct from the other actors with which they evolve will be necessary to creating a richer understanding of resilience across scales.

How can resilience be defined more critically and problematized in policymaking? One obvious way forward is to safeguard the presence of farmer perspectives in consultations. This may prove difficult, given that the present consultative system, like much of current climate research, privileges industry ties rather than individual, expert farmer perspectives. In both research and policymaking, farmer expertise is often cited as important, but rarely employed as data (Julie Ingram, 2008; Sherren & Darnhofer, 2018; Sumane et al., 2017) apart from verification against historical data (Soubry et al., 2020b). Moreover, government consultative processes tend to privilege access to actors who have significantly more time and resources to build and maintain relationships with governments—which is to say, lobbyists and industry representatives (McInnes, 1998; Skogstad, 1985, 2008; Tourangeau & Sherren, 2019). The strictures of government consultation processes disincentivize farmer participation; the lack of participation,

in turn, may justify the lack of farmer consultation⁵. Responsibility lies in the hands of government institutions to adequately reflect the experience of farmers from across the industry in their consultations and recommendations. We would also echo others (Thorén & Olsson, 2017) in arguing that academic researchers must also step forward: future work on resilience theory must communicate the normative, political nature of resilience, especially in adaptation practice.

7.6 Conclusions

The Canadian government keeps using the word "resilience". We do not think it means what the government thinks it means. Though discourse sometimes overlaps thematically, policymakers and farmers have valid, but largely different conceptions of resilience, some of which work at cross-purposes. Our findings show that farmers see resilience from a relational perspective, focusing not only on farm adaptations but also on financial capacity, market and community relationships, and diversification, among others. Meanwhile, government policy on climate change and agriculture considers resilience as the capacity to maintain the status quo of industry-driven economic growth.

Our objective was to compare the definitions of resilience between two datasets: the final reports and government responses to the Canadian Parliamentary AGRI and AGFO committees'

⁵ Presenting before a committee requires a significant amount of planning and strategy to be effective (McInnes, 1998)—not to mention time, which is more readily available to those on hourly wages than those whose livelihood depends on selling their harvest. When one of this paper's authors was invited to present to the Senate committee, for example, they gave up a day's work: first to take the train in from Oxford to London, then to present for two hours during the committee meeting, and finally to take the train back. For this, they were repaid the cost of the train ticket and a meal.

inquiries into climate change and agriculture, and semi-structured interviews with small-scale farmers in the Canadian Maritimes. The differences between the two suggest that the presence of resilience as a boundary object, a term to which all attach importance but which is not critically defined, creates opportunities for government to build policy which perpetuates *status quo* industrial agriculture without acknowledging farmers' differing conceptions of climate resilience for the food system.

The gulf between these two visions of resilience relate closely to the divide in the theoretical literature between “transformative” and “conservative” understandings of resilience (M. Scott, 2013). They also betray a power imbalance in the representation of farmer voices in building food policy, particularly in relation to climate change; and reflect the tendency of certain government institutions to use consultation and boundary object terms to co-opt transformative action for the sake of the economic status quo (Beilin et al., 2012; Laforge et al., 2017). The findings highlight the need for the definition of resilience in climate and agriculture policy to be problematized. It corroborates the calls in adaptation theory for resilience to be understood as a normative term rather than a politically neutral one; and for broader inclusion of concerned stakeholders in consultations.

Acknowledgements

Deep thanks to the farmers who participated in the interviews and shared their expertise and wisdom. We are grateful to two anonymous reviewers whose suggestions made this paper more cogent. BS is grateful for the support of the Global Land and Water Resources Lab at McGill

University, and Dr. Graham MacDonald in particular, for offering shelter during the writing of this article. Thanks to the Rhodes Trust and the Pierre Elliott Trudeau Foundation for their unwavering support of BS.

Funding

This work was supported by the Rhodes Trust and by the Pierre Elliott Trudeau Foundation.

8. Conclusion

This thesis explores the potential and actual contributions of farmer knowledge to the goal of successful adaptation for regional and global food systems. It also contributes to both the discussion and implementation of resilience and climate adaptation policy for the food system at regional and global levels. The insights I've presented through chapters 5-7 show that farmer knowledge is, even now, rarely integrated in research; that the perspectives of those for tackling climate and food systems can be disconnected from the interests of their constituents; and that, despite this, the collective work of farmers can be—and often is—a worthy contribution to effective adaptation solutions for food systems.

In what follows, I summarize the principal contributions of this thesis and lay out their implications for policy and practice of adaptation, as well as for research communities more broadly. I also recommend future research directions, considering the limitations of this research project.

8.1 Summary of research insights

Each of the research papers in this thesis presents its own findings and integrate to contribute to understanding how farmer knowledge can contribute to climate change adaptation. I give a summary of each paper's individual insights, then consider their cumulative contributions to the questions I asked in Chapter 1.

8.1.1 Insights from papers

Chapter 5 presents a systematic literature review on farmer perceptions of climate change which explores whether, given calls in the literature to respect and integrate farmer knowledge (Fazey et al., 2013; Scherr et al., 2012; Sumane et al., 2017), such knowledge is being reflected in current research on farmer perceptions of climate change. Chapter 6 examines the role of collective action in building resilience and adaptive capacity in the smallholder land-based food system of the Canadian Maritimes region. Finally, drawing on studies by Canadian Senate and House of Commons committees on the effects of climate change and agriculture, as well as on semi-structured interviews with farmers across the Maritimes, Chapter 7 finds that the usages of “resilience” vary significantly between the two sets, suggesting a significant disconnect in policy discourse and practice.

Table 8.1 summarizes each of the papers’ approaches and findings, and links each insight to the research sub-questions discussed in Chapter 1. After summarizing these insights, I consider how they help answer this thesis’ overarching research question.

What are the implications of the current practice of sidelining farmer knowledge in research and policy for building food systems adaptation to climate change?

Q1: What is the role of farmer knowledge in informing avenues for research and policy on food systems adaptation to climate change?

Q2: How do farmers’ endogenous adaptation practices emerge and interact with planned adaptive structures in land-based food systems?

Q3: What opportunities and challenges exist in building successful food systems adaptation policies which complement existing endogenous efforts and local knowledge?

Table 8.1 Synthesis of papers and links to research questions

Chap.	Paper	Summary of insights	Link to research sub-questions (Q1, Q2, Q3)
5	Are we taking farmers seriously? A systematic literature review of farmer “perceptions” of climate change.	- Though a significant literature exists which stresses the importance of farmer knowledge in understanding climate change, most available literature assesses farmers’ observations or considers farmers without agency. - Research practices perpetuate colonial, extractive practices which do not fully describe socioeconomic or cultural contexts. Farmers from the Global South are assessed far more frequently than those from the North.	- The role of farmer knowledge is acknowledged in the literature, but farmers are largely portrayed as passive rather than active. (Q1) - Research largely focuses on verifying whether farmers are correct in their observations, rather than describing context which would be crucial to building adaptation policy. (Q3) - Farmer knowledge is largely being assessed through quantitative methods, which erase the qualitative nature of farmer adaptations and socioeconomic relationships. (Q3)
6	Farming along desire lines Examines the role of collective action in building adaptive capacity to climate change in the food system of the Canadian Maritimes.	- By employing three forms of collective action—farm-based, community-based, and market-based—farmers and food system actors create immediate benefits and systemic building blocks of adaptive capacity to climate change. - Collective action can serve as a “desire line” for policymakers hoping to develop adaptation policy, indicating the needs of farmers and food system actors, as well as establishing tried forms of endogenous adaptation to be supported.	- The applied nature of farmer knowledge cuts across levels and scales, and can thus create adaptive responses to multiple shocks, including climate change. (Q1, Q2, Q3) - Endogenous adaptation practices emerge at the farm, community, and market levels, and involve food system actors at all levels—not just farmers. (Q2) - Successful adaptation can be achieved more effectively by governance institutions which observe endogenous adaptation patterns and support them, rather than attempt to enact policy exclusively from the top down. (Q2, Q3)
7	You keep saying that word... Problematizes the concept of “resilience” across food systems by comparing its use by a set of Canadian parliamentary committees and by farmers in the Canadian Maritimes.	- The definition of “resilience” varies greatly between Canadian policymakers and a subset of the farming population that the former hope to represent. - The nature of resilience as a “boundary object” allows actors to use it without clear definitions, thereby infusing it with assumptions and worldviews about food systems and their aims. - When adaptation policy is involved, this may result in “resilience” being coopted to promote a return to status-quo neoliberal food economics, despite the fact that farmers consider it to be a separate and different effort toward transformation.	- Farmer knowledge considers resilience from a relational perspective, enlarging it beyond on-farm techniques to financial capacity, market diversification, and community relationships. (Q1, Q2) - The presence of resilience as a boundary object in government discourse provides an opportunity for government to build policy which perpetuates status quo agricultural practice without acknowledging farmers’ different ideas of resilience. (Q3) - Future work on resilience theory must communicate the normative, political nature of resilience in adaptation practice; for example, by identifying power dynamics between actors. (Q3)

8.1.2 *Cumulative insights of the thesis*

This thesis asks an overarching question: what are the implications of the current practice of sidelining farmer knowledge in research and policy for building food systems adaptation to climate change? The cumulative lessons learned across its three research papers all address it in their own way. Here, by progressing through each sub-question, I sum up the insights that form the beginnings of an answer.

Q1: *What is the role of farmer knowledge in informing avenues for research and policy on food systems adaptation to climate change?*

Firstly, whether in research or in policy, **farmer knowledge about successful adaptation is nowhere as respected as the literature suggests it ought to be.** Chapter 5 makes clear how large this gap is when considering farmer perceptions of climate change. Farmers are lauded as “applied scientists” (Sherren & Darnhofer, 2018; Sumane et al., 2017), recommended as agents in landscape management (Kroma, 2006; Pape & Prokopy, 2017), and discussed as essential to land management and climate policy in the literature and in policy (FAO, 2020; FAO et al., 2018; Osbahr et al., 2011; UNFCCC, 2017). Yet when it comes to research practice, the voices of farmers are more often recast as vulnerable, unreliable actors devoid of useful knowledge or agency. Meanwhile, Chapter 7 posits that policy around the food-climate nexus is likely to invoke the idea of a resilient food system, but rarely consult with farmers about what that resilience might imply for those who will first be affected by policies. What are the mechanisms of this systemic contradiction that calls for farmer voices with one face and silences them with the other?

My research demonstrates that there remain widespread methodological and institutional barriers which prevent farmer involvement in discussions of climate adaptation, both in policy and in research.

Chapter 5 calls attention to the quantitative slant of farmer perceptions research. The use of historical climate and weather data tests farmer observations, while household surveys which gather data of great geographical breadth; neither bring a nuanced view of farmers' understanding of ecosystems and food systems. Chapter 7, meanwhile, hypothesizes that the recommendations to build resilience in the Canadian agriculture industry, most of which center around technologies and economic growth and ignore farmer-led innovations, may stem from a low number of consultations with actual farmers, or farmers' groups.

The resulting marginalization of farmers in institutional and research processes creates a situation where, excluded from adaptation research and policy, farmers take adaptation processes into their own hands. Chapter 6 shows how small farmers in the Maritimes, deprived of research or policy support, have turned inward to build their own endogenous adaptation techniques within the food system community. The techniques, whether based in social or in marketing processes occur without the support of institutions or academic research; if anything, they often emerge in spite of them. In that spirit, the current framework for engagement with farmer knowledge falls—intentionally or not—within neoliberal paradigms for climate adaptation (Müller, 2008; Stock et al., 2014): responsibility for change falls not on institutions but on the farmers themselves.

Q2: *How do endogenous adaptation practices emerge and interact with planned adaptive structure in land-based food systems?*

This thesis argues that, **while endogenous adaptations by food system actors can generate the building blocks of capacity, the farmers leading them still require external, systems-wide support.** Chapter 6 demonstrates that collective action is one powerful tool among many to build

adaptive capacity in food systems. Farming is an adaptive craft; the farmers presented here are clearly capable, viably adapting actors in food systems who can share and benefit from the expertise and support of their peers in a way which ultimately benefits the wider food system. Yet the desire lines of collective action are limited in their scope and effect—they cannot change policy by themselves, and require a government presence which wishes for that cooperation rather than co-opting in policy design (Beilin et al., 2012).

This thesis makes clear that real collaboration is needed to reconcile a networked, relational farmer knowledge of climate adaptation with the institutional heft of governments and research. Farmers and food system actors cannot overhaul a food system toward successful adaptation and resilience in isolation. Neither can top-down governance build successful and equitable policy in processes which rarely consult farmers. Any resolution requires a delicate balance that is mutually supportive rather than co-opting or undercutting.

Such a balance may be difficult to uphold if the **institutional mechanisms in place to understand and collect farmer knowledge tend to reinforce the status quo rather than leverage that knowledge into transformative policy change**. Chapter 6 highlights a number of ways that farmers and other food system actors have adopted techniques or projects to build resilience to various shocks, whether to markets or to crop production—yet these initiatives largely take place outside the sphere of research or government institutions. The resulting disconnect, which becomes clear in chapters 5 and 7, exemplifies the notion that larger institutions guiding policy in the food-climate nexus are better at perpetuating themselves than at solving problems for farmers (Laforge et al., 2017). Research and policy that purport to examine farmer knowledge tends to overwhelmingly benefit researchers and policymakers rather than farmers, cementing sources of funding and influence over established

programmes (Hendrix, 2017). This leads to what Willis (2017) has termed “climate taming”: policymakers are often selective of their use of climate-related terms, not mentioning abrupt or irreversible changes, in order to “tame” climate change and avoid confronting difficult realities. The government’s studies of resilience explored in chapter 7, for example, concluded that very little needs to be changed from national food agendas to adapt to climate change—except perhaps to cleave ever more tightly to established patterns of export-driven production, growth, technological investment, and industrial scaling which largely put the burden of risk on farmers.

Q: What are the implications of the current practice of sidelining farmer knowledge in research and policy for building food systems adaptation to climate change?

I have tried to answer this question in as much of its complexity as possible throughout this thesis. When I reflect on the answers and further questions my work has delivered, my gut says: nothing good. Farmers have been pushed to the side in most research practice, and their lived experience exists more as an object to be verified than as a contribution to scholarship. They have demonstrated time and again that their tacit scholarship of the land and climate can lead to robust, systemic, and—above all—effective adaptation practices. And despite the clear opportunities for governance institutions to model policy on farmer-led adaptation, new policy consultations in Canada have failed to meaningfully include farmers. The result of this sidelining manifests as a research agenda that, while purporting to integrate farmer knowledge into its scientific assessment, misses the ways in which social capital and cooperation help build adaptive capacity. It manifests as policy which claims to build resilience to climate change, but cleaves to the old furrows of export-driven profit over food security. In short, it manifests as insufficient research and bad policy—at a time when the world can afford little of either.

Whose knowledge should count when preparing for an uncertain future? Who should get a voice, and how do those voices get translated from the kitchen table to the policymaker's desk? Farmers are the first to feel the effects of climate change on food systems. Their knowledge—botanical, social, economic—has allowed rural communities to exist across continents and over millennia. They are complex actors with deep understandings of the consequences of climate change on food systems. But they will suffer when policies misunderstand their contexts, or favour economic goals over social ones, or abandon to the markets their most knowledgeable and vulnerable constituents. And they will suffer, too, the consequences of research by physical or social scientists who come to learn from them but who, for lack of funding or from narrow-mindedness, treat them as data to be plotted rather than as applied researchers in their own right. Food systems adaptation policy and research cannot afford to merely exist as an exercise in masking a continuous status quo. They must be representative, not only so that they are effective, but so that they are just. Anything less will mean a failure to adapt, and our battered world will be the more fragile for it.

Current food-climate policy and research mechanisms present a performative concern for farmers' experience and well-being that masks their institutional inertia and reluctance to transform. This inertia makes it impossible to, on the one hand, understand the complexity of food producers' needs; and, on the other, respond to them with the scale and efficacy that might provide genuine support. I consider some options to achieve the latter goal in the remaining pages of this thesis.

8.2 Research limitations

The constraints to this research project, in the form of both logistics and my own abilities, have affected the final analysis. I discuss limitations for each of the three research papers in their respective

chapters. Beyond these, there are three points which are necessary to highlight and which can guide future research in this topic area.

My data collection was primarily centered around small-scale farmers interacting within the land-based food system. I chose this participant group because of my affinity with the small-scale farming community in the region, which provided me with significantly more access than I could have had otherwise (see Chapter 4). Yet larger-scale producers exist in the region and interact differently with food systems both on-farm and in their relationships with markets. As it stands, my analysis is reflective of smaller-scale interactions globally, but would benefit from a cross-scalar perspective.

Additional limitations come from the fact that I chose a cross-sectional rather than longitudinal approach, interviewing each participant only once in the course of my fieldwork. Returning to farmers over different seasons could have highlighted changing relationships and perspectives. Given logistical and financial constraints, however, this was not possible.

Finally, I was limited in my capacity to approach policymakers for longer interviews. While this skewed my interview data toward a distinctly agricultural perspective, policymaking in climate and agriculture is significantly better-documented than farmer perspectives through grey literature and academic literature. I was able to work from secondary data to perform my analysis.

8.3 Implications for research and policy

Considering some of the lessons and limitations of this project points to avenues for future research that are both interesting and necessary.

8.3.1 *Future research in the food-climate nexus*

One of the significant findings of this thesis is the potential of qualitative research to illuminate farmers' roles as key food systems actors who build resilience not only in production systems, but at across food systems in general. A qualitative approach to food systems research about climate change reveals the networked and relational aspects of resilience and successful adaptation both on- and off-farm. It bridges adaptation theory and agricultural practice in novel ways, allowing for political concepts such as collective action to be included in a field of study which has thus far primarily concerned itself with simply growing more (Porter et al., 2017). It also dovetails with analyses of social networks which reveal that the robustness of communities is influenced more by their social relationships than the availability of the resources they need (Baggio et al., 2016)

The project's limitation of scale gives a number of potential avenues for future qualitative research on food and climate change. I focused my work on small-scale producers in the Maritimes for reasons of concision and funding, and because their situation provides a useful analogue to smallholders worldwide. Yet further research should explore how food actors at different scales may differ in their responses. What kinds of long-term risks do larger-scale vegetable producers perceive, and how are they presently mitigating them? Are there scale-based limits to collective action? What does "resilience" mean to the individual members of an industrial agriculture organization, and how different are those definitions from the ones shared in chapter 7? All these are questions which become possible when research focus expands from quantifiable data—acreage in production, weather patterns—to include the climate-food nexus as a network of relations, power, and socioeconomic forces.

Such a research project must be based in genuine, systemic attempts to integrate farmer perspectives into research design. This thesis reveals a strong need for researchers to build what Carolan calls “interactional expertise”: the capacity to work between two different discourses and spheres of knowledge (Carolan, 2006; see also Collins, 2004). Farmers’ livelihoods rarely provide a moment, let alone a training programme, to learn how to interact with and lobby government; public servants, meanwhile, are often loaded with portfolios that discourage deep interventions into any one area (Shaw & Maythorne, 2013). Researchers are well-positioned to become not only knowledge agents, but translators of sorts for actors in the food-climate nexus.

Such a positioning will require individual researchers and their institutions to value and support long-term projects that allow for sustained contact rather than rapid field visits (Hendrix, 2017). It will require research design to turn from being researcher-led toward being participant-led (Parsons et al., 2016). And it will require research which places an emphasis, regardless of the focus of inquiry, on the social, cultural, and political overtones and undertones of the actors involved (Stock et al., 2014) in order to be sensitive to the forces shaping the research itself. These are significant, maybe even naïve, requests. Yet I think that this thesis, as well as its preceding Master’s work (Soubry, 2017a), has been able to grasp a certain qualitative depth because it aims to embody this kind of expertise: an empathy for and lived experience shared with farmers, as well as the institutional authority and discourse of academic and policy work.

8.3.2 *Food-climate policy*

The research papers presented earlier in this thesis each make their own recommendations for current policy. Each recommendation rests on one principle: to listen to farmers’ voices, both within policy

arenas and outside of them. Only a shift in the perceived legitimacy of farmers in policy discussions will allow for policy which is both effective and just.

It is difficult, moreover, to suggest direct changes to policy when one considers how ineffective national policies have been in the past at addressing adaptation in the food-climate nexus. Discussions on centering farmers in policy began thirty years ago (see Scoones & Thompson, 1994), yet farmer knowledge is rarely put forward in national or international policy in the current climate (Hönle et al., 2019). An academic suggesting that policymakers simply *change their mind* is the drumbeat of the past three decades, and its result is a gentle move from total ignorance about farmers' possible contributions to policy into a performative concern that seems to harm farmers more, or at most as often, as it helps them (Beilin et al., 2012; Laforge et al., 2017; Sumane et al., 2017).

I would suggest an indirect strategy. For farmers' experience to help build successful adaptation in the food system, its introduction will have to be targeted, and it will have to come from two dedicated groups. The first are non-state actors: NGOs, private enterprises, and coalitions that have influence in national or international fora and can repeatedly raise their voices on behalf of farmers (Abbott, 2012; Clapp & Scott, 2018). At national levels, it will require climate-focused advocacy groups to change their own procedures to include a diversity of voices, and to include farmers in their discussions of the food-climate nexus. And regionally, in the Maritimes, it will require a coalition of farm-based and climate-focused groups to share their collective paths and demand recognition—the beginnings of which seem to be sprouting in the Maritimes as I write (Everybody Eats, 2018; Qualman, 2019).

The second are researchers. Institutional privilege, both in public trust and relative financial security, means that food and climate researchers are often best placed to inform subnational actors and

policymakers that their chosen paths are disharmonious with their aims. Policy change can only come about if climate and food researchers break from the simple cycle of publishing and presenting, and remind both policymakers and the public that speaking about farmers isn't the same as listening to them; that resilience may not mean what they think it means; and that we are running out of time. It will not be enough to write about it amongst ourselves. Research must write, and speak, outwards.

Understanding the lessons presented above is essential if research and policy ever want to go beyond the veil of *appearing* to listen to farmers' experience and actions, and into actually entering into partnership with, and learning from, insights won at ground level. Successful climate adaptation on farms and in food systems will require researchers and policymakers alike to get to grips with the substantive practice of adaptations. Farmers and food system workers can teach us how to do this; but for now, research moves slowly, and farmers do not have the luxury of time.

9. References

- Abbott, K. W. (2012). The transnational regime complex for climate change. *Environment and Planning C: Government and Policy*, 30(4), 571–590. <https://doi.org/10.1068/c11127>
- Abson, D. J., von Wehrden, H., Baumgärtner, S., Fischer, J., Hanspach, J., Härdtle, W., Heinrichs, H., Klein, A. M., Lang, D. J., Martens, P., & Walmsley, D. (2014). Ecosystem services as a boundary object for sustainability. *Ecological Economics*, 103, 29–37. <https://doi.org/10.1016/j.ecolecon.2014.04.012>
- ACASA. (2016). *Report of ACASA Expert Panel on Climate Change Adaptation*. https://atlanticadaptation.ca/en/islandora/search/mods_genre_doctype_t%3A%28report%29?islandora_solr_search_navigation=0&sort=mods_originInfo_dateIssued_dt_desc
- Adams, W. M., & Sandbrook, C. (2013). Conservation, evidence and policy. *Oryx*, 47(03), 329–335. <https://doi.org/10.1017/S0030605312001470>
- Adger, W. N. (2003). Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography*, 79(4), 387–404.
- Adger, W. N., Arnell, N. W., Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful Adaptation to Climate Change Across Scales. *Global Environmental Change*, 15, 77–86. <https://doi.org/10.1016/j.gloenvcha.2004.12.005>
- Adger, W. N., Barnett, J., & Brien, K. O. (2012). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change*, 3(2), 112–117. <https://doi.org/10.1038/nclimate1666>
- Adger, W. N., Brown, K., Nelson, D. R., Berkes, F., Eakin, H., Folke, C., Galvin, K., Gunderson, L., Goulden, M., O'Brien, K., Ruitenbeek, J., & Tompkins, E. L. (2011). Resilience implications of policy responses to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 2(5), 757–766. <https://doi.org/10.1002/wcc.133>
- Adger, W. N., Hulme, M., Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., Otto, L., Johanna, N., & Anita, W. (2009). Are There Social Limits to Adaptation to Climate Change? *Climatic Change*, 93(January). <https://doi.org/10.1007/s10584-008-9520-z>
- Adger, W. N., Quinn, T., & Sweeney, J. C. (2012). Changing social contracts in climate-change adaptation. *Nature Climate Change*, 2(11), 1–4. <https://doi.org/10.1038/nclimate1751>
- Agrawal, A. (1995). Dismantling the Divide Between Indigenous and Scientific Knowledge. *Development and Change*, 26(3), 413–439. <https://doi.org/10.1111/j.1467-7660.1995.tb00560.x>
- Agrawal, A. (2008). *The Role of Local Institutions in Adaptation to Climate Change* (Social Dimensions of Climate Change). <http://www.icarus.info/wp-content/uploads/2009/11/agrawal-adaptation-institutions-livelihoods.pdf>
- Agriculture and Agri-Food Canada. (2020). *Growing Forward 2 : a Federal - Provincial -Territorial Framework Agreement on Agriculture , Agri-Food and Agri-Based Products Policy*. Government of Canada. <https://www.agr.gc.ca/eng/agricultural-programs-and-services/agristability/resources/agristability-growing-forward-2-program-guidelines/?id=1366309611983>
- Ahern, J. (2011). From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. *Landscape and Urban Planning*, 100(4), 341–343. <https://doi.org/10.1016/j.landurbplan.2011.02.021>
- Alexandratos, N., & Bruinsma, J. (2003). World agriculture: towards 2015/2030: an FAO perspective. *Land Use Policy*, 20(4), 375. [https://doi.org/10.1016/S0264-8377\(03\)00047-4](https://doi.org/10.1016/S0264-8377(03)00047-4)
- Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015a). Agroecology and the design of climate change- resilient farming systems farming systems. *Agronomy for Sustainable Development*, May. <https://doi.org/10.1007/s13593-015-0285-2>
- Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015b). Agroecology and the design of

- climate change-resilient farming systems. *Agronomy for Sustainable Development*, 35(3), 869–890. <https://doi.org/10.1007/s13593-015-0285-2>
- Altieri, M. A., & Rosset, P. (1999). Ten reasons why biotechnology will not ensure food security, protect the environment and reduce poverty in the developing world. *AgBioForum*, 2(3–4), 155–162.
- Andersson, E., & Gabrielsson, S. (2012). “Because of poverty, we had to come together”: Collective action for improved food security in rural Kenya and Uganda. *International Journal of Agricultural Sustainability*, 10(3), 245–262. <https://doi.org/10.1080/14735903.2012.666029>
- Andrée, P., Clark, J. K., Levkoe, C. Z., & Lowitt, K. (2019). Civil Society and Social Movements in Food System Governance. In P. Andrée, J. K. Clark, C. Z. Levkoe, & K. Lowitt (Eds.), *Civil Society and Social Movements in Food System Governance*. Routledge. <https://doi.org/10.4324/9780429503597>
- Andrée, P., Levkoe, C. Z., & Wilson, A. (2018). *Guest Editorial Special Issue on building an integrated Food Policy for Canada : An open letter to the Canadian food policy community*. 5(3), 1–5. <https://doi.org/10.15353/cfs-rcea.v5i3.335>
- Arbuckle, J. G. G., Tyndall, J. C. C., Morton, L. W. W., & Hobbs, J. (2017). Climate change typologies and audience segmentation among Corn Belt farmers. *Journal of Soil and Water Conservation*, 72(3), 205–214. <https://doi.org/10.2489/jswc.72.3.205>
- Arbuckle, J. G., Morton, L. W., & Hobbs, J. (2013). Farmer beliefs and concerns about climate change and attitudes toward adaptation and mitigation: Evidence from Iowa. *Climatic Change*, 118(3–4), 551–563. <https://doi.org/10.1007/s10584-013-0700-0>
- Arbuckle, J. G., Morton, L. W., & Hobbs, J. (2015). Understanding Farmer Perspectives on Climate Change Adaptation and Mitigation. *Environment and Behavior*, 47(2), 205–234. <https://doi.org/10.1177/0013916513503832>
- 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*. <https://doi.org/10.1038/NCLIMATE1944>
- 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., McConney, P., Pinkerton, E. W., & Wollenberg, E. K. (2009). Adaptive co-management for social–ecological complexity. *Frontiers in Ecology and the Environment*, 7(2), 95–102. <https://doi.org/10.1890/070089>
- Arnold, S., & Fenech, A. (2017). Prince Edward Island Climate Change Adaptation Recommendations Report. In *University of Prince Edward Island Climate Lab*. <http://www.deslibris.ca.uml.idm.oclc.org/ID/219849>
- Arora-Jonsson, S. (2011). Virtue and vulnerability: Discourses on women, gender and climate change. *Global Environmental Change*, 21(2), 744–751. <https://doi.org/10.1016/j.gloenvcha.2011.01.005>
- Ashwood, L., Harden, N., Bell, M. M., & Bland, W. (2014). Linked and situated: Grounded knowledge. *Rural Sociology*, 79(4), 427–452. <https://doi.org/10.1111/ruso.12042>
- Atkinson, R., Dörfler, T., Hasanof, M., Rothfuß, E., & Smith, I. (2017). Making the case for self-organisation: understanding how communities make sense of sustainability & climate change through collective action. *International Journal of Sustainable Society*, 9, 193–209.
- Audefroy, J. F., Nelly, B., & Sánchez, C. (2017). *Integrating local knowledge for climate change adaptation in Yucatán, Mexico*. <https://doi.org/10.1016/j.ijlsbe.2017.03.007>
- Auditors General of Canada. (2018). *Perspectives on climate change action in Canada*. http://www.bcauditor.com/sites/default/files/publications/files/Collaborative_Audit_Perspectives_on_Climate_Change_Action_in_Canada.pdf
- Ayal, D. Y., & Filho, W. L. (2017). Farmers’ perceptions of climate variability and its adverse impacts on crop and livestock production in Ethiopia. *Journal of Arid Environments*, 140, 20–28.

<https://doi.org/10.1016/j.jaridenv.2017.01.007>

- Ayer, H. W. (1997). Grass roots collective action: Agricultural opportunities. *Journal of Agricultural and Resource Economics*, 22(1), 1–11. <https://doi.org/10.1016/j.regsciurbeco.2013.10.001>
- Ayeri, O. S., Christian, V. R., Josef, E., & Michael, H. (2012). Local perceptions and responses to climate change and variability: The case of Laikipia District, Kenya. *Sustainability*, 4(12), 3302–3325. <https://doi.org/10.3390/su4123302>
- Ayres, L. (2012). Thematic Coding and Analysis. In *The SAGE Encyclopedia of Qualitative Research Methods* (p. 868). SAGE Publications, Inc. <https://doi.org/10.4135/9781412963909.n451>
- Baggio, J. A., Burnsilver, S. B., Arenas, A., Magdanz, J. S., Kofinas, G. P., & De Domenico, M. (2016). Multiplex social ecological network analysis reveals how social changes affect community robustness more than resource depletion. *Proceedings of the National Academy of Sciences of the United States of America*, 113(48), 13708–13713. <https://doi.org/10.1073/pnas.1604401113>
- Bahadur, A., Ibrahim, M., & Tanne, T. (2010). *The resilience renaissance ? Unpacking of resilience for tackling climate change and disasters* (Issue July).
- Barton, K. C. (2015). Elicitation techniques: Getting people to talk about ideas they dont usually talk about. *Theory and Research in Social Education*, 43(2), 179–205. <https://doi.org/10.1080/00933104.2015.1034392>
- Bauermeister, M. R. (2016). Social capital and collective identity in the local food movement. *International Journal of Agricultural Sustainability*, 14(2), 123–141. <https://doi.org/10.1080/14735903.2015.1042189>
- Baul, T. K., & Mcdonald, M. (2015). Integration of Indigenous knowledge in addressing climate change. *Indian Journal of Traditional Knowledge*, 1(1), 20–27. http://nopr.niscair.res.in/bitstream/123456789/32021/1/IJTK_1%281%29_20-27.pdf
- Baul, T. K., Ullah, K. M. A., Tiwari, K. R., & McDonald, M. A. (2013). People's local knowledge of climate change in the middle-hills of Nepal. *Indian Journal of Traditional Knowledge*, 12(4), 585–595.
- Beaulieu, M. S. (2015). Demographic Changes in Canadian Agriculture. In *Statistics Canada* (Issue 96). <http://www.statcan.gc.ca/pub/96-325-x/2014001/article/11905-eng.htm>
- Bednarek, A. T., Wyborn, C., Cvitanovic, C., Meyer, R., Colvin, R. M., Addison, P. F. E., Close, S. L., Curran, K., Farooque, M., Goldman, E., Hart, D., Mannix, H., McGreavy, B., Parris, A., Posner, S., Robinson, C., Ryan, M., & Leith, P. (2018). Boundary spanning at the science–policy interface: the practitioners' perspectives. *Sustainability Science*, 13(4), 1175–1183. <https://doi.org/10.1007/s11625-018-0550-9>
- Beilin, R., Sysak, T., & Hill, S. (2012). Farmers and perverse outcomes: The quest for food and energy security, emissions reduction and climate adaptation. *Global Environmental Change*, 22(2), 463–471. <https://doi.org/10.1016/j.gloenvcha.2011.12.003>
- Bennett, N. J. (2016). Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, 30(3), 582–592. <https://doi.org/10.1111/cobi.12681>
- Berbés-Blázquez, M., González, J. A., & Pascual, U. (2016). Towards an ecosystem services approach that addresses social power relations. *Current Opinion in Environmental Sustainability*, 19, 134–143. <https://doi.org/10.1016/j.cosust.2016.02.003>
- Berkes, F. (2007). Community-based conservation in a globalized world. *PNAS*, 104(39), 15188–15193. <https://doi.org/10.1073/pnas.0702098104>
- Berkes, Fikret. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management*, 90(5), 1692–1702. <https://doi.org/10.1016/j.jenvman.2008.12.001>
- Berkes, Fikret, & Ross, H. (2013). Community Resilience: Toward an Integrated Approach. *Society and Natural Resources*, 26(1), 5–20. <https://doi.org/10.1080/08941920.2012.736605>

- Berry, W. (2003). The Agrarian Standard. In N. Wirzba (Ed.), *The Essential Agrarian Reader* (pp. 23–33). University Press of Kentucky. <http://www.jstor.org/stable/j.ctt2jch99.5>
- Bezner Kerr, R., Hickey, C., Lupafya, E., & Dakishoni, L. (2019). Repairing rifts or reproducing inequalities? Agroecology, food sovereignty, and gender justice in Malawi. *Journal of Peasant Studies*, 46(7), 1499–1518. <https://doi.org/10.1080/03066150.2018.1547897>
- Bhathasara, S. (2017). Rethinking climate change research in Zimbabwe. *Journal of Environmental Studies and Sciences*, 7, 39–52. <https://doi.org/10.1007/s13412-015-0298-9>
- Biggs, R., Schlüter, M., Biggs, D., Bohensky, E. L., BurnSilver, S., Cundill, G., Dakos, V., Daw, T. M., Evans, L. S., Kotschy, K., Leitch, A. M., Meek, C., Quinlan, A., Raudsepp-Hearne, C., Robards, M. D., Schoon, M. L., Schultz, L., & West, P. C. (2012). Toward Principles for Enhancing the Resilience of Ecosystem Services. *Annual Review of Environment and Resources*, 37(1), 421–448. <https://doi.org/10.1146/annurev-environ-051211-123836>
- Birkenholtz, T., & Birkenholtz, T. (2014). Knowing Climate Change: Local Social Institutions and Adaptation in Indian Groundwater Irrigation. *Professional Geographer*, 66(3), 354–362. <https://doi.org/10.1080/00330124.2013.821721>
- Birks, M., & Mills, J. E. (2015). *Grounded theory : a practical guide* (Second Edi). SAGE Publications.
- Björkhaug, H., Almås, R., & Brobakk, J. (2012). Emerging Neo-Productivist Agriculture as an Approach to Food Security and Climate Change in Norway. *Research in Rural Sociology and Development*, 18(April), 211–234. [https://doi.org/10.1108/s1057-1922\(2012\)0000018012](https://doi.org/10.1108/s1057-1922(2012)0000018012)
- Blay-Palmer, A. D., Sonnino, R., & Custot, J. (2016). A food politics of the possible? Growing sustainable food systems through networks of knowledge. *Agriculture and Human Values*, 33, 27–43. <https://doi.org/10.1007/s10460-015-9592-0>
- Bohle, H.-G., Etzold, B., & Keck, M. (2009). *Reframing Resilience: From Systems-Oriented to People-Centred Perspectives Resilience as Agency*. https://www.researchgate.net/publication/263111355_Resilience_as_Agency
- Bottrell, D. (2009). Understanding “marginal” perspectives: Towards a social theory of resilience. *Qualitative Social Work*, 8(3), 321–339. <https://doi.org/10.1177/1473325009337840>
- Boyle, J., Cunningham, M., & Dekens, J. (2013). *Climate Change Adaptation and Canadian Infrastructure: A review of the literature*. http://www.iisd.org/pdf/2013/adaptation_can_infrastructure.pdf
- 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(1). <http://www.ecologyandsociety.org/vol12/iss1/art23/%0ASynthesis>
- Bronson, K., Knezevic, I., & Clement, C. (2019). The Canadian family farm, in literature and in practice. *Journal of Rural Studies*, January, 0–1. <https://doi.org/10.1016/j.jrurstud.2019.01.003>
- Brooks, N., & Adger, W. N. (2005). *The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation national level and the implications for adaptation*. January. <https://doi.org/10.1016/j.gloenvcha.2004.12.006>
- Brown, K. (2011). Policy discourses of resilience. In M. Pelling, D. Manuel-Navarrete, & M. Redclift (Eds.), *Climate Change and the Crisis of Capitalism: A Chance to Reclaim Self, Society and Nature*. Routledge.
- Brown, K. (2014). Global environmental change I: A social turn for resilience? *Progress in Human Geography*, 38(1), 107–117. <https://doi.org/10.1177/0309132513498837>
- Brown, K. (2015). Resilience, development and global change. In *Resilience, Development and Global Change*. <https://doi.org/10.4324/9780203498095>
- Brown, K., Adger, W. N., Devine-Wright, P., Anderies, J. M., Barr, S., Bousquet, F., Butler, C., Evans, L., Marshall, N., & Quinn, T. (2019). Empathy, place and identity interactions for sustainability.

- Global Environmental Change*, 56(December 2018), 11–17.
<https://doi.org/10.1016/j.gloenvcha.2019.03.003>
- 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(1), 321–342. <https://doi.org/10.1146/annurev-environ-052610-092905>
- Burge, M. (1987). The Political Education of Bud the Spud: Producers and Plebiscites on Prince Edward Island. In G. Burrill & I. McKay (Eds.), *People, Resources, and Power: Critical perspectives on underdevelopment and primary industries in the Atlantic region* (pp. 36–41). Acadiensis Press.
- Burke, M., & Emerick, K. (2016). Adaptation to climate change: Evidence from US agriculture. *American Economic Journal: Economic Policy*, 8(3), 106–140.
<https://doi.org/10.1257/pol.20130025>
- Bush, E., Gillett, N., Bonsal, B., Cohen, S., Derksen, C., Flato, G., Greenan, B., Shepherd, M., & Zhang, X. (2019). *Canada's Changing Climate Report - Executive Summary* (E. Bush & D. S. Lemmen (Eds.)). Government of Canada. www.changingclimate.ca/CCCR2019
- C-CIARN. (2002). *Agricultural Adaptation in a Changing Climate*. http://www.uoguelph.ca/c-ciarn/documents/2002_pdf_summary_fewgraphics.pdf
- Cabas, J., Weersink, A., & Olale, E. (2010). Crop yield response to economic, site and climatic variables. *Climatic Change*, 101(3–4), 599–616. <https://doi.org/10.1007/s10584-009-9754-4>
- Cameron, E. S. (2012). Securing indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. *Global Environmental Change*, 22(1), 103–114. <https://doi.org/10.1016/j.gloenvcha.2011.11.004>
- Canadian Federation of Agriculture. (2019). *Our Members Organizations | CFA-FCA*.
<https://www.cfa-fca.ca/about-us/our-members-organizations/>
- Canadian Organic Growers, Canada Organic Trade Association, USC Canada, & Organic Federation of Canada. (2016). *Investing in Organic Agriculture: A Path To Clean, Inclusive, Economic Growth: Recommendations for the Next Agricultural Policy Framework*.
- Carolan, M. S. (2006). Sustainable agriculture, science and the co-production of “expert” knowledge: The value of interactional expertise. *Local Environment*, 11(4), 421–431.
<https://doi.org/10.1080/13549830600785571>
- Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? *Ecosystems*, 4(8), 765–781. <https://doi.org/10.1007/s10021-001-0045-9>
- Carr, E. R. (2019). Properties and projects : Reconciling resilience and transformation for adaptation and development. *World Development*, 122, 70–84.
<https://doi.org/10.1016/j.worlddev.2019.05.011>
- 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. *Canadian Geographer*, 56(2), 160–179.
<https://doi.org/10.1111/j.1541-0064.2012.00432.x>
- CCAFS. (2016). *Annual Report 2015: Change for the Better*. 84.
<https://doi.org/10.1017/CBO9781107415324.004>
- Chambers, R., Pacey, A., & Thrupp, L. A. (Eds.). (1989). *Farmer First: Farmer Innovation and Agricultural Research*. Intermediate Technology Publications.
- Chandra, A., McNamara, K. E., & Dargusch, P. (2018). Climate-smart agriculture: perspectives and framings. *Climate Policy*, 18(4), 526–541. <https://doi.org/10.1080/14693062.2017.1316968>
- Chandra, A., McNamara, K. E., Dargusch, P., Damen, B., Rioux, J., Dallinger, J., & Bacudo, I. (2016). Resolving the UNFCCC divide on climate-smart agriculture. *Carbon Management*, 7(5–6), 295–

299. <https://doi.org/10.1080/17583004.2016.1235420>
- Charmaz, K. (2006). *Constructing grounded theory : a practical guide through qualitative analysis*. Sage Publications.
- Charmaz, K. (2016). Constructivist Grounded Theory. *The Journal of Positive Psychology*, 1743–9760.
- Chen, H., Ejaz, Q., Gao, X., Huang, J., & Morris, J. (2016). *Food / Water / Energy / Climate Outlook: Perspectives From 2016*. <https://globalchange.mit.edu/publications/signature/2016-food-water-energy-climate-outlook>
- Chérif, S., Filho, W. L., & Azeiteiro, U. (2016). The role of farmers ' perceptions in coping with climate change in Sub - Saharan Africa. *Int . J . Global Warming*. <https://doi.org/10.1504/IJGW.2017.10005907>
- Chouinard, O., Plante, S., & Martin, G. (2008). The Community Engagement Process: A Governance Approach in Adaptation to Coastal Erosion and Flooding in Atlantic Canada *. *Canadian Journal of Regional Science*, 507–520.
- Christmann, S., Aw-Hassan, A., Rajabov, T., & Rabbimov, A. (2015). Collective Action for Common Rangelands Improvement: A Climate Change Adaptation Strategy in Uzbekistan. *Society and Natural Resources*, 28(3), 280–295. <https://doi.org/10.1080/08941920.2014.933927>
- Chromy, J. R. (2011). Snowball Sampling. In *Encyclopedia of Survey Research Methods* (p. 824). SAGE Publications, Inc. <https://doi.org/10.4135/9781412963947>
- Clapp, J. (2014). Financialization, distance and global food politics. *Journal of Peasant Studies*, 41(5), 797–814. <https://doi.org/10.1080/03066150.2013.875536>
- Clapp, J. (2015). Distant agricultural landscapes. *Sustainability Science*, 10(2), 305–316. <https://doi.org/10.1007/s11625-014-0278-0>
- Clapp, J. (2017). The trade-ification of the food sustainability agenda. *Journal of Peasant Studies*, 44(2), 335–353. <https://doi.org/10.1080/03066150.2016.1250077>
- Clapp, J. (2018). Mega-Mergers on the Menu: Corporate Concentration and the Politics of Sustainability in the Global Food System. *Global Environmental Politics*, 18(2), 82–101. <https://doi.org/10.1162/GLEP>
- Clapp, J. (2019). The rise of financial investment and common ownership in global agrifood firms ownership. *Review of International Political Economy*, 0(0), 1–26. <https://doi.org/10.1080/09692290.2019.1597755>
- Clapp, J., & Isakson, S. R. (2018). Risky Returns: The Implications of Financialization in the Food System. *Development and Change*, 49(2), 437–460. <https://doi.org/10.1111/dech.12376>
- Clapp, J., Newell, P., & Brent, Z. W. (2018). The global political economy of climate change, agriculture and food systems. *Journal of Peasant Studies*, 45(1), 80–88. <https://doi.org/10.1080/03066150.2017.1381602>
- Clapp, J., & Purugganan, J. (2020). Contextualizing corporate control in the agrifood and extractive sectors. *Globalizations*, 0(0), 1–11. <https://doi.org/10.1080/14747731.2020.1783814>
- Clapp, J., & Scott, C. (2018). Introduction: The Global Environmental Politics of Food. *Global Environmental Politics*, 18(2), 82–101. <https://doi.org/10.1162/GLEP>
- Clapp, J., & Stephens, P. (2019). Financialising nature. In A. Kalfagianni, D. Fuchs, & A. Hayden (Eds.), *Routledge Handbook of Global Sustainability Governance* (pp. 172–175). Routledge. <https://doi.org/10.4324/9781315170237>
- Coady, M. M. (1939). *Masters of their Own Destiny: The Story of The Antigonish Movement of Adult Education Through Economic Cooperation*. Harper & Brothers.
- Cockburn, J. (2015). Local Knowledge/Lacking Knowledge: Contradictions in Participatory Agroecology Development in Bolivia. *Anthropologica*, 57(1), 169–183.
- Coe, R., & Stern, R. D. (2011). Assessing and addressing climate-induced risk in sub-Saharan rainfed agriculture: Lessons learned. *Experimental Agriculture*, 47(02), 395–410.

<https://doi.org/10.1017/S001447971100010X>

- Coghlan, D., & Brydon-Miller, M. (2014). Antigonish Movement. *The SAGE Encyclopedia of Action Research*, 39–40. <https://doi.org/10.4135/9781446294406.n23>
- Cohn, A. S., Newton, P., Gil, J. D. B., Kuhl, L., Samberg, L., Ricciardi, V., Manly, J. R., & Northrop, S. (2017). Smallholder Agriculture and Climate Change. *Annual Review of Environment and Resources*, 42(1), 347–375. <https://doi.org/10.1146/annurev-environ-102016-060946>
- Collins, H. (2004). Interactional Expertise as a Third Kind of Knowledge. *Phenomenology and the Cognitive Sciences*, 3, 125–143. <https://doi.org/10.1023/B>
- Comberti, C., Thornton, T. F., Wylliede Echeverria, V., & Patterson, T. (2015). Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. *Global Environmental Change*, 34, 247–262. <https://doi.org/10.1016/j.gloenvcha.2015.07.007>
- Comoé, H., Finger, R., & Barjolle, D. (2014). Farm management decision and response to climate variability and change in Côte d'Ivoire. *Mitig Adapt Strateg Glob Change*, 19, 123–142. <https://doi.org/10.1007/s11027-012-9436-9>
- Corner, A., Marshall, G., & Clarke, J. (2016). Communicating effectively with the centre-right about household energy-efficiency and renewable energy technologies. Retrieved On September, 21, 2016. <https://www.yaleclimateconnections.org/dl/Climate-Outreach-Centre-right-Energy-report-March-2016.pdf>
- 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(4), 475–489. <https://doi.org/10.1177/0309132511425708>
- Council of Canadian Academies. (2014). *Aboriginal Food Security in Northern Canada: An Assessment of the State of Knowledge*. https://doi.org/10.1162/LEON_r_00884
- Crate, S. A. (2011). Climate and Culture : Anthropology in the Era of Contemporary Climate Change. *Annual Review of Anthropology*, 40, 174–194. <https://doi.org/10.1146/annurev.anthro.012809.104925>
- Crespo, J., Réquier-Desjardins, D., & Vicente, J. (2014). Why can collective action fail in Local Agri-food Systems? A social network analysis of cheese producers in Aculco, Mexico. *Food Policy*, 46, 165–177. <https://doi.org/10.1016/j.foodpol.2014.03.011>
- Cunsolo Willox, A., Harper, S. L., Ford, J. D., Edge, V. L., Landman, K., Houle, K., Blake, S., & Wolfrey, C. (2013). Climate change and mental health: an exploratory case study from Rigolet, Nunatsiavut, Canada. *Climatic Change*, 121(2), 255–270. <https://doi.org/10.1007/s10584-013-0875-4>
- Curry, N., & Kirwan, J. (2014). The Role of Tacit Knowledge in Developing Networks for Sustainable Agriculture. *Sociologia Ruralis*, 54(3), 341–361. <https://doi.org/10.1111/soru.12048>
- 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(4), 598–606. <https://doi.org/10.1016/j.gloenvcha.2008.07.013>
- Daigle, R. (2012). *Sea Level Rise and Flooding: What They Mean for New Brunswick's Coastal Communities*. <http://atlanticadaptation.ca/reports>
- Dale, P. J. (2002). The environmental impact of genetically modified (GM) crops: a review. *The Journal of Agricultural Science*, 138, 245–248. <https://doi.org/10.1017/S0021859602001971>
- Daloğlu, I., Nassauer, J. I., Riolo, R. L., & Scavia, D. (2014). Development of a farmer typology of agricultural conservation behavior in the american corn belt. *Agricultural Systems*, 129, 93–102. <https://doi.org/10.1016/j.agsy.2014.05.007>
- Darnhofer, I. (2014). Resilience and why it matters for farm management. *European Review of Agricultural Economics*, 41(3), 461–484. <https://doi.org/10.1093/erae/jbu012>

- Darnhofer, I., Bellon, S., Dedieu, B., & Milestad, R. (2010). Adaptiveness to enhance the sustainability of farming systems. A review. *Agronomy for Sustainable Development*, 30(3), 545–555. <https://doi.org/10.1051/agro/2009053>
- Darnhofer, I., Fairweather, J., & Moller, H. (2010). Assessing a farm's sustainability: Insights from resilience thinking. *International Journal of Agricultural Sustainability*, 8(3), 186–198. <https://doi.org/10.3763/ijas.2010.0480>
- Darnhofer, I., Lamine, C., Strauss, A., & Navarrete, M. (2016). The resilience of family farms: Towards a relational approach. *Journal of Rural Studies*, 44(April), 111–122. <https://doi.org/10.1016/j.jrurstud.2016.01.013>
- Davidson, D. J. (2010). The applicability of the concept of resilience to social systems: Some sources of optimism and nagging doubts. *Society and Natural Resources*, 23(12), 1135–1149. <https://doi.org/10.1080/08941921003652940>
- Delaney, A., Chesterman, S., Crane, T. A., Tamás, P., & Ericksen, P. (2014). *A systematic review of local vulnerability to climate change: in search of transparency, coherence and comparability* (No. 97). CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). <http://hdl.handle.net/10568/56692>
- DeMarrais, E., & Earle, T. (2017). Collective Action Theory and the Dynamics of Complex Societies. *Annual Review of Anthropology*, 46, 183–201.
- DeSchutter, O. (2012). *Report of the Special Rapporteur on the right to food* (Issue December). http://www.srfood.org/images/stories/pdf/officialreports/201205_canadaprelim_en.pdf
- Desmarais, A. A., & Wittman, H. (2014). Farmers, Foodies & First Nations: Getting to Food Sovereignty in Canada. *The Journal of Peasant Studies*, 41(6), 1153–1173. <https://doi.org/10.1080/03066150.2013.876623>
- Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Ram Adhikari, J., Arico, S., Bá ldi, A., Bartuska, A., Andreas Baste, I., Bilgin, A., Brondizio, E., Chan, K., Elsa Figueroa, V., Duraiappah, A., Fischer, M., Hill, R., ... Zlatanova, D. (2015). The IPBES Conceptual Framework — connecting nature and people. *Current Opinion in Environmental Sustainability*, 14, 1–16. <https://doi.org/10.1016/j.cosust.2014.11.002>
- Dinesh, D., & Vermeulen, S. (2016). *Climate change adaptation in agriculture: practices and technologies*. <https://cgspace.cgiar.org/handle/10568/71053>
- Dovers, S. R., & Hezri, A. A. (2010). Institutions and policy processes: The means to the ends of adaptation. *Wiley Interdisciplinary Reviews: Climate Change*, 1(2), 212–231. <https://doi.org/10.1002/wcc.29>
- Dubey, S. K., Trivedi, R. K., Chand, B. K., Mandal, B., & Rout, S. K. (2017). Farmers' perceptions of climate change, impacts on freshwater aquaculture and adaptation strategies in climatic change hotspots: A case of the Indian Sundarban delta. *Environmental Development*, 21, 38–51. <https://doi.org/10.1016/j.envdev.2016.12.002>
- Dunne, C. (2011). The place of the literature review in grounded theory research. *International Journal of Social Research Methodology*, 14(2), 111–124. <https://doi.org/10.1080/13645579.2010.494930>
- Earth Negotiations Bulletin. (2017). *Summary of the seventh session of the governing body of the International Treaty on Plant Genetic Resources for Food and Agriculture* (Vol. 9, Issue 691). https://s3.us-west-2.amazonaws.com/enb.iisd.org/archive/download/pdf/enb09691e.pdf?X-Amz-Content-Sha256=UNSIGNED-PAYLOAD&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIA6QW3YWTJ6YORWEEL%2F20210524%2Fus-west-2%2Fs3%2Faws4_request&X-Amz-Date=20210524T
- Earth Negotiations Bulletin. (2019). *Summary of the Seventeenth Session of the Commission on Genetic Resources for Food and Agriculture* (Vol. 9, Issue 730). <https://s3.us-west-2.amazonaws.com/enb.iisd.org/archive/download/pdf/enb09730e.pdf?X-Amz-Content->

- Sha256=UNSIGNED-PAYLOAD&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIA6QW3YWTJ6YORWEEL%2F20210524%2Fus-west-2%2Fs3%2Faws4_request&X-Amz-Date=20210524T
- Edelman, M., Weis, T., Baviskar, A., Borrás Jr, S. M., Holt-Giménez, E., Kandiyoti, D., & Wolford, W. (2014). Introduction: critical perspectives on food sovereignty. *Journal of Peasant Studies*, 41(6), 911–931. <https://doi.org/10.1080/03066150.2014.963568>
- Egeru, A. (2012). Role of Indigenous Knowledge in Climate Change Adaptation: A case study of the Teso Sub-Region, Eastern Uganda. *Indian Journal of Traditional Knowledge*, 11(2), 217–224. http://nopr.niscair.res.in/bitstream/123456789/13849/1/IJTK_11%282%29_217-224.pdf
- Eilola, S., Käyhkö, N., Fagerholm, N., & Kombo, Y. H. (2014). Linking Farmers' Knowledge, Farming Strategies, and Consequent Cultivation Patterns into the Identification of Healthy Agroecosystem Characteristics at Local Scales. *Agroecology and Sustainable Food Systems*, 38(9), 1047–1077. <https://doi.org/10.1080/21683565.2014.923800>
- Endfield, G. H. (2012). The resilience and adaptive capacity of social-environmental systems in colonial Mexico. *Proceedings of the National Academy of Sciences of the United States of America*, 109(10), 3676–3681. <https://doi.org/10.1073/pnas.1114831109>
- Engle, N. L. (2011). Adaptive capacity and its assessment. *Global Environmental Change*, 21(2), 647–656. <https://doi.org/10.1016/j.gloenvcha.2011.01.019>
- Ericksen, P. J., Ingram, J. S. I., & Liverman, D. M. (2009). Food security and global environmental change: emerging challenges. *Environmental Science & Policy*, 12(4), 373–377. <https://doi.org/10.1016/j.envsci.2009.04.007>
- Ericksen, P. J., Stewart, B., Eriksen, S., Tschakert, P., Sabates-Wheeler, R., Hansen, J., & Thornton, P. K. (2010). Adapting Food Systems. In John Ingram, P. J. Ericksen, & D. M. Liverman (Eds.), *Food Security and Global Environmental Change*. Earthscan.
- Eriksen, S., Schipper, E. L. F., Scoville-Simonds, M., Vincent, K., Adam, H. N., Brooks, N., Harding, B., Khatri, D., Lenaerts, L., Liverman, D., Mills-Novoa, M., Mosberg, M., Movik, S., Muok, B., Nightingale, A., Ojha, H., Sygna, L., Taylor, M., Vogel, C., & West, J. J. (2021). Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance? *World Development*, 141(January), 105383. <https://doi.org/10.1016/j.worlddev.2020.105383>
- Escobar, A. (2012a). Conclusion: Imagining a Postdevelopment Era. In *Encountering Development: the making and unmaking of the Third World*. Princeton University Press.
- Escobar, A. (2012b). *Encountering development : the making and unmaking of the Third World*. Princeton University Press. <https://press.princeton.edu/titles/9564.html>
- Escobar, A. (2012c). The Problematization of Poverty: The tale of three worlds and development. In *Encountering Development: the making and unmaking of the Third World*. Princeton University Press.
- Everybody Eats. (2018). *What We Heard* (Issue June). <https://foodforallnb.ca/media/docs/What-We-Heard-English-Final.pdf>
- Fairbairn, M. (2012). Framing transformation: The counter-hegemonic potential of food sovereignty in the US context. *Agriculture and Human Values*, 29(2), 217–230. <https://doi.org/10.1007/s10460-011-9334-x>
- Fairhead, J., & Scoones, I. (2005). Local knowledge and the social shaping of soil investments: Critical perspectives on the assessment of soil degradation in Africa. *Land Use Policy*, 22(1), 33–41. <https://doi.org/10.1016/j.landusepol.2003.08.004>
- Falardeau, M., Raudsepp-Hearne, C., & Bennett, E. M. (2019). A novel approach for co-producing positive scenarios that explore agency: case study from the Canadian Arctic. *Sustainability Science*, 14(1), 205–220. <https://doi.org/10.1007/s11625-018-0620-z>

- Fanzo, J., McLaren, R., Davis, C., & Choufani, J. (2017). *Climate change and variability: What are the Risks for Nutrition, Diets, and Food Systems?* May, 96.
<https://books.google.co.uk/books?id=liMmDwAAQBAJ&pg=PA96&dq=pasta+carbon+footprint+co2&hl=de&sa=X&ved=0ahUKEwjS4bSPt8TXAhXKAsAKHRvwDtwQ6AEIPDAD#v=onepage&q&f=false>
- FAO. (2013). *Climate-Smart Agriculture Sourcebook*. <http://www.fao.org/3/a-i3325e.pdf>
- FAO. (2015). *Climate change and food systems : global assessments and implications for food security and trade*. <http://www.fao.org/3/a-i4332e/index.html>
- FAO. (2016a). *The State of Food and Agriculture*. <http://www.fao.org/3/a-i6030e.pdf>
- FAO. (2016b). *The State of Food and Agriculture 2016 - Climate Change, Agriculture and Food Security*. In *FAO*. <https://doi.org/ISBN:978-92-5-107671-2> I
- FAO. (2017). *The future of food and agriculture - Trends and challenges*. <http://www.fao.org/3/a-i6583e.pdf>
- FAO. (2018). “Mixed Farming.” FAO Term Portal.
<http://www.fao.org/faoterm/viewentry/en/?entryId=396>
- FAO. (2020). *The State of Food and Agriculture 2020: Overcoming water challenges in agriculture*.
https://doi.org/10.1057/978-1-137-56671-3_22
- FAO, IFAD, UNICEF, WFP, & WHO. (2018). *The State of Food Security and Nutrition in the World: Building climate resilience for food security and nutrition*.
<http://www.fao.org/3/I9553EN/i9553en.pdf>
- FAO, IFAD, UNICEF, WFP, & WHO. (2020). Transforming food systems for affordable healthy diets. In *The State of Food Security and Nutrition in the World 2020*. <https://doi.org/10.4060/ca9692en>
- Farmers’ Markets of Nova Scotia. (2013). *Cultivating Community Economy: Nova Scotia Farmers’ Market Economic Impact Study 2013*. http://farmersmarketsnovascotia.ca/wp-content/uploads/2015/03/cultivatingcommunityeconomy_highlights.pdf
- Fazey, I., Evely, A. C., Reed, M. S., Stringer, L. C., Kruijsen, J., White, P. C. L., Newsham, A., Jin, L., Cortazzi, M., Phillipson, J., Blackstock, K., Entwistle, N., Sheate, W., Armstrong, F., Blackmore, C., Fazey, J., Ingram, J., Gregson, J., Lowe, P., ... Trevitt, C. (2013). Knowledge exchange: A review and research agenda for environmental management. *Environmental Conservation*, 40(1), 19–36. <https://doi.org/10.1017/S037689291200029X>
- Fetterman, D. M. (2008). Perception. In *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 289–292). <https://doi.org/10.5860/CHOICE.46-4214>
- Fischer, G., Shah, M., Tubiello, F. N., Van Velhuizen, H., N. Tubiello, F., & Van Velhuizen, H. (2005). Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(360), 2067–2083. <https://doi.org/10.1098/rstb.2005.1744>
- Fletcher, A. J., Akwen, N. S., Hurlbert, M., & Diaz, H. P. (2020). “You relied on God and your neighbour to get through it”: social capital and climate change adaptation in the rural Canadian Prairies. *Regional Environmental Change*, 20(2). <https://doi.org/10.1007/s10113-020-01645-2>
- Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, 16(3), 253–267. <https://doi.org/10.1016/j.gloenvcha.2006.04.002>
- Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. *Ambio*, 31(5), 437–440. <https://doi.org/10.1579/0044-7447-31.5.437>
- Ford, J. D. (2008). Supporting Adaptation: A Priority for Action on Climate Change for Canadian Inuit. *Sustainable Development Law & Policy*, 8(3), 25–29.
<http://digitalcommons.wcl.american.edu/sdlp>
- Ford, J. D., Stephenson, E., Cunsolo Willox, A., Edge, V., Farahbakhsh, K., Furgal, C., Harper, S.,

- Chatwood, S., Mauro, I., Pearce, T., Austin, S., Bunce, A., Bussalleu, A., Diaz, J., Finner, K., Gordon, A., Huet, C., Kitching, K., Lardeau, M. P., ... Sherman, M. (2016). Community-based adaptation research in the Canadian Arctic. *Wiley Interdisciplinary Reviews: Climate Change*, 7(2), 175–191. <https://doi.org/10.1002/wcc.376>
- Foucault, M., & Gordon, C. (1980). *Power/knowledge : selected interviews and other writings, 1972-1977*. Pantheon Books.
- Fox, M., & Daigle, M. (2012). *Planning for Sustainability in New Brunswick*. <https://atlanticadaptation.ca/en/islandora/object/acasa%253A656>
- Friedmann, H. (1995). Food politics: new dangers, new possibilities. In P. D. McMichael (Ed.), *Food and Agrarian Orders in the World-Economy*. Greenwood Press. <https://www.bookdepository.com/Food-Agrarian-Orders-World-Economy-Philip-D-McMichael/9780313293993>
- Future Agricultures Consortium. (2011). *Farmers' Knowledge and Climate Change Adaptation: Insights from Policy Processes in Kenya and Namibia*. <http://www.future-agricultures.org/search-documents/research-and-analysis/policy-briefs/1454-farmers-knowledge-and-climate-change-adaptation-insights-from-policy-processes-in-kenya-namibia/file>
- Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16(3), 293–303. <https://doi.org/10.1016/j.gloenvcha.2006.02.004>
- Gamble, D. W., Campbell, D., Allen, T. L., Barker, D., Curtis, S., McGregor, D., Popke, J., Douglas, R., -Gamble, W., Campbell^, D., & Barker^, D. (2010). Climate Change, Drought, and Jamaican Agriculture: Local Knowledge and the Climate. *Annals of the Association of American Geographers Climate Change*, 100(4), 880–893. <http://www.jstor.org/stable/40863608>
- Giller, K. E., Hijbeek, R., Andersson, J. A., & Sumberg, J. (2021). Regenerative Agriculture: An agronomic perspective. *Outlook on Agriculture*, 50(1), 13–25. <https://doi.org/10.1177/0030727021998063>
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory : strategies for qualitative research*. Aldine Pub. Co. https://books.google.co.uk/books/about/The_Discovery_of_Grounded_Theory.html?id=oUxEAQAAIAAJ&redir_esc=y
- Glover, D. (2010). The corporate shaping of GM crops as a technology for the poor. *Journal of Peasant Studies*, 37(1), 67–90. <https://doi.org/10.1080/03066150903498754>
- Glover, J. (2012). Rural resilience through continued learning and innovation. *Local Economy*, 27(4), 355–372. <https://doi.org/10.1177/0269094212437833>
- Gluckman, P. (2016). The science-policy interface. *Science*, 353(6303), 969. <https://doi.org/10.1126/science.aai8837>
- Goldstein, B., & Newell, J. P. (2020). How to track corporations across space and time. *Ecological Economics*, 169(September 2018), 106492. <https://doi.org/10.1016/j.ecolecon.2019.106492>
- 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(4). <https://doi.org/10.5751/ES-06288-180472>
- Gosnell, H., Gill, N., & Voyer, M. (2019). Transformational adaptation on the farm: Processes of change and persistence in transitions to ‘climate-smart’ regenerative agriculture. *Global Environmental Change*, 59(August 2018), 101965. <https://doi.org/10.1016/j.gloenvcha.2019.101965>
- Goulet, F. (2013). Narratives of experience and production of knowledge within farmers' groups. *Journal of Rural Studies*, 32, 439–447. <https://doi.org/10.1016/j.jrurstud.2013.09.006>
- Government of Canada. (2015). *Minister of Agriculture and Agri-Food Mandate Letter | Prime Minister of Canada*. Government of Canada. <http://pm.gc.ca/eng/minister-agriculture-and-agri->

food-mandate-letter

- Government of Canada. (2018). Pan-Canadian Framework on Clean Growth and Climate Change. In *Government of Canada Canada* (Issue December).
<https://doi.org/https://www.canada.ca/content/dam/themes/environment/documents/weather1/20170113-1-en.pdf>
- Government of Canada. (2019a). *AgriStability and AgriInvest programs for farmers - Canada.ca*.
<https://www.canada.ca/en/revenue-agency/services/tax/businesses/farmers-fishers/agristability-agriinvest-programs-farmers.html>
- Government of Canada. (2019b). *Canada's new superclusters - Innovation Superclusters Initiative*. Innovation, Science and Economic Development Canada.
<https://www.ic.gc.ca/eic/site/093.nsf/eng/00008.html>
- Government of Canada. (2019c). *Food Policy for Canada*. <https://www.canada.ca/en/agriculture-agri-food/news/2019/06/food-policy-for-canada--backgrounder.html>
- Government of Canada. (2019d). *Government Response to the Report of the Standing Committee on Agriculture and Agri-Food*. Government of Canada.
- Government of New Brunswick. (2016). *Transitioning to a Low-Carbon Economy*.
<https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf>
- An Act to Achieve Environmental Goals and Sustainable Prosperity*, (2019) (testimony of Government of Nova Scotia). https://nslegislature.ca/sites/default/files/legc/PDFs/annual_statutes/2019_Fall/c026.pdf
- Gramig, B. M., Barnard, J. M., & Prokopy, L. S. (2013). Farmer beliefs about climate change and carbon sequestration incentives. *Climate Research*, 56(2), 157–167.
<https://doi.org/10.3354/cr01142>
- Grosfoguel, R. (2013). The Structure of Knowledge in Westernized Universities: Epistemic Racism/Sexism and the Four Genocides/Epistemicides of the Long 16th Century. *Human Architecture: Journal of the Sociology of Self-Knowledge*, 11(1), 73–90. <https://doi.org/Doi10.1002/Mma.1475>
- Guillem, E. E., Barnes, A. P., Rounsevell, M. D. A., & Renwick, A. (2012). Refining perception-based farmer typologies with the analysis of past census data. *Journal of Environmental Management*, 110, 226–235. <https://doi.org/10.1016/j.jenvman.2012.06.020>
- Haden, V. R., Niles, M. T., Lubell, M., Perlman, J., Jackson, L. E., & Clifton, J. (2012). Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change? *PLoS ONE*, 7(12). <https://doi.org/10.1371/journal.pone.0052882>
- Hall, J. R. (2016). Social futures of global climate change: A structural phenomenology. *American Journal of Cultural Sociology*, 4(1), 1–45. <https://doi.org/10.1057/ajcs.2015.12>
- Hallegatte, S., Bangalore, M., & Bonzanigo, L. (2016). Shock Waves: Managing the Impacts of Climate Change on Poverty. In *World Bank Group* (Vol. 106).
<https://doi.org/10.1017/S0022112081001535>
- Hallegatte, S., Shah, A., Brown, C., Lempert, R., & Gill, S. (2012). Investment Decision Making Under Deep Uncertainty: Application to Climate Change. *Policy Research Working Paper*, 6193, 41.
<https://doi.org/doi:10.1596/1813-9450-6193>
- Hatfield, J., & Takle, G. (2014). National Climate Assessment 2014: Chapter 6, Agriculture. In *Climate Change Impacts in the United States: The Third National Climate Assessment*.
<https://doi.org/10.7930/J02Z13FR.On>
- Hendrix, C. S. (2017). The streetlight effect in climate change research on Africa. *Global Environmental Change*, 43, 137–147. <https://doi.org/10.1016/j.gloenvcha.2017.01.009>
- Hertel, T. W., Brown, M. E., & Funk, C. C. (2015). Food security under climate change. *Nature*

- Climate Change*, 6(1), 10–13. <https://doi.org/10.1038/nclimate2834>
- Himanen, S. J., Rikkonen, P., & Kahiluoto, H. (2016). Codesigning a resilient food system. *Ecology and Society*, 21(4). <https://doi.org/10.5751/ES-08878-210441>
- HLPE. (2017). High Level Panel of Experts. 2017. Nutrition and food systems. In *High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security* (Issue September). <http://www.fao.org/3/a-i7846e.pdf>
- HLPE. (2020a). Food Security and Nutrition: Building a Global Narrative towards 2030. In *High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. <http://www.fao.org/3/ca9731en/ca9731en.pdf>
- HLPE. (2020b). Impacts of COVID-19 on food security and nutrition: developing effective policy responses to address the hunger and malnutrition pandemic. *HLPE Issues Paper, September*, 1–24. <https://doi.org/10.4060/cb1000en>
- Holling, C. S. (1973). Resilience and stability of ecological systems. *Annu.Rev.Ecol.Syst.*, 4, 1–23.
- Holt Giménez, E., Shattuck, A., Giménez, E. H., & Shattuck, A. (2011). Food crises, food regimes and food movements: rumblings of reform or tides of transformation? *The Journal of Peasant Studies*, 38(1), 109–144. <https://doi.org/10.1080/03066150.2010.538578>
- Holtslander, C. (2015). *Losing Our Grip: 2015 Update*. 36.
- Hönle, S. E., Heidecke, C., & Osterburg, B. (2019). Climate change mitigation strategies for agriculture: an analysis of nationally determined contributions, biennial reports and biennial update reports. *Climate Policy*, 19(6), 688–702. <https://doi.org/10.1080/14693062.2018.1559793>
- Hornborg, A. (2013). Revelations of resilience: From the ideological disarmament of disaster to the revolutionary implications of (p)anarchy. *Resilience*, 1(2), 116–129. <https://doi.org/10.1080/21693293.2013.797661>
- Hospes, O., & Brons, A. (2016). Food system governance: a systematic literature review. *Food Systems Governance: Challenges for Justice, Equality and Human Rights, May 2016*, 13–42.
- House of Commons of Canada. (2018). *Toward a resilient Canadian agriculture and agri-food system: adapting to climate change*. <https://www.ourcommons.ca/Content/Committee/421/AGRI/Reports/RP9814809/agrirp11/agrirp11-e.pdf>
- Houser, M., Stuart, D., & Carolan, M. (2017). Is seeing believing? Applying a realist framework to examine agriculture and climate change. *Environmental Sociology*, 3(4), 321–336. <https://doi.org/10.1080/23251042.2017.1335380>
- Howard, P. (2013). “Everywhere you go always take the weather with you”: Phenomenology and the pedagogy of climate change education. *Phenomenology & Practice*, 7(2), 3–18. <https://doi.org/10.29173/pandpr21165>
- Hulme, T. (2013). *Desire Paths & Great Design (at G8)*. Blog. <http://thulme.com/media/Williams-College-Desire-Path.png>
- IISD Reporting Services. (2019). Summary of the Bonn Climate Change Conference: 17-27 June 2019. *Earth Negotiations Bulletin*, 12(759), 1–46. <http://www.iisd.ca/download/pdf/enb12619e.pdf>
- Ingram, John. (2011). A food systems approach to researching food security and its interactions with global environmental change. *Food Security*, 3(4), 417–431. <https://doi.org/10.1007/s12571-011-0149-9>
- Ingram, John, Andersson, J., Bammer, G., Brown, M., Giller, K., Henrichs, T., Holmes, J., Jones, J. W., Schilpzand, R., & Young, J. (2010). Engaging Stakeholders at a Regional Level. In John Ingram, P. J. Ericksen, & Liverm (Eds.), *Food Security and Global Environmental Change*. Earthscan.
- Ingram, John, Dyball, R., Howden, M., Vermeulen, S., Garnett, T., Redlingshöfer, B., Guilbert, S., & Porter, J. R. (2016). Food Security, Food Systems, and Environmental Change. *The Solutions*

Journal, Ma, 63–73.

- Ingram, John, Ericksen, P. J., Liverman, D. M., & Ericksen, P. J. (2010). *Food security and global environmental change*. Earthscan. <https://doi.org/10.1016/j.envsci.2009.04.007>
- Ingram, John, Ericksen, P., & Liverman, D. (2012). Food security and global environmental change. In John Ingram, D. M. Liverman, & P. J. Ericksen (Eds.), *Food Security and Global Environmental Change* (pp. 1–364). Earthscan. <https://doi.org/10.4324/9781849776615>
- Ingram, Julie. (2008). Are farmers in England equipped to meet the knowledge challenge of sustainable soil management? An analysis of farmer and advisor views. *Journal of Environmental Management*, 86, 214–228. <https://doi.org/10.1016/j.jenvman.2006.12.036>
- Ingram, Julie, Fry, P., & Mathieu, A. (2010). Revealing different understandings of soil held by scientists and farmers in the context of soil protection and management. *Land Use Policy*, 27, 51–60. <https://doi.org/10.1016/j.landusepol.2008.07.005>
- IPCC. (2001). *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf
- IPCC. (2014a). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (V. . Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. 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.)). Cambridge University Press.
- IPCC. (2014b). *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* (R. K. Pachauri & L. A. Meyer (Eds.)).
- IPCC. (2014c). *Climate Change 2014: Synthesis Report Summary Chapter for Policymakers*.
- IPCC. (2014d). Summary for Policymakers. In V. Masson-Delmotte, 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, & T. Waterfield (Eds.), *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*, (pp. 1–33). World Meteorological Organization. <https://doi.org/10.1017/CBO9781107415324>
- IPCC. (2014e). Technical summary. In C. Field, V. Barros, K. Mach, & M. van Aalst (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. <https://doi.org/10.1016/j.renene.2009.11.012>
- IPCC. (2018a). Annex I: Glossary. In V. Masson-Delmotte, 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, & T. Waterfield (Eds.), *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*,. World Meteorological Organization.
- IPCC. (2018b). *Global Warming of 1.5°C. Summary for Policymakers* (Issue October 2018). http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf
- IPCC. (2019a). *Climate Change and Land - Summary for Policymakers*.
- IPCC. (2019b). *IPCC Special Report on Climate Change and Land: Chapter 4: Land Degradation*. 1–112. <https://www.ipcc.ch/report/srccl/>

- IPCC. (2019c). Summary for Policymakers. 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* (pp. 1–15). <https://doi.org/10.1002/9781118786352.wbieg0538>
- iPES Food. (2016). *From Uniformity to Diversity: A paradigm shift from industrial agriculture to diversified agroecological systems*. http://www.ipes-food.org/images/Reports/UniformityToDiversity_FullReport.pdf
- Isaac, M. E., Isakson, S. R., Dale, B., Levkoe, C. Z., Hargreaves, S. K., Méndez, V. E., Wittman, H., Hammelman, C., Langill, J. C., Martin, A. R., Nelson, E., Ekers, M., Borden, K. A., Gagliardi, S., Buchanan, S., Archibald, S., & Ciani, A. G. (2018). Agroecology in Canada: Towards an integration of agroecological practice, movement, and science. *Sustainability*, 10(9), 1–17. <https://doi.org/10.3390/su10093299>
- Isakson, S. R. (2014). Food and finance: the financial transformation of agro-food supply chains. *Journal of Peasant Studies*, 41(5), 749–775. <https://doi.org/10.1080/03066150.2013.874340>
- Jackson, T. (2010). Prosperity without Growth? – The transition to a sustainable economy. *Journal of Cleaner Production*, 18(6), 596–597. <https://doi.org/10.1016/j.jclepro.2009.07.001>
- Jacques, P. J., & Jacques, J. R. (2012). Monocropping Cultures into ruin: The loss of food varieties and cultural diversity. *Sustainability*, 4(11), 2970–2997. <https://doi.org/10.3390/su4112970>
- Jagers, S. C., Haring, N., Löfgren, Å., Sjöstedt, M., Alpizar, F., Brülde, B., Langlet, D., Nilsson, A., Almroth, B. C., Dupont, S., & Steffen, W. (2019). On the preconditions for large-scale collective action. *Ambio*. <https://doi.org/10.1007/s13280-019-01284-w>
- Jansen, K. (2015). The debate on food sovereignty theory: agrarian capitalism, dispossession and agroecology. *Journal of Peasant Studies*, 42(1), 213–232. <https://doi.org/10.1080/03066150.2014.945166>
- Jarosz, L. (2012). Growing inequality: agricultural revolutions and the political ecology of rural development. *International Journal of Agricultural Sustainability*, 10(2), 192–199. <https://doi.org/10.1080/14735903.2011.600605>
- Jellett, M. (2013). Food, floods, and farms: Agricultural Vulnerability to Sea-Level Rise in new Brunswick's Tantramar Dykelands [Mount Allison University]. In *Mount Allison University Department of Environmental Science: Vol. May*. <https://doi.org/10.1017/CBO9781107415324.004>
- Jerneck, A., Olsson, L., Ness, B., Anderberg, S., Baier, M., Clark, E., Hickler, T., Hornborg, A., Kronsell, A., Lövbrand, E., & Persson, J. (2011). Structuring sustainability science. *Sustainability Science*, 6(1), 69–82. <https://doi.org/10.1007/s11625-010-0117-x>
- Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M.-L., Nelson, S., & Kristjanson, P. (2017). *Climate and Development Understanding gender dimensions of agriculture and climate change in smallholder farming communities Understanding gender dimensions of agriculture and climate change in smallholder farming communities*. <https://doi.org/10.1080/17565529.2015.1050978>
- Kabir, M. J., Cramb, R., Alauddin, M., Roth, C., & Crimp, S. (2017). Farmers' perceptions of and responses to environmental change in southwest coastal Bangladesh. *Asia Pacific Viewpoint*. <https://doi.org/10.1111/apv.12165>
- Kelloway, C., & Miller, S. (2019). *Food and Power: Addressing Monopolization in America's Food System*. March, 21. <https://openmarketsinstitute.org/reports/food-power-addressing-monopolization-americas-food-system/>
- Kenny, G. (2011). Adaptation in agriculture: lessons for resilience from eastern regions of New Zealand. *Climatic Change*, 106, 441–462. <https://doi.org/10.1007/s10584-010-9948-9>
- Kent, C., & Sherren, K. (2017). *The View from the Farm Sector: Discourse in Producer Organizations*

- around *Climate, Science and Agricultural Policy, 2010-2015* (Issue 3).
<https://doi.org/10.13140/RG.2.2.33011.94249>
- Kloppenburg, J. (1991). Social Theory and the De/Reconstruction of Agricultural Science: Local Knowledge for an Alternative Agriculture. *Rural Sociology*, 56(4), 519–548.
- Kloppenburg, J. (2010). Impeding dispossession, enabling repossession: Biological open source and the recovery of seed sovereignty. *Journal of Agrarian Change*, 10(3), 367–388.
<https://doi.org/10.1111/j.1471-0366.2010.00275.x>
- Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy*, 32, 25–48.
<https://doi.org/10.1016/j.foodpol.2006.01.003>
- Kroma, M. M. (2006). Organic Farmer Networks : Facilitating Learning and Innovation for Sustainable Agriculture. *Journal of Sustainable Agriculture*, 28(4), 37–41. <https://doi.org/10.1300/J064v28n04>
- La Via Campesina. (n.d.). *Peasant Agroecology: For food sovereignty and mother earth*.
- Laforge, J. M. L., Anderson, C. R., & McLachlan, S. M. (2017). Governments, grassroots, and the struggle for local food systems: containing, coopting, contesting and collaborating. *Agriculture and Human Values*, 34(3), 663–681. <https://doi.org/10.1007/s10460-016-9765-5>
- Lamarque, P., Meyfroidt, P., Nettiér, B., & Lavorel, S. (2014). How ecosystem services knowledge and values influence farmers' decision-making. *PLoS ONE*, 9(9).
<https://doi.org/10.1371/journal.pone.0107572>
- Leclère, D., Jayet, P. A., & de Noblet-Ducoudré, N. (2013). Farm-level Autonomous Adaptation of European Agricultural Supply to Climate Change. *Ecological Economics*, 87, 1–14.
<https://doi.org/10.1016/j.ecolecon.2012.11.010>
- Lehébel-Péron, A., Sidawy, P., Dounias, E., & Schatz, B. (2016). Attuning local and scientific knowledge in the context of global change: The case of heather honey production in southern France. *Journal of Rural Studies*, 44, 132–142. <https://doi.org/10.1016/J.JRURSTUD.2016.01.005>
- Lemmen, D. S., Warren, F. J., Lacroix, J., & Bush, E. (2008). From impacts to adaptation: Canada in a changing climate 2007. Government of Canada. *From Impacts to Adaptation: Canada in a Changing Climate*. Ottawa, ON., 448. <https://doi.org/10.1029/2005GL024234>.
- Lieske, D. J., Roness, L. A., Phillips, E. A., & Fox, M. J. (2015). Climate Change Adaptation Challenges Facing New Brunswick Coastal Communities: A Review of the Problems and a Synthesis of Solutions Suggested by Regional Adaptation Research. *Revue D'Études Sur Le Nouveau Brunswick*, 6(October 2012), 32–54.
- Lindenmayer, D. B., & Fischer, J. (2007). Tackling the habitat fragmentation panchreston. *Trends in Ecology and Evolution*, 22(3), 127–132. <https://doi.org/10.1016/j.tree.2006.11.006>
- Liverman, D. M., & Kapadia, K. (2010). Food Systems and the Global Environment: An Overview. In *Food Security and Global Environmental Change* (pp. 3–25). Earthscan.
- Loboguerrero, A. M., Boshell, F., León, G., Martinez-Baron, D., Giraldo, D., Recaman Mejía, L., Díaz, E., & Cock, J. (2018). Bridging the gap between climate science and farmers in Colombia. *Climate Risk Management*, 22(July), 67–81. <https://doi.org/10.1016/j.crm.2018.08.001>
- Macaulay, S. (2001). The community economic development tradition in Eastern Nova Scotia , Canada : ideological continuities and discontinuities between the Antigonish Movement and the Family of community corporation. *Community Development*, 36(2), 111–121.
- Macinnes, D. W. (1978). *Clerics, Fishermen, Farmers and Workers: The Antigonish movement and identity in Eastern Nova Scotia, 1928-1939*. McMaster University.
- Macleod, M., & Scott, J. M. (2010). Is Nova Scotia Eating Local ? In *Ecology Action Centre* (Issue July). https://www.ecologyaction.ca/files/images-documents/file/Food/FM_Final_2010.pdf
- MacMillan, T., & Benton, T. (2014). Engage farmers in research. *Nature*, 509, 25–27.
- MacRae, R., Cuddeford, V., Young, S. B., & Matsubuchi-Shaw, M. (2013). The Food System and

- Climate Change: An Exploration of Emerging Strategies to Reduce GHG Emissions in Canada. *Agroecology and Sustainable Food Systems*, 37(8), 933–963.
<https://doi.org/10.1080/21683565.2013.774302>
- Madan, G. R. (2017). Seed, Skill, and Soil: Organizing for Food Justice, with Leticia Boahen, Rachelle Sauve, Vanessa Ling Yu, and Gabriel Allahdua. *Upping the Anti*, 19.
- Mahler, A. G. (2018). *Global South*. Oxford Bibliography of Literary and Critical Theory.
<http://www.oxfordbibliographies.com/view/document/obo-9780190221911/obo-9780190221911-0055.xml?rskey=eMzKAW&result=16#firstMatch>
- Manandhar, S., Vogt, D. S., Perret, S. R., & Kazama, F. (2011). Adapting cropping systems to climate change in Nepal: A cross-regional study of farmers' perception and practices. *Regional Environmental Change*, 11(2), 335–348. <https://doi.org/10.1007/s10113-010-0137-1>
- Manuel, P., Rapaport, E., Keefe, J., & Krawchenko, T. (2015). Coastal climate change and aging communities in Atlantic Canada: A methodological overview of community asset and social vulnerability mapping. *The Canadian Geographer / Le Géographe Canadien*, 59(4), 433–446.
<https://doi.org/10.1111/cag.12203>
- Mapfumo, P., Adjei-Nsiah, S., Mtambanengwe, F., Chikowo, R., & Giller, K. E. (2013). Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa. *Environmental Development*, 5(1), 6–22.
<https://doi.org/10.1016/j.envdev.2012.11.001>
- Marino, E. K. (2014). Losing ground: An ethnography of vulnerability and climate change in Shishmaref, Alaska. *Dissertation Abstracts International Section A: Humanities and Social Sciences*. https://www.uaf.edu/anthro/gradresearch-files/Marino_Elizabeth.pdf
- Marino, E., & Schweitzer, P. (2009). Talking and Not Talking about Climate Change in Northwestern Alaska. In S. A. Crate & M. Nuttall (Eds.), *Anthropology and climate change : from encounters to actions* (pp. 209–218). Left Coast Press.
- Martin, G. (2015). A conceptual framework to support adaptation of farming systems - Development and application with Forage Rummy. *Agricultural Systems*, 132(January 2014), 52–61.
<https://doi.org/10.1016/j.agsy.2014.08.013>
- Martinez-Baron, D., Orjuela, G., Renzoni, G., Loboguerrero Rodríguez, A. M., & Prager, S. D. (2018). Small-scale farmers in a 1.5°C future: The importance of local social dynamics as an enabling factor for implementation and scaling of climate-smart agriculture. *Current Opinion in Environmental Sustainability*, 31(March), 112–119. <https://doi.org/10.1016/j.cosust.2018.02.013>
- Mason, R. E., White, A., Bucini, G., Anderzén, J., Méndez, V. E., & Merrill, S. C. (2021). The evolving landscape of agroecological research. *Agroecology and Sustainable Food Systems*, 45(4), 551–591. <https://doi.org/10.1080/21683565.2020.1845275>
- Matyas, D., & Pelling, M. (2014). Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. *Disasters*, 39(1), 1–19.
<https://onlinelibrary.wiley.com/doi/abs/10.1111/disa.12107>
- Matyas, D., & Pelling, M. (2015). Positioning resilience for 2015: The role of resistance, incremental adjustment and transformation in disaster risk management policy. *Disasters*, 39(s1), s1–s18.
<https://doi.org/10.1111/disa.12107>
- Mauro, I. J., & McLachlan, S. M. (2008). Farmer knowledge and risk analysis: postrelease evaluation of herbicide-tolerant Canola in western Canada. *Risk Analysis*, 28(2), 463–476.
<https://doi.org/10.1111/j.1539-6924.2008.01027.x>
- Mauro, I. J., McLachlan, S. M., & Acker, R. C. Van. (2009). Farmer knowledge and a priori risk analysis: pre-release evaluation of genetically modified Roundup Ready wheat across the Canadian prairies. *Environ Sci Pollut Res*, 16, 689–701. <https://doi.org/10.1007/s11356-009-0177-6>

- McGreavy, B. (2016). Resilience as Discourse. *Environmental Communication*, 10(1), 104–121. <https://doi.org/10.1080/17524032.2015.1014390>
- McGuire, J. M., Morton, L. W., Arbuckle, J. G., & Cast, A. D. (2015). Farmer identities and responses to the social-biophysical environment. *Journal of Rural Studies*, 39(May), 145–155. <https://doi.org/10.1016/j.jrurstud.2015.03.011>
- McInnes, D. (1998). Testifying Before Parliamentary Committees. *Canadian Parliamentary Review*, 21(3), 15.
- McKitterick, L., Quinn, B., McAdam, R., & Dunn, A. (2016). Innovation networks and the institutional actor-producer relationship in rural areas: The context of artisan food production. *Journal of Rural Studies*, 48, 41–52. <https://doi.org/10.1016/j.jrurstud.2016.09.005>
- McLaughlin, D. (1987). From Self-Reliance to Dependence to Struggle: Agribusiness and the Politics of Potatoes in New Brunswick. In G. Burrill & I. McKay (Eds.), *People, Resources, and Power: Critical perspectives on underdevelopment and primary industries in the Atlantic region* (p. 202). Acadiensis Press.
- McManus, P., Walmsley, J., Argent, N., Baum, S., Bourke, L., Martin, J., Pritchard, B., & Sorensen, T. (2012). Rural community and rural resilience: What is important to farmers in keeping their country towns alive? *Journal of Rural Studies*, 28(1), 20–29. <https://doi.org/10.1016/j.jrurstud.2011.09.003>
- Meadows, D., & Sustainability Institute. (1999). Leverage Points: Places to Intervene in a System. *World*, 1–12. <https://doi.org/10.1080/02604020600912897>
- Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience : A review. *Landscape and Urban Planning*, 147, 38–49. <https://doi.org/10.1016/j.landurbplan.2015.11.011>
- Meinzen-Dick, R., Markelova, H., & Moore, K. (2010). *The role of collective action and property rights in climate change strategies* (No. 7; CGIAR Systemwide Program on Collective Action and Property Rights, Issue May). https://capri.cgiar.org/files/pdf/Resources_Rights_Cooperation_E-05.pdf
- Mersha, A. A., & van Laerhoven, F. (2018). The interplay between planned and autonomous adaptation in response to climate change: Insights from rural Ethiopia. *World Development*, 107, 87–97. <https://doi.org/10.1016/j.worlddev.2018.03.001>
- Mertins-Kirkwood, H. (2019). *Heating Up, Backing Down: Evaluating recent climate policy progress in Canada*. <https://www.policyalternatives.ca/publications/reports/heating-backing-down>
- Microsoft. (2018). *Microsoft Excel*.
- Miller, M., Anderson, M., Francis, C. A., Kruger, C., Barford, C., Park, J., & McCown, B. H. (2013). Critical research needs for successful food systems adaptation to climate change. *Journal of Agriculture, Food Systems, and Community Development*, 3(34), 161–175. <https://doi.org/10.5304/jafscd.2013.034.016>
- Mills, J., Bonner, A., & Francis, K. (2006). The Development of Constructivist Grounded Theory. *International Journal of Qualitative Methods*, 5(51). http://www.ualberta.ca/~iiqm/backissues/5_1/pdf/mills.pdf
- Millward, H. (1999). The location of farmland in the Maritime Provinces: historical, regional, and local perspectives. *Salzburger Geographische Arbeiten*, 34(January 1999), 175–188.
- Minister of Agriculture and Agri-Food. (2019). *Government Response to Senate Standing Committee*. Government of Canada. <https://www.ourcommons.ca/DocumentViewer/en/42-1/AGRI/report-11/response-8512-421-405>
- Mooney, P., Jacobs, N., Villa, V., Thomas, J., Bacon, M., Vandelac, L., Schiavoni, C., Chappell, J., Clapp, J., Declerck, F., Dillon, M., Escalante, M. A., Felicien, A., Frison, E., Goïta, M., Guttal, S., & Herren, H. (2021). *A Long Food Movement: Transforming Food Systems by 2045*. 176.
- Morton, L. W., Roesch-McNally, G., & Wilke, A. K. (2017). Upper midwest farmer perceptions: Too

- much uncertainty about impacts of climate change to justify changing current agricultural practices. *Journal of Soil and Water Conservation*, 72(3), 215–225.
<https://doi.org/10.2489/jswc.72.3.215>
- Morton, Lois Wright, McGuire, J. M., & Cast, A. D. (2017). A good farmer pays attention to the weather. *Climate Risk Management*, 15, 18–31. <https://doi.org/10.1016/j.crm.2016.09.002>
- Moser, S., Meerow, S., Arnott, J., & Jack-scott, E. (2019). The turbulent world of resilience : interpretations and themes for transdisciplinary dialogue. *Climatic Change*, 153, 21–40.
- Mulenga, B. P., Wineman, A., & Sitko, N. J. (2017). Climate Trends and Farmers' Perceptions of Climate Change in Zambia. *Environmental Management*, 59, 291–306.
<https://doi.org/10.1007/s00267-016-0780-5>
- Müller, B. (2008). Still feeding the world? The political ecology of Canadian prairie farmers. *Anthropologica*, 50(2), 389–407. <https://doi.org/10.2307/25605429>
- Murphy, T. (1987). Potato Capitalism: McCain and Industrial Farming in New Brunswick. In G. Burrill & I. McKay (Eds.), *People, Resources, and Power: Critical perspectives on underdevelopment and primary industries in the Atlantic region* (pp. 19–29). Acadiensis Press.
- Mylona, K., Maragkoudakis, P., Bock, A.-K., Woolgast, J., Caldeira, S., & Ulberth, F. (2016). Delivering on EU food safety and nutrition in 2050 - Future challenges and policy preparedness. In *Joint Research Centre* (Issue EUR27957). <https://doi.org/doi:10.2787/625130>
- Nadasdy, P. (2007). Adaptive co-management and the gospel of resilience. In D. R. Armitage, F. Berkes, & N. C. Doubleday (Eds.), *Adaptive co-management: collaboration, learning, and multilevel governance* (pp. 208–227). UBC Press.
- Nainggolan, D., Termansen, M., Reed, M. S., Cebollero, E. D., & Hubacek, K. (2013). Farmer typology, future scenarios and the implications for ecosystem service provision: A case study from south-eastern Spain. *Regional Environmental Change*, 13(3), 601–614.
<https://doi.org/10.1007/s10113-011-0261-6>
- Nakashima, D. J., Galloway McLean, K., Thulstrup, H. D., Ramos Castillo, A., & Rubis, J. T. (2012). Weathering Uncertainty. In *UNESCO*. UNESCO and UNU.
- Nally, D. (2015). Governing precarious lives: Land grabs, geopolitics, and “food security.” *Geographical Journal*, 181(4), 340–349. <https://doi.org/10.1111/geoj.12063>
- National Farmers Union. (2014). *Submission of the National Farmers Union to the house of Commons Standing Committee on Agriculture and Agri-food regarding Bill C-18, the Agricultural Growth Act*. 306, 1–9.
- Natural Resources Canada. (2016). *Climate Risks and Adaptation Practices for the Canadian Transport Sector 2016*. <https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-risks-adaptation-practices-canadian-transportation-sector-2016/19623>
- NB Govt. (2013). *New Brunswick Climate Change Action Plan 2014-2020*.
[http://www.atlanticaenergy.org/uploads/file/publications/NB Climate Change Action Plan.pdf](http://www.atlanticaenergy.org/uploads/file/publications/NB%20Climate%20Change%20Action%20Plan.pdf)
- 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(December), 395–419. <https://doi.org/10.1146/annurev.energy.32.051807.090348>
- Neufeldt, H., Jahn, M., Campbell, B. M., Beddington, J. R., DeClerck, F., De Pinto, A., Gullledge, J., Hellin, J., Herrero, M., Jarvis, A., LeZaks, D., Meinke, H., Rosenstock, T., Scholes, M., Scholes, R., Vermeulen, S., Wollenberg, E., & Zougmore, R. (2013). Beyond climate-smart agriculture: toward safe operating spaces for global food systems. *Agriculture & Food Security*, 2(1), 12.
<https://doi.org/10.1186/2048-7010-2-12>
- Newell, P., & Taylor, O. (2018). Contested landscapes: the global political economy of climate-smart agriculture. *Journal of Peasant Studies*, 45(1), 108–129.
<https://doi.org/10.1080/03066150.2017.1324426>

- Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K., & Johns, C. (2020). What Is Regenerative Agriculture? A Review of Scholar and Practitioner Definitions Based on Processes and Outcomes. *Frontiers in Sustainable Food Systems*, 4(October), 1–11. <https://doi.org/10.3389/fsufs.2020.577723>
- Nichols, L. (2014). Social desire paths: a new theoretical concept to increase the usability of social science research in society. *Theory and Society*, 43(6), 647–665. <https://doi.org/10.1007/s11186-014-9234-3>
- Niles, M. T., Brown, M., & Dynes, R. (2016). Farmer's intended and actual adoption of climate change mitigation and adaptation strategies. *Climatic Change*, 135(2), 277–295. <https://doi.org/10.1007/s10584-015-1558-0>
- Niles, M. T., & Brown, M. E. (2017). A multi-country assessment of factors related to smallholder food security in varying rainfall conditions. *Scientific Reports*, 7(1), 1–11. <https://doi.org/10.1038/s41598-017-16282-9>
- Niles, M. T., Lubell, M., & Brown, M. (2015). How limiting factors drive agricultural adaptation to climate change. *Agriculture, Ecosystems and Environment*, 200(February), 178–185. <https://doi.org/10.1016/j.agee.2014.11.010>
- Niles, M. T., Lubell, M., & Haden, V. R. (2013). Perceptions and responses to climate policy risks among California farmers. *Global Environmental Change*, 23(6), 1752–1760. <https://doi.org/10.1016/j.gloenvcha.2013.08.005>
- O'Connor, E. (2007). Embodied knowledge in glassblowing: The experience of meaning and the struggle towards proficiency. *Sociological Review*, 55(SUPPL. 1), 126–141. <https://doi.org/10.1111/j.1467-954X.2007.00697.x>
- OECD, & FAO. (2017). *OECD-FAO Agricultural Outlook*. OECD Publishing. <http://www.agri-outlook.org/executivesummary/>
- Oliver, D. M., Fish, R. D., Winter, M., Hodgson, C. J., Heathwaite, A. L., & Chadwick, D. R. (2012). Valuing local knowledge as a source of expert data: Farmer engagement and the design of decision support systems. *Environmental Modeling and Software*, 36(76–85). <https://doi.org/10.1016/j.envsoft.2011.09.013>
- Olson, M. (1971). *The Logic of Collective Action : Public Goods and the Theory of Groups*. Harvard University Press. <http://ezproxy-prd.bodleian.ox.ac.uk:2090/login.aspx?direct=true&db=nlebk&AN=282683&site=ehost-live&authtype=ip,uid>
- Olsson, L., Jerneck, A., Thoren, H., Persson, J., Byrne, D. O., & O'Byrne, D. (2015). Why resilience is unappealing to social science: Theoretical and empirical investigations of the scientific use of resilience. *Sci. Adv.*, 1(4), 1–12. <https://doi.org/10.1126/sciadv.1400217>
- Olsson, P., Folke, C., & Berkes, F. (2004). Adaptive Comanagement for Building Resilience in Social-Ecological Systems. *Environmental Management*, 34(1), 75–90. <https://doi.org/10.1007/s00267-003-0101-7>
- Olsson, P., Folke, C., & Hahn, T. (2004). Social-ecological transformation for ecosystem management: The development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society*, 9(4). <https://doi.org/10.5751/ES-00683-090402>
- Osbahr, H., Dorward, P., Stern, R., & Cooper, S. (2011). Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variable with farmer perceptions. *Experimental Agriculture*, 47(2), 293–316. <https://doi.org/10.1017/S0014479710000785>
- Ostrom, E. (2000). Collective Action and the Evolution of Social Norms. *Journal of Economic Perspectives*, 14(3), 137–158.
- Ostrom, E. (2008). *Polycentric systems as one approach for solving collective-action problems*. <https://doi.org/10.2139/ssrn.1304697>

- Ostrom, E. (2010a). Analyzing collective action. *International Association of Agricultural Economists*, 41(1), 155–166. <https://doi.org/10.1111/j.1574-0862.2010.00497.x>
- Ostrom, E. (2010b). Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, 20(4), 550–557. <https://doi.org/10.1016/j.gloenvcha.2010.07.004>
- Ostrom, E. (2014). A Polycentric Approach for Coping with Climate Change. *Annals of Economics and Finance*, 15(1), 97–134. <http://down.aefweb.net/AefArticles/aef150102Ostrom.pdf>
- Palsson, G., Szerszynski, B., Sörlin, S., Marks, J., Avril, B., Crumley, C., Hackmann, H., Holm, P., Ingram, J., Kirman, A., Buendía, M. P., & Weehuizen, R. (2013). Reconceptualizing the “Anthropos” in the Anthropocene: Integrating the social sciences and humanities in global environmental change research. *Environmental Science and Policy*, 28, 3–13. <https://doi.org/10.1016/j.envsci.2012.11.004>
- Pape, A., & Prokopy, L. S. (2017). Delivering on the potential of formal farmer networks: Insights from Indiana. *Journal of Soil and Water Conservation*, 72(5), 463–470. <https://doi.org/10.2489/jswc.72.5.463>
- Parsons, M., Fisher, K., & Nalau, J. (2016). Alternative approaches to co-design: insights from indigenous/academic research collaborations. *Current Opinion in Environmental Sustainability*, 20, 99–105. <https://doi.org/10.1016/J.COSUST.2016.07.001>
- Paul, C. J., Weinthal, E. S., Bellemare, M. F., & Jeuland, M. A. (2016). Social capital, trust, and adaptation to climate change: Evidence from rural Ethiopia. *Global Environmental Change*, 36, 124–138. <https://doi.org/10.1016/j.gloenvcha.2015.12.003>
- Paul, R. (2013). *Participatory Rural Appraisal (PRA) Manual* | FAO. Food and Agriculture Organizations of the United Nations. <http://www.fao.org/family-farming/detail/en/c/292329/>
- Pearce, T., Ford, J., Willox, A. C., Smit, B., Smit, B., & Smit, B. (2015). Inuit Traditional Ecological Knowledge (TEK), Subsistence Hunting and Adaptation to Climate Change in the Canadian Arctic. *Arctic*, 68(2), 233–245. <https://doi.org/10.14430>
- Pecorino, P. (2015). Olson’s Logic of Collective Action at fifty. *Public Choice*, 162(3–4), 243–262. <https://doi.org/10.1007/s11127-014-0186-y>
- PEI Department of Communities Land and Environment. (2018). *Taking Action: A Climate Change Action Plan for Prince Edward Island*. <https://www.princeedwardisland.ca/en/information/environment-water-and-climate-change/climate-change-action-plan-2018-2023>
- PEI Govt. (2017). *Agriculture on PEI | Prince Edward Island*. Government of Prince Edward Island. <https://www.princeedwardisland.ca/en/information/agriculture-and-fisheries/agriculture-pei>
- Pelling, M. (2011). *Adaptation to Climate Change: From resilience to transformation*. Routledge.
- Pelling, M., & Manuel-Navarrete, D. (2011). From Resilience to Transformation : the Adaptive Cycle in Two Mexican. *Ecology and Society*, 16(2).
- Petticrew, M., & Roberts, H. (2006). *Systematic Reviews in the Social Sciences : A Practical Guide*. Wiley-Blackwell. <http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=141287&site=ehost-live&authtype=ip,uid>
- Philp, G., & Cohen, A. (2019). Municipal climate change adaptation and mitigation: from planning to action in Nova Scotia. *Journal of Environmental Planning and Management*, 0(0), 1–19. <https://doi.org/10.1080/09640568.2019.1691509>
- Pinkerton, E. (1989). *Co-operative management of local fisheries : new directions for improved management and community development*. University of British Columbia Press.
- Pittaway, L. (2011). Systematic Literature Reviews. In *The SAGE Dictionary of Qualitative Management Research* (pp. 217–218). Sage Publications.

- <https://doi.org/10.4135/9780857020109.n103>
- Pizzo, B. (2015). Problematizing resilience: Implications for planning theory and practice. *Cities*, 43, 133–140. <https://doi.org/10.1016/j.cities.2014.11.015>
- Plummer, R., & Armitage, D. (2007). A resilience-based framework for evaluating adaptive co-management: Linking ecology, economics and society in a complex world. *Ecological Economics*, 61(1), 62–74. <https://doi.org/10.1016/j.ecolecon.2006.09.025>
- Popke, J., Curtis, S., & Gamble, D. W. (2016). *A social justice framing of climate change discourse and policy: Adaptation, resilience and vulnerability in a Jamaican agricultural landscape*. <https://doi.org/10.1016/j.geoforum.2014.11.003>
- Porreca, L. (2010). *The influence of collective action and policy in the development of local food systems*. Utah State University.
- Porter, J. R., Howden, M., & Smith, P. (2017). Considering agriculture in IPCC assessments. *Nature Climate Change*, 7(10), 680–683. <https://doi.org/10.1038/nclimate3404>
- Prokopy, L. S., Arbuckle, J. G., Barnes, A. P., Haden, V. R., Hogan, A., Niles, M. T., Tyndall, J., G Arbuckle, B. J., Andrew Barnes, B. P., Hogan, A., Meredith Niles, B. T., John Tyndall, B., Arbuckle, J. G., Barnes, A. P., Haden, V. R., Hogan, A., Niles, M. T., & Tyndall, J. (2015). Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries. *Environmental Management*, 56(2), 492–504. <https://doi.org/10.1007/s00267-015-0504-2>
- QSR International. (2019). *NVivo 12* (12.2.0). QSR International.
- Qualman, D. (2019). *Tackling the Farm Crisis and the Climate Crisis*. <https://www.nfu.ca/publications/tackling-the-farm-crisis-and-the-climate-crisis/>
- Radel, C., Schmook, B., Carte, L., & Mardero, S. (2018). Toward a Political Ecology of Migration: Land, Labor Migration, and Climate Change in Northwestern Nicaragua. *World Development*, 108, 263–273. <https://doi.org/10.1016/j.worlddev.2017.04.023>
- Rahman, H. M. T., & Hickey, G. M. (2019). What Does Autonomous Adaptation to Climate Change Have to Teach Public Policy and Planning About Avoiding the Risks of Maladaptation in Bangladesh? *Frontiers in Environmental Science*, 7(January). <https://doi.org/10.3389/fenvs.2019.00002>
- Raj, A., Jhariya, M. K., & Bargali, S. S. (2017). Climate – smart Agriculture and soil- carbon sequestration. *Climate Change and Agroforestry*, May, 1–19.
- Rapaport, E., Starkman, S., & Towns, W. (2017). Chapter 8: Atlantic Canada. In *Climate risks and adaptation practices for the Canadian transportation sector 2016* (pp. 218–262). Government of Canada. <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2016/Chapter-8e.pdf>
- Rapley, T. J. (2001). The art(fulness) of open-ended interviewing: some considerations on analysing interviews. *Qualitative Research*, 1(3), 303–323. <https://doi.org/https://ezproxy-prd.bodleian.ox.ac.uk:2091/10.1177/146879410100100303>
- Raworth, K. (2017). *Doughnut economics : seven ways to think like a 21st century economist*. Chelsea Green Publishing.
- Raymond, C. M., Fazey, I., Reed, M. S., Stringer, L. C., Robinson, G. M., & Evely, A. C. (2010). Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management*, 91(8), 1766–1777. <https://doi.org/10.1016/j.jenvman.2010.03.023>
- Reddit. (2019). “The Oval walkways at Ohio State University were paved based on the students’ desire paths.” <https://i.redd.it/xd0huvd527111.jpg>
- Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, 141(10), 2417–2431. <https://doi.org/10.1016/j.biocon.2008.07.014>

- Reimer, A., Thompson, A., Prokopy, L. S., Arbuckle, J. G., Genskow, K., Jackson-Smith, D., Lynne, G., McCann, L., Morton, L. W., & Nowak, P. (2014). People, place, behavior, and context: A research agenda for expanding our understanding of what motivates farmers' conservation behaviors. *Journal of Soil and Water Conservation*, 69(2), 57A-61A. <https://doi.org/10.2489/jswc.69.2.57a>
- Reiner, R. (1987). *The Princess Bride*. 20th Century Fox.
- Ribot, J. (2014). Cause and response: vulnerability and climate in the Anthropocene. *Journal of Peasant Studies*, 41(5), 667–705. <https://doi.org/10.1080/03066150.2014.894911>
- Riessman, C. (2007). Thematic Analysis. In *Narrative Methods for the Human Sciences* (pp. 53–76). Sage Publications. http://www.sagepub.com/sites/default/files/upm-binaries/19279_Chapter_3.pdf
- Rodale Institute. (2014). *Regenerative Organic Agriculture and Climate Change*. <https://rodaleinstitute.org/wp-content/uploads/Regenerative-Organic-Agriculture-White-Paper.pdf>
- Rodima-Taylor, D., Olwig, M. F., & Chhetri, N. (2011). Adaptation as innovation, innovation as adaptation : An institutional approach to climate change. *Applied Geography*, 1–5. <https://doi.org/10.1016/j.apgeog.2011.10.011>
- Roesch-McNally, G. E., Arbuckle, J. G., & Tyndall, J. C. (2018). Barriers to implementing climate resilient agricultural strategies: The case of crop diversification in the U.S. Corn Belt. *Global Environmental Change*, 48(January), 206–215. <https://doi.org/10.1016/j.gloenvcha.2017.12.002>
- Roesch-McNally, G. E., Basche, A., & Schewe, R. (2018). Climate change challenges require collaborative research to drive agrifood system transformation. *Renewable Agriculture and Food Systems*, 33(April), 1–2. <https://doi.org/10.1017/s1742170518000157>
- Roesch-McNally, G. E., Gordon Arbuckle, J., & Tyndall, J. C. (2017). What would farmers do? Adaptation intentions under a Corn Belt climate change scenario. *Agriculture and Human Values*, 34(2), 333–346. <https://doi.org/10.1007/s10460-016-9719-y>
- Romero-Lankao, P., & Dodman, D. (2011). Cities in transition: Transforming urban centers from hotbeds of GHG emissions and vulnerability to seedbeds of sustainability and resilience. Introduction and Editorial overview. *Current Opinion in Environmental Sustainability*, 3(3), 113–120. <https://doi.org/10.1016/j.cosust.2011.02.002>
- Rosenzweig, C., Ruane, A. C., Antle, J., Elliott, J., Ashfaq, M., Chatta, A. A., Ewert, F., Folberth, C., Hathie, I., Havlik, P., Hoogenboom, G., Lotze-Campen, H., MacCarthy, D. S., Mason-D'Croz, D., Contreras, E. M., Müller, C., Perez-Dominguez, I., Phillips, M., Porter, C., ... Wiebe, K. (2018). Coordinating AgMIP data and models across global and regional scales for 1.5°C and 2.0°C assessments. *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences*, 376(2119), 20160455. <https://doi.org/10.1098/rsta.2016.0455>
- Rotz, S., & Wood, L. (2018). Settler colonialism and the (im) possibilities of a national food policy. *Canadian Food Studies / La Revue Canadienne Des Études Sur l'alimentation*, 5(3), 248–258. <https://doi.org/10.15353/cfs-rcea.v5i3.275>
- Ruiz, J. R., & Ruiz Ruiz, J. (2009). Sociological Discourse Analysis: Methods and Logic. *Forum: Qualitative Social Research*, 10(2), 1–22. <https://doi.org/10.17169/FQS-10.2.1298>
- Rutten, M., Achterbosch, T. J., de Boer, I. J. M., Cuaresma, J. C., Geleijnse, J. M., Havlik, P., Heckeley, T., Ingram, J., Leip, A., Marette, S., van Meijl, H., Soler, L.-G., Swinnen, J., van't Veer, P., Vervoort, J., Zimmermann, A., Zimmermann, K. L., & Zurek, M. (2016). Metrics, models and foresight for European sustainable food and nutrition security: The vision of the SUSFANS project. *Agricultural Systems*. <https://doi.org/10.1016/j.agsy.2016.10.014>
- Ryan, G. W., & Bernard, H. R. (2003). Techniques to Identify Themes. *Field Methods*, 15(1), 85–109. <https://doi.org/10.1177/1525822X02239569>
- Sacouman, R. J. (1977). Underdevelopment and the Structural Origins of Antigonish Movement Co-operatives In Eastern Nova Scotia. *Acadiensis*, 7(1), 66–85.

- Saj, S., Torquebiau, E., Hainzelin, E., Pages, J., & Maraun, F. (2017). The way forward: An agroecological perspective for Climate-Smart Agriculture. *Agriculture, Ecosystems and Environment*, 250, 20–24. <https://doi.org/10.1016/j.agee.2017.09.003>
- Sautier, M., Piquet, M., Duru, M., & Martin-Clouaire, R. (2017). Exploring adaptations to climate change with stakeholders: A participatory method to design grassland-based farming systems. *Journal of Environmental Management*, 193, 541–550. <https://doi.org/10.1016/j.jenvman.2017.02.050>
- Savard, J.-P., Van Proosdij, D., & O’Carroll, S. (2016). Chapter 4 : Perspectives on Canada’s East Coast Region. In D. S. Lemmen, F. J. Warren, T. S. James, & C. S. L. Mercer Clarke (Eds.), *Canada’s Marine Coasts in a Changing Climate* (pp. 99–152). https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2016/Coastal_Assessment_Chapter4_EastCoastRegion.pdf
- Schattman, R. E., Méndez, V. E., Merrill, S. C., & Zia, A. (2018). Mixed methods approach to understanding farmer and agricultural advisor perceptions of climate change and adaptation in Vermont, United States. *Agroecology and Sustainable Food Systems*, 42(2), 121–148. <https://doi.org/10.1080/21683565.2017.1357667>
- Schattman, R., Méndez, E., Westdijk, K., Caswell, M., Conner, D., Koliba, C., Zia, A., Hurley, S., Adair, C., Berlin, L., & Darby, H. (2014). Vermont Agricultural Resilience in a Changing Climate: A Transdisciplinary and Participatory Action Research (PAR) Process. In *Agroecology, Ecosystems, and Sustainability* (pp. 325–346). <https://doi.org/10.1201/b17775-17>
- Scherr, S. J., Shames, S., & Friedman, R. (2012). From climate-smart agriculture to climate-smart landscapes. *Agriculture & Food Security*, 1(1), 12. <https://doi.org/10.1186/2048-7010-1-12>
- Schipanski, M. E., MacDonald, G. K., Rosenzweig, S., Chappell, M. J., Bennett, E. M., Kerr, R. B., Blesh, J., Crews, T., Drinkwater, L., Lundgren, J. G., & Schnarr, C. (2016). Realizing resilient food systems. *BioScience*, 66(7), 600–610. <https://doi.org/10.1093/biosci/biw052>
- Schipper, E. L. F. (2020). Maladaptation: When Adaptation to Climate Change Goes Very Wrong. *One Earth*, 3(4), 409–414. <https://doi.org/10.1016/j.oneear.2020.09.014>
- Schoenfeld, P. (2014). Systematic reviews. *GI Epidemiology: Diseases and Clinical Methodology*, 1–6. <https://doi.org/10.1097/01.NAJ.0000446779.99522.f6>
- Schultz, T., Abdulla, D., Ansari, A., Canlı, E., Keshavarz, M., Kiem, M., Martins, L. P. de O., & J.S. Vieira de Oliveira, P. (2018). What Is at Stake with Decolonizing Design? A Roundtable. *Design and Culture*, 10(1), 81–101. <https://doi.org/10.1080/17547075.2018.1434368>
- Scoones, I., & Thompson, J. (Eds.). (1994). *Beyond Farmer First: Rural people’s knowledge, agricultural research and extension practice*. Intermediate Technology Publications.
- Scoones, I., & Thompson, J. (Eds.). (2009). *Farmer First Revisited: Innovation for Agricultural Research and Development*. Intermediate Technology Publications.
- Scotia, G. of N. (2008). *Economic Output of the Agri-food Sector*. <https://novascotia.ca/agri/documents/business-research/agstats-Economic-Output-of-the-Agri-food-Sector.pdf>
- Scotia, G. of N. (2009). *Toward a Greener Future: Nova Scotia’s Climate Change Action Plan* (Issue January). <https://climatechange.novascotia.ca/sites/default/files/uploads/ccap.pdf>
- Scott, J., & Colman, R. (2008). *The GPI Soils and Agriculture Accounts - Towards a Healthy Farm and Food System: Indicators of Genuine Pr.* <http://www.gpiatlantic.org/pdf/agriculture/thffs.pdf>
- Scott, M. (2013). Resilience: a Conceptual Lens for Rural Studies? *Geography Compass*, 7(9), 597–610. <https://doi.org/10.1111/gec3.12066>
- Senate of Canada. (2018). *Feast or famine: Impacts of climate change and carbon pricing on agriculture, agri-food and forestry* (Issue December). <http://sencanada.ca/agfo>
- Shaw, K., & Maythorne, L. (2013). Managing for local resilience: Towards a strategic approach. *Public*

- Policy and Administration*, 28(1), 43–65. <https://doi.org/10.1177/0952076711432578>
- Sherren, K. (2009). The pieces we have. *Environments*, 37(2), 51–59.
- Sherren, K., Beckley, T. M., Parkins, J. R., Stedman, R. C., Keilty, K., & Morin, I. (2016). Learning (or living) to love the landscapes of hydroelectricity in Canada: Eliciting local perspectives on the Mactaquac Dam via headpond boat tours. *Energy Research and Social Science*, 14, 102–110. <https://doi.org/10.1016/j.erss.2016.02.003>
- Sherren, K., & Darnhofer, I. (2018). Precondition for Integration: In Support of Stand-alone Social Science in Rangeland and Silvopastoral Research. *Rangeland Ecology & Management*, 71(5), 545–548. <https://doi.org/10.1016/J.RAMA.2017.08.003>
- Shrestha, R., Chaweewan, N., & Arunyawat, S. (2017). Adaptation to Climate Change by Rural Ethnic Communities of Northern Thailand. *Climate*, 5(3), 57. <https://doi.org/10.3390/cli5030057>
- Skogstad, G. (1985). Interest groups, Representation and Conflict Management in the Standing Committees of the House of Commons. *Canadian Journal of Political Science / Revue Canadienne de Science Politique*, 18(4), 739–772.
- Skogstad, G. (2008). Internationalization and Canadian agriculture. *Policy and Governing Paradigms*, 30.
- Smit, B., & Skinner, M. W. (2002). Adaptation Options in Agriculture To Climate Change : a Typology. *Mitigation and Adaptation Strategies for Global Change*, 7(1), 85–114. <https://doi.org/10.1023/A:1015862228270>
- Smith, B. M., Chakrabarti, P., Chatterjee, A., Chatterjee, S., Dey, U. K., Dicks, L. V., Giri, B., Laha, S., Majhi, R. K., & Basu, P. (2017). *Collating and validating indigenous and local knowledge to apply multiple knowledge systems to an environmental challenge: A case-study of pollinators in India*. <https://doi.org/10.1016/j.biocon.2017.04.032>
- Smith, N., & Walters, P. (2018). Desire lines and defensive architecture in modern urban environments. *Urban Studies*, 55(13), 2980–2995. <https://doi.org/10.1177/0042098017732690>
- Smith, P., Adams, J., Beerling, D. J., Beringer, T., Calvin, K. V., Fuss, S., Griscom, B., Hagemann, N., Kammann, C., Kraxner, F., Minx, J. C., Popp, A., Renforth, P., Vicente Vicente, J. L., & Keesstra, S. (2019). Impacts of Land-Based Greenhouse Gas Removal Options on Ecosystem Services and the United Nations Sustainable Development Goals. *Annual Review of Environment and Resources*, 44(1), 1–32. <https://doi.org/10.1146/annurev-environ-101718-033129>
- Smith, W. N., Grant, B. B., Desjardins, R. L., Kroebel, R., Li, C., Qian, B., Worth, D. E., McConkey, B. G., & Drury, C. F. (2013). Assessing the effects of climate change on crop production and GHG emissions in Canada. *Agriculture, Ecosystems and Environment*, 179, 139–150. <https://doi.org/10.1016/j.agee.2013.08.015>
- Soini, K., Diaz, C., Gandini, G., de Haas, Y., Lilja, T., Martin-Collado, D., Pizzi, F., & Hiemstra, S. J. (2012). Developing a typology for local cattle breed farmers in Europe. *Journal of Animal Breeding and Genetics*, 129(6), 436–447. <https://doi.org/10.1111/j.1439-0388.2012.01009.x>
- Soler, R., Peri, P. L., Bahamonde, H., Gargaglione, V., Ormaechea, S., Huertas Herrera, A., Sánchez Jardón, L., Lorenzo, C., & Martínez Pastur, G. (2018). Assessing Knowledge Production for Agrosilvopastoral Systems in South America. *Rangeland Ecology and Management*, 71(5), 637–645. <https://doi.org/10.1016/j.rama.2017.12.006>
- Soubry, B. (2017a). *Climate Resilience on Maritime Farms: Examining agricultural impacts and adaptation to climate change in the Canadian Maritimes*. University of Oxford.
- Soubry, B. (2017b). Comparing Farmer Observations and Modelled Projections of Climate Change in the Canadian Maritimes. *SSRN Electronic Journal*, 1–27. <https://doi.org/10.2139/ssrn.3035172>
- Soubry, B. (2017c). *How can governments support adaptation to climate change by small-scale farmers? A case study from the Canadian Maritime provinces*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3035782

- Soubry, B., Sherren, K., & Thornton, T. F. (2020a). Farming along desire lines : Collective action and food systems adaptation to climate change. *People and Nature*, 1(438), 1–47. <https://doi.org/10.1002/pan3.10075>
- Soubry, B., Sherren, K., & Thornton, T. F. (2020b). Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007–2018. *Journal of Rural Studies*, 74, 210–222. <https://doi.org/10.1016/J.JRURSTUD.2019.09.005>
- Sova, C. A., Thornton, T. F., Zougmore, R., Helfgott, A., & Chaudhury, A. S. (2017). *Climate and Development Power and influence mapping in Ghana's agricultural adaptation policy regime*. *Power and influence mapping in Ghana's agricultural adaptation policy regime*. <https://doi.org/10.1080/17565529.2016.1154450>
- Sova, C., Vervoort, J., Thornton, T., Helfgott, A., Matthews, D., & Chaudhury, A. (2015). Exploring farmer preference shaping in international agricultural climate change adaptation regimes. *Environmental Science and Policy*, 54, 463–474. <https://doi.org/10.1016/j.envsci.2015.08.008>
- Standing Senate Committee on Agriculture and Forestry. (2017). Proceedings of the Standing Senate Committee on Agriculture and Forestry. *Study the Potential Impact of the Effects of Climate Change on the Agriculture, Agri-Food and Forestry Sectors*, 51611–51614. <https://sencanada.ca/Content/SEN/Committee/421/AGFO/pdf/36issue.pdf>
- Statistics Canada. (2017a). *2016 Census of Agriculture*. <https://www.statcan.gc.ca/eng/ca2016>
- Statistics Canada. (2017b). *Table 004-0201 - Census of Agriculture, farms classified by total farm area, every 5 years (number)*. Statistics Canada. <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210040401>
- Statistics Canada. (2019). *Statistics Canada. Table 32-10-0156-01 Farms classified by size, historical data*. <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210015601>
- Stock, P. V, Er Emie Forney, J., Emery, S. B., & Wittman, H. (2014). Neoliberal natures on the farm: Farmer autonomy and cooperation in comparative perspective. *Journal of Rural Studies*, 36, 411–422. <https://doi.org/10.1016/j.jrurstud.2014.06.001>
- Stock, P. V, & Forney, J. (2014). Farmer autonomy and the farming self. *Journal of Rural Studies*, 36, 160–171. <https://doi.org/10.1016/j.jrurstud.2014.07.004>
- Strauss, A., & Darnhofer, I. (2015). Organic farming and resilience (Austria). In *RETHINK project* (Issue February).
- Street, H. (2016). *The role of soil moisture and vegetation in determining the spatial location of landslides during Nepal ' s Ghorka earthquake , 2015 The role of soil moisture and vegetation in determining the spatial location of landslides during Nepal ' s Ghorka*. 1–15.
- Suddaby, R. (2006). From the Editors : What Grounded Theory Is Not. *Academy of Management Journal*, 49(4), 633–642.
- Sumane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Des, I., Rios, I., Rivera, M., Chebach, T., & Ashkenazy, A. (2017). Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *Journal of Rural Studies*, *In press*, 1–10. <https://doi.org/10.1016/j.jrurstud.2017.01.020>
- Tadaki, M., Sinner, J., & Chan, K. (2017). Making sense of environmental values: a typology of concepts. *Ecology and Society*, 22(1). <https://doi.org/10.5751/ES-08999-220107>
- Tambo, J. A., & Abdoulaye, T. (2013). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Regional Environmental Change*, 13(2), 375–388. <https://doi.org/10.1007/s10113-012-0351-0>
- Taylor, M. (2018). Climate-smart agriculture: what is it good for? *Journal of Peasant Studies*, 45(1), 89–107. <https://doi.org/10.1080/03066150.2017.1312355>
- Thorén, H., & Olsson, L. (2017). Is resilience a normative concept? *Resilience*, 6(2), 1–17. <https://doi.org/10.1080/21693293.2017.1406842>

- Thorn, J., Thornton, T. F., & Helfgott, A. (2015). Autonomous adaptation to global environmental change in peri-urban settlements: Evidence of a growing culture of innovation and revitalisation in Mathare Valley Slums, Nairobi. *Global Environmental Change*, 31, 121–131. <https://doi.org/10.1016/j.gloenvcha.2014.12.009>
- Thornton, T. F. (2008). *Being and Place Among the Tlingit*. University of Washington Press.
- Thornton, T. F., & Manasfi, N. (2011). Adaptation—Genuine and Spurious: Demystifying Adaptation Processes in Relation to Climate Change. *Environment and Society*, 1(1), 132–155. <https://doi.org/10.3167/ares.2010.010107>
- Thornton, T. F., Puri, R. K., Bhagwat, S., & Howard, P. (2019). Human adaptation to biodiversity change: An adaptation process approach applied to a case study from southern India. *Ambio*, 48(12), 1431–1446. <https://doi.org/10.1007/s13280-019-01225-7>
- Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Pnas*, 108(50), 20260–20264. <https://doi.org/10.1073/pnas.1116437108>
- Tompkins, E. L., & Adger, W. N. (2005). Defining Response Capacity to Enhance Climate Change Policy. *Environmental Science and Policy*, 8, 562–571. <https://doi.org/10.1016/j.envsci.2005.06.012>
- Tourangeau, W., & Sherren, K. (2019). Why is grazing management a blind spot in climate policy? Discourse analysis of two Canadian parliamentary studies. *Submitted.*, 1–32.
- Tourangeau, W., Sherren, K., Kent, C., & Macdonald, B. H. (2019). Of climate and weather: Examining Canadian farm and livestock organization discourses from 2010 to 2015. *Weather, Climate, and Society*, 11(1), 95–111. <https://doi.org/10.1175/WCAS-D-18-0028.1>
- Toussaint, P., & Martínez Blanco, A. (2019). A human rights-based approach to loss and damage under the climate change regime. *Climate Policy*, 0(0), 1–15. <https://doi.org/10.1080/14693062.2019.1630354>
- Tseganeh Kassie, B., Hengsdijk, H., Rötter, R., Kahiluoto, H., Asseng, S., Van Ittersum, M., Kassie, B. T., Van Ittersum, Á. M., & Hengsdijk, H. (2013). Adapting to Climate Variability and Change: Experiences from Cereal-Based Farming in the Central Rift and Kobo Valleys, Ethiopia. *Environmental Management*, 52, 1115–1131. <https://doi.org/10.1007/s00267-013-0145-2>
- Tsioumani, E. (2021). *Fair and Equitable Benefit-Sharing in Agriculture: Reinventing Agrarian Justice*. Earthscan. <https://www.taylorfrancis.com/books/9780429584183>
- Tuck, E. (2009). Suspending damage: A letter to communities. *Harvard Educational Review*, 79(3), 409–427. <https://doi.org/10.17763/haer.79.3.n0016675661t3n15>
- Tuck, E., & McKenzie, M. (2015). Relational Validity and the “Where” of Inquiry: Place and Land in Qualitative Research. *Qualitative Inquiry*, 21(7), 633–638. <https://doi.org/10.1177/1077800414563809>
- Tuck, E., McKenzie, M., & McCoy, K. (2014). Land education: Indigenous, post-colonial, and decolonizing perspectives on place and environmental education research. *Environmental Education Research*, 20(1), 1–23. <https://doi.org/10.1080/13504622.2013.877708>
- Turner, N. J., Gregory, R., Brooks, C., Failing, L., & Satterfield, T. (2008). From Invisibility to transparency: Identifying the implications. *Ecology and Society*, 13(2)(2), 14. [https://doi.org/10.1890/1059-0933\(2008\)13\[14:FTIT\]2.0.CO;2](https://doi.org/10.1890/1059-0933(2008)13[14:FTIT]2.0.CO;2)
- Tyler, S., & Moench, M. (2012). A framework for urban climate resilience. *Climate and Development*, 4(4), 311–326. <https://doi.org/10.1080/17565529.2012.745389>
- Ulrichs, M., Cannon, T., Newsham, A., Naess, L. O., & Marshall, M. (2015). *Climate Change and Food Security Vulnerability Assessment. Toolkit for assessing community-level potential for adaptation to climate change* (No. 108). <https://ccafs.cgiar.org/publications/climate-change-food-security-vulnerability-assessment-toolkit-assessing-community-level>
- UNCTAD. (2013). *Wake up before it is too late: Make agriculture truly sustainable now for food*

- security in a changing climate* (Issue September). <https://doi.org/UNCTAD/DITC/TED/2012/3>
- UNFCCC. (2017). *Decision CP.23: Koronivia joint work on agriculture*. <https://www.canada.ca/content/dam/aaac-aac/documents/20190614-en.pdf>
- UPEI Climate Lab. (2017). *Prince Edward Island Climate Change Adaptation Recommendations Report Draft*.
- Urquhart, C. (2013). *Grounded theory for qualitative research : a practical guide*. SAGE.
- van Bers, C., Pahl-Wostl, C., Eakin, H., Ericksen, P., Lenaerts, L., Foerch, W., Korhonen-Kurki, K., Methner, N., Jones, L., Vasileiou, I., & Eriksen, S. (2016). *Transformation in governance towards resilient food systems* (No. 190).
- van Dijk, M. (2012). A review of global scenario exercises for food security analysis: Assumptions and results. *FOODSECURE Working Paper 2*, 02.
- van Vliet, J. A., Schut, A. G. T., Reidsma, P., Descheemaeker, K., Slingerland, M., Van de Ven, G. W. J., & Giller, K. E. (2015). De-mystifying family farming: Features, diversity and trends across the globe. *Global Food Security*, 5, 11–18. <https://doi.org/10.1016/j.gfs.2015.03.001>
- Vanderlee, L., Goorang, S., Karbasy, K., Schermel, A., & L'Abbé, M. (2017). *Creating healthier food environments in Canada: Current policies and priority actions Report Authors*. www.labbelab.utoronto.ca/Food-EPI-Canada-2017
- Varadan, R. J., & Kumar, P. (2014). Indigenous knowledge about climate change: Validating the perceptions of dryland farmers in Tamil Nadu. *Indian Journal of Traditional Knowledge*, 13(2), 390–397. http://nopr.niscair.res.in/bitstream/123456789/27934/1/IJTK_13%282%29_390-397.pdf
- Vasseur, L., Catto, N. R., Burton, D. L., Lemmen, D. S., Warren, F. J., Lacroix, J., & Bush, E. (2008). Atlantic Canada. In D. S. Lemmen, F. J. Warren, J. Lacroix, & E. Bush (Eds.), *Impacts to Adaptation: Canada in a Changing Climate 2007*. Government of Canada. http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2007/pdf/ch4_e.pdf
- Vermeulen, S., & Dinesh, D. (2016). *Info note: Measures for climate change adaptation in agriculture*. <https://cgspace.cgiar.org/handle/10568/71053>
- Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate Change and Food Systems. *Annual Review of Environment and Resources*, 37(1), 195–222. <https://doi.org/10.1146/annurev-environ-020411-130608>
- Vermeulen, S. J., Challinor, A. J., Thornton, P. K., Campbell, B. M., Eriyagama, N., Vervoort, J. M., Kinyangi, J., Jarvis, A., Läderach, P., Ramirez-Villegas, J., Nicklin, K. J., Hawkins, E., & Smith, D. R. (2013). Addressing uncertainty in adaptation planning for agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, 110(21), 8357–8362. <https://doi.org/10.1073/pnas.1219441110>
- Vervoort, J. (2013). Using scenarios for collaborative sense-making and action in food systems: opportunities for social entrepreneurs. *Skoll Centre for Social Entrepreneurship, University of Oxford, FAO*.
- von Glasenapp, M., & Thornton, T. F. (2011). Traditional Ecological Knowledge of Swiss Alpine Farmers and their Resilience to Socioecological Change. *Human Ecology*, 39(6), 769–781. <https://doi.org/10.1007/s10745-011-9427-6>
- Wade, T., & Robichaud, I. (2011). *Planning and Policy in Atlantic Canada*. www.atlanticadaptation.ca
- Webb, J., Misselbrook, T. H., Tscharrntke, T., Clough, Y., Wanger, T. C., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J., Whitbread, A., Tilman, D., Cassman, K. G., Matson, P. a, Naylor, R., Polasky, S., Balzer, C., Hill, J., Befort, B. L., Thévenot, A., ... The Government Office for Science. (2011). The Future of Food and Farming: Challenges and choices for global sustainability - Final Project Report. *The Government Office for Science, London*, 149(February), 211. <https://doi.org/10.1016/j.anifeedsci.2011.04.036>
- Weiler, A. M. (2018). *Commentary A food policy for Canada , but not just for Canadians : Reaping*

- justice for migrant farm workers*. 5(3), 279–284. <https://doi.org/10.15353/cfs-rcea.v5i3.312>
- Weiler, A. M., Levkoe, C. Z., & Young, C. (2016). Cultivating equitable ground: Community-based participatory research to connect food movements with migrant farmworkers. *Journal of Agriculture, Food Systems, and Community Development*, 6(2). <https://doi.org/https://doi.org/10.5304/jafscd.2016.062.012>
- Weiler, A. M., Otero, G., & Wittman, H. (2016). Rock Stars and Bad Apples: Moral Economies of Alternative Food Networks and Precarious Farm Work Regimes. *Antipode*, 48(4), 1140–1162. <https://doi.org/10.1111/anti.12221>
- Wheeler, T., & von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science*, 341, 508–513. <https://doi.org/10.1126/science.1239402>
- Whitfield, S. (2015). *Adapting to Climate Uncertainty in African Agriculture*. Routledge. <https://doi.org/10.4324/9781315725680>
- Wiebe, N., Desmarais, A. A., & Wittman, H. (2011). *Food sovereignty in Canada : creating just and sustainable food systems*. Fernwood Pub.
- Wieland, R., Ravensbergen, S., Gregr, E. J., Satterfield, T., & Chan, K. M. A. (2016). Debunking trickle-down ecosystem services: The fallacy of omnipotent, homogeneous beneficiaries. *Ecological Economics*, 121, 175–180. <https://doi.org/10.1016/j.ecolecon.2015.11.007>
- Wilkinson, C. (2012). Social-ecological resilience: Insights and issues for planning theory. *Planning Theory*, 11(2), 148–169. <https://doi.org/10.1177/1473095211426274>
- Willis, R. (2017). Taming the Climate? Corpus analysis of politicians' speech on climate change. *Environmental Politics*, 26(2), 212–231. <https://doi.org/10.1080/09644016.2016.1274504>
- Wilson, S. (2008). *Research is ceremony: indigenous research methods*. Fernwood Publishing.
- Winthrop, R. H. (2014). The strange case of cultural services: Limits of the ecosystem services paradigm. *Ecological Economics*, 108, 208–214. <https://doi.org/10.1016/j.ecolecon.2014.10.005>
- World Bank. (2015). *Future of Food: Shaping a Climate-Smart Global Food System*. <http://documents1.worldbank.org/curated/en/645981468189237140/pdf/100046-WP-PUBLIC-disclose-7am-10-8-15-Box393216B.pdf>
- Wynne-Jones, S. (2017). Understanding farmer co-operation: Exploring practices of social relatedness and emergent affects. *Journal of Rural Studies*, 53, 259–268. <https://doi.org/10.1016/j.jrurstud.2017.02.012>
- Zabel, F., Putzenlechner, B., & Mauser, W. (2014). Global agricultural land resources - A high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. *PLoS ONE*, 9(9), 1–12. <https://doi.org/10.1371/journal.pone.0107522>
- Zimmerer, K. S. (2010). Biological Diversity in Agriculture and Global Change. *Annual Review of Environment and Resources*, 35(1), 137–166. <https://doi.org/10.1146/annurev-environ-040309-113840>

10. Appendices

10.1 Appendix: Supervisory statements

Environmental *Change* Institute

School of Geography and the Environment
OUCE, South Parks Road, Oxford OX1 3QY, UK
Tel: +44(0)1865 275848 Fax: +44(0)1865 275850
enquiries@eci.ox.ac.uk www.eci.ox.ac.uk



Thomas F. Thornton, Ph.D., Associate Professor and Senior Research Fellow (Part-time)

11 August 2020

Dear Director of Graduate Studies, School of Geography and the Environment,

Regarding candidate Bernard Soubry's papers submitted the DPhil thesis, for which I serve as a supervisor, I certify that the majority of that work is his own.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'T. F. Thornton', written over a horizontal line.

Thomas F. Thornton, Ph.D.



School of Geography and Environment (SOGE)
Environmental Change Institute
South Parks Road
Oxford, OX1 3QY UK

August 15, 2020

Dear Director of Graduate Studies, SOGE

Regarding candidate Bernard Soubry's papers submitted for the DPhil thesis, for which I serve as co-supervisor, I certify that the majority of that work is his own.

Sincerely,

A handwritten signature in black ink, appearing to read "K. Sherren", with a long horizontal flourish extending to the right.

Kate Sherren PhD,
Full Professor & Academic Program Coordinator
School for Resource and Environmental Studies

FACULTY OF MANAGEMENT | *School for Resource and Environmental Studies*

Kenneth C. Rowe Management Building, Suite 5010 | 6100 University Avenue | PO Box 15000 | Halifax NS B3H 4R2 Canada
902.494.3632 | FAX: 902.494.3728 | sres@dal.ca | dal.ca/sres

DAL.CA

10.2 Appendix: Research Outreach

This appendix details my participation in activities which, though directly related to and stemming from my research, are not observed within the D.Phil examination process. A researcher's worth is often by their tangible outputs (papers and theses, for example). Yet so much essential work is unremarkable, largely untraceable, and often ignored by those whose decisions shape a researcher's life—say, thesis examiners or hiring committees. It is important to state them, to show that they are part of our worth, and to insist on their recognition.

Public presentations and lectures

2020	Academic adviser, Mock COP. Advised youth climate activists as they negotiated and elaborated their own treaty to bring an end to the climate crisis. Video available here: https://youtu.be/PppItCeRx8o
2018-2020	Departmental lectures for the School of Resource and Environmental Studies: - Qualitative methodologies and relational accountability - Multilateral environmental negotiations
2019	"Farming Along Desire Lines: Collective Action and Adaptive Capacity to Climate Change." <i>Canadian Rural Revitalization Foundation/North Atlantic Forum Conference</i> . St. John's, Canada. October 2019.
2018	"Climate Resilience and Organic Agriculture". Online webinar presented for the Atlantic Canada Organic Regional Network. January 2018.

Media outreach

August 2020	Radio interview. "Dal researcher says COVID-19 food crisis could have been prevented." Available here: https://www.cbc.ca/listen/live-radio/1-27-information-morning-ns/clip/15790694-dal-researcher-says-covid-19-food-crisis-prevented
June 2020	Op-Ed. "COVID-19 shows what's wrong with how Canada feeds itself." <i>Chronicle Herald</i> , Nova Scotia, Canada. Available here: https://www.thechronicleherald.ca/opinion/local-perspectives/bernard-soubry-covid-19-shows-whats-wrong-with-how-canada-feeds-itself-461380/

- 2019 “Farming Along Desire Lines: Collective Action and Adaptive Capacity to Climate Change.” Canadian Rural Revitalization Foundation/North Atlantic Forum Conference. St. John’s, Canada. October 2019.
- 2018 “Climate Resilience and Maritime Farms”. [Adventures in Local Food](#), a blog of the [EAC’s Our Food Project](#). Available [here](#).
- 2018 "Climate Resilience and Organic Agriculture". Online webinar presented for the Atlantic Canada Organic Regional Network. January 2018.

Journal reviewing

In the course of my D.Phil, I was invited to review at the following journals: *Climate and Development*; *Society and Natural Resources*; *Journal of Agricultural Science*.

Consultations

In my capacity as a doctoral candidate in Geography and Environment, I have provided advice to the following regional organizations:

<u>Organization</u>	<u>Purpose and role</u>
Food for All (New Brunswick)	Member, Food and Climate Crisis advisory committee,
Atlantic Canada Organic Regional Network	Grant advisor, climate change and agriculture projects
Coastal Action (Nova Scotia)	Advisor, carbon sequestration and agriculture projects

Government testimony

On October 26, 2017, I provided expert testimony to the Senate of Canada’s Committee on Agriculture and Forestry. The testimony informed the Senate’s recommendations to the Government of Canada on climate change, some of which is discussed in Chapter 7.

The full testimony can be found here:

Standing Senate Committee on Agriculture and Forestry. (2017). *Proceedings of the Standing Senate Committee on Agriculture and Forestry*. 51611–51614.
<https://sencanada.ca/Content/SEN/Committee/421/AGFO/pdf/36issue.pdf>

The report given to the Government was published here:

Senate of Canada. (2018). *Feast or famine: Impacts of climate change and carbon pricing on agriculture, agri-food and forestry*. Ottawa, ON. <http://sencanada.ca/agfo>

10.3 Appendix: Participant outreach

10.3.1 Participant recruitment

Participants were recruited using advertisements which sent them to an online registration form (see chapter 4). Participants contacted via snowball sampling methods were also asked to sign up using the online form.



Hello! (Le français suit.)

My name is Bernard Soubry. I'm a doctoral candidate in Geography and Environmental Studies at the University of Oxford's Environmental Change Institute. I'm also an apprentice market gardener who has farmed in the Maritimes from 2014 onwards.

I'm contacting you because I'm running a project on farm adaptation and resilience in Eastern Canada. The project is called "Climate Resilience and Maritime Farms". We're trying to figure out how growers in the Maritimes are adapting to changing weather, where the biggest uncertainties for the future are, and where other groups in the food system can connect with producers to form a resilient food system.

Would you be interested in being interviewed for this research project? The project would involve either an hour-long phone interview, or a farm visit where I could interview you at your leisure—and help out, if there's anything you need help with. Your insight and experience as a grower, and as a key member in the Maritime food system, would be absolutely invaluable.

If this interests you, I'd love to talk. [Click here](#) and you'll be sent to a form where I'll get your contact information; I'll call or e-mail you in the next few days. You can also just call or e-mail me (below).

If you have questions, you can contact me at bernard.soubry@ouce.ox.ac.uk, or by calling me at 438.838.8218 .

Thanks for your time, and best wishes—

Bernard Soubry

The following online form collected data, which was sent to a private spreadsheet:

Climate Resilience on Maritime Farms / Résilience climatique sur les fermes maritimes

Thanks for your interest in the project! Merci de vouloir travailler avec nous!

Si vous avez des questions, envoyez-moi un message à bernard.soubry@ouce.ox.ac.uk.

***Required**

Quel est votre nom? / What's your name? *

Your answer

Quel âge avez-vous? / What age range are you in? *

- ☐ 20-30
- ☐ 30-40
- ☐ 40-50
- ☐ 50-60
- ☐ 60-70
- ☐ 70+

Getting in touch with you / communiquer avec vous

What's your e-mail address? / Votre adresse courriel?

Your answer _____

Votre no de téléphone? / What's your phone number?

Your answer _____

Votre ferme / Your farm

Comment s'appelle votre ferme? / What's the name of your farm?

Your answer _____

Location / Où demeurez-vous? *

Your answer _____

What do you produce? / Que produisez-vous?

- ☐ Livestock / bétail
- ☐ Porc / pork
- ☐ Volaille / poultry
- ☐ Dairy / Produits laitiers
- ☐ Légumes / vegetables
- ☐ Other: _____

Êtes-vous intéressé à passer en entrevue? / Are you interested in being interviewed? *

- ☐ Yes! Oui!
- ☐ No thanks, but keep me up to date. / Non merci, mais informez-moi du reste du projet.

Submit

Page 1 of 1

Never submit passwords through Google Forms.

This content is neither created nor endorsed by Google. [Report Abuse](#) - [Terms of Service](#) - [Privacy Policy](#)

Google Forms

10.3.2 Sample introductory e-mail

Other e-mails were translated and written for non-farmer actors.

Hello!

My name is Bernard Soubry. I'm a doctoral candidate in Geography and Environmental Studies at the University of Oxford's Environmental Change Institute. I'm also an apprentice market gardener from Montreal who farmed in the Maritimes from 2013 to 2016.

I'm contacting you because I'm running a project on farm adaptation and resilience in Eastern Canada. The project is called "Climate Resilience and Maritime Farms". We're trying to figure out how growers in the Maritimes are adapting to climate change, where the biggest uncertainties for the future are, and where other groups in the food system can connect with producers to form a resilient food system.

Would you be interested in being interviewed for this research project? The project would involve either an hour-long phone interview, or a farm visit where I could interview you at your leisure—and help out, if there's anything you need help with. Your insight as a grower, and as a key member in the Maritime food system, would be absolutely invaluable.

If this interests you, I'd love to talk and give you more information! You can contact me either by replying, or by calling me at _____.

Thanks for your time, and best wishes—

Bernard Soubry

10.3.3 Participant Follow-Up

To be used after interviews

Step one: Thanking you

THANK YOU! Thank you for participating in the Climate Resilience on Maritime Farms project, and agreeing to be interviewed. You've helped a lot, and we appreciate the gift of your knowledge and of your time.

Step Two: The Research Project

What happens to my interview now?

I'll be transcribing the interview once the fieldwork is complete. You should expect a transcript of your interview by the last week of March at the latest. You can then review it. In the meantime, the data will be securely stored on the servers at the School of Geography at Oxford.

I'd like to retract my interview. Can I stop participating in the project?

Of course. Please contact me before June 1, 2018 if you'd like:

- For any data concerning you to be permanently erased
- To be anonymized (I'll still use our interview, but won't mention you by name or any identifying details)
- To correct or rectify anything you said during the interview.

What happens with this research project?

Once I've collected and coded the interviews, I'll assemble them and analyze the results. A preliminary report of the results will be sent out to you as soon as possible.

These interview results, as well as other parts of the research, will be transformed into policy briefs and papers and public presentations. I'll keep you up to date with any analysis which emerges from the data I've collected. Please let me know what you think of them—especially if you disagree with what I think! That's the best way to make sure I'm really representing people's views.

My contact information:

Bernard Soubry
c/o Hertford College Catte St., Oxford
OX1 3BW
[Canadian phone number]
bernard.soubry@hertford.ox.ac.uk

10.3.4 Participant consent form



Bernard Soubry
bernard.soubry@ouce.ox.ac.uk
 School of Geography and the Environment
 South Parks Road, Oxford University
 United Kingdom

Climate Resilience and Maritime Farms

Background and aims of the study:

The purpose of this research project is to develop an understanding of what farmers in the Maritimes know about changes in weather and climate, what information they need, and what they themselves have been doing on their own operations to adapt to environmental changes in their region. We want to use it to help farmers, retailers, and other people involved in the Maritime food system to build a collective plan for the food system in the Maritimes in the coming decades

The project is being undertaken by Bernard Soubry, a D.Phil candidate in Geography and Environmental Studies at the University of Oxford.

As a farmer and a valuable stakeholder in the food system in the Maritimes, we'd like to invite you to share your knowledge, your experience, and your insights. We'd like to use the information you give us to help the farming and food communities better understand how to adapt to climate change in the Maritimes. The goal of the project is also to help identify techniques and policy impacts that would be useful to you, from your own unique and informed perspective.

How will the research project work?

You'll be asked to participate in an interview about climate change and your farm. I'll record the interview on-farm, at a location of your choice. The interview should not take more than an hour of your time. If there's more time, we might also walk around your farm, and talk more as we work. I may take photos of your farm, with your permission.

If you'd like to participate, you'll be asked to sign a consent form (attached).

The interviews will be transcribed and coded according to a process called “grounded theory” (Chamaz 2006)⁶, which finds common themes and stories within interviews to link different people's experiences together. The coded data will be used to refine future interviews and select the most common themes. The hope—you can participate in this, too!—is to use farmers' perspectives, knowledge, and insights to create viable recommendations which will help them plan for and adapt to climate change.

Are there any risks?

The risks involved in this research project are minimal. The risks you'll undertake will be no more than the risks you undertake in everyday life.

We understand that talking about farming, and about climate change, can be political, and close to the heart. You can choose not to provide an answer to any question which makes you uncomfortable

⁶ Chamaz, Kathy. “Constructing Grounded Theory”. SAGE Publications: 2006.

or unwilling to do so. You don't need to answer any questions that might lead to loss of reputation, harassment, or loss of future income. If you want to, we can anonymize your responses when we use them in publications.

By participating, you'll be contributing to a project that seeks to understand climate change in the Maritimes and how the food system can adapt to it. The conversations you have, and the data that's collected, may be useful to you in your own work.

What will happen to the data that's collected?

Your personal data (i.e., your contact information), as well as the interview records and transcripts, will be stored on a secure internal file server at the University of Oxford as long as the research project continues to require them. They'll also be on encrypted hard drives in the meantime.

By agreeing to participate in this research project, you also agree that the researcher may quote you directly in the project. At any time, you can request that your name not be used in the study. You can also request to be removed from the research project, meaning that any data concerning you will be destroyed.

Will the research be published?

This work as a report: Because the point of this research is to help build adaptive capacity in the Maritimes, it's possible that the data collected in this research project will be used to provide information to farmers, policy-makers, and the general public. This may be in the form of a report, of a website, or of other means of dissemination.

This work as a thesis: The University of Oxford has an online archive of research materials that archives includes digital copies of student theses successfully submitted as part of degree programs: this means that researchers can freely access the full text of freely available theses which can help later research be more impactful.

The research will be written up as a thesis and deposited both in print and online in the University archive. The thesis will be published with completely open access, and will be available to every internet user.

Who has reviewed this project?

This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee. It's also been reviewed by Drs. Thomas Thornton and Kate Sherren, Bernard's supervisors, both of whom are professors of Geography.

Who should I talk to about any concerns I have?

If you have a concern about any aspect of this project, please speak to Bernard Soubry (contact information above), who will do his best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how he intends to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the chair of the Research Ethics Committee at the University of Oxford (using the contact details below) who will seek to resolve the matter in a reasonably expeditious manner:

Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee

Email: ethics@socsci.ox.ac.uk

Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD, UK

DECLARATION OF INFORMED CONSENT

I've read the information provided in the participant information sheet (attached) about the research project being carried out by Bernard Soubry at the University of Oxford.

I've been able to ask questions about my involvement and to receive whatever additional details I require.

I understand that, if I agree to participate, I can also withdraw from this research project at any time.

I agree that the researcher can quote me directly in research publications, even though they may not use my name.

I have been given a copy of this form, and I agree to participate in this study.

Can we record the interview? (Please mark these with an X.)

☐ I agree to the audio recording of the interview.

☐ I agree that my farm can appear in photographs or videos for the use of the research project.

☐ I agree to appear in photographs or videos for the use of the research project.

Can we contact you beyond the interview? (Please mark these with an X.)

☐ I don't want to be contacted about the results of the project.

☐ Please send me a summary of the project. You can send it

to this e-mail address: _____

or

to this postal address: _____

Participant signature

Date

Researcher signature

Date

10.4 Appendix: Interview guides

These questions are meant to be guidelines towards a semi-structured conversation. They should not be so rigorously followed as to impede the study.

Preliminary questions

- What is your name?
- How long have you been involved in agriculture?
- What is the name of your business/organization?
- What type of business/organization is it?
 - For farmers:
 - What do you produce?
 - How would you describe the kind of production that you do?
 - What kind of acreage?
 - How do you sell your produce?
- Can you tell me a bit about the history of your farm?
 - What's the history of your land? Do you own it?

Farm practices [for farmers]

- Can you tell me about how and why you farm?
 - Feed or seed
 - Use of fertilizer / pesticide
 - Mechanization levels
 - Irrigation
 - Permanent and semipermanent infrastructure (greenhouses, hoopouses, etc.)
- What infrastructure on your farm do you consider most vulnerable to weather (storms, erosion, etc.)?

Weather changes

- Have you noticed differences in weather patterns in the past years?
 - What kinds? How are things changing?
- What are you hearing about the possible effects of climate change to your region?
 - Where from?
 - What do you think about that?

Adaptation

- (if farmers mention weather changes) Are you changing the way you farm in response to these weather changes?
- What kind of methods do you use to protect your crops/your livestock from adverse weather?

Financial

- Are you receiving financial support (loans, grants, credit, other programs) for your business?
 - How constant is that support? Where does it come from?
- What are the biggest uncertainties in terms of your financial relationships (with markets, with retailers, etc. / with farmers, with producers)?

Information

- How do you get information for the decisions you'll be making on the farm?
- What information do you wish you had, from whom?

Governance

- How would you describe your relationship with the department of agriculture?
- Is there anything you wish the government knew about farmers which they don't know presently?

Markets

- Can you describe your relationship with the markets?
- Where do you think markets are headed in the next decades?

Further questions

- Do you think other farmers feel the same way you do? Who disagrees?
- Is there anything else you'd like to add, or have on record?
- Do you have any questions for me?
- Who else should I talk to about this, in the Maritime agriculture community or outside of it?

10.5 Appendix to Chapter 5: List of reviewed papers

- Abrha, M.G., Simhadri, S., 2015. Local Climate Trends and Farmers' Perceptions in Southern Tigray, Northern Ethiopia. *Am. J. Environ. Sci.* 11, 262–277.
- Adebisi-Adelani, O., Oyesola, O.B., 2014. Farmers' Perceptions of the Effect of Climate Change on Tomato Production in Nigeria. *Int. J. Veg. Sci.* 20, 366–373. doi:10.1080/19315260.2013.813890
- Adebisi-Adelani, O., Oyesola, O.B., 2013. Fruit vegetable farmers' perception of climate change and adaptation strategies in Gombe State, Nigeria. *Acta Hort.* 925–933. doi:10.17660/ActaHortic.2013.1007.111
- Akpene Tambo, J., Abdoulaye, T., 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Reg. Environ. Chang.* 13, 375–388. doi:10.1007/s10113-012-0351-0
- Alam, G.M.M., Alam, K., Mushtaq, S., 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. *Clim. Risk Manag.* 17, 52–63. doi:10.1016/j.crm.2017.06.006
- Alauddin, M., Sarker, M.A.R., 2014. Climate change and farm-level adaptation decisions and strategies in drought-prone and groundwater-depleted areas of Bangladesh: an empirical investigation. *Ecol. Econ.* 106, 204–213. doi:10.1016/j.ecolecon.2014.07.025
- Arshad, M., Kächele, H., Krupnik, T.J., Amjath-Babu, T.S., Aravindakshan, S., Abbas, A., Mehmood, Y., Müller, K., 2017. Climate variability, farmland value, and farmers' perceptions of climate change: implications for adaptation in rural Pakistan. *Int. J. Sustain. Dev. World Ecol.* 24, 532–544. doi:10.1080/13504509.2016.1254689
- Ayal, D.Y., Filho, W.L., 2017. Farmers' perceptions of climate variability and its adverse impacts on crop and livestock production in Ethiopia. *J. Arid Environ.* 140, 20–28. doi:10.1016/j.jaridenv.2017.01.007
- Ayanlade, A., Radeny, M., Akin-Onigbinde, A., 2017. Climate variability/change and attitude to adaptation technologies: a pilot study among selected rural farmers' communities in Nigeria. *GeoJournal*. doi:10.1007/s10708-017-9771-1
- Ayanlade, A., Radeny, M., Morton, J.F., 2017. Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. *Weather Clim. Extrem.* 15, 24–33. doi:10.1016/j.wace.2016.12.001
- Ayeri, O.S., Christian, V.R., Josef, E., Michael, H., 2012. Local perceptions and responses to climate change and variability: The case of Laikipia District, Kenya. *Sustainability* 4, 3302–3325. doi:10.3390/su4123302
- Banerjee, R.R., 2015. Farmers' perception of climate change, impact and adaptation strategies: a case study of four villages in the semi-arid regions of India. *Nat. Hazards* 75, 2829–2845. doi:10.1007/s11069-014-1466-z
- Barbier, B., Hamma, A., Ae, Y., Karambiri, H., Malick, A., Ae, Z., Somé, B., 2009. Human Vulnerability to Climate Variability in the Sahel: Farmers' Adaptation Strategies in Northern Burkina Faso. *Environ. Manage.* 43, 790–803. doi:10.1007/s00267-008-9237-9
- Barnes, A.P., Islam, M.M., Toma, L., 2013. Heterogeneity in climate change risk perception amongst dairy farmers: A latent class clustering analysis. *Appl. Geogr.* 41, 105–115. doi:10.1016/j.apgeog.2013.03.011
- Barnes, A.P., Toma, L., 2012. A typology of dairy farmer perceptions towards climate change. *Clim. Change* 112, 507–522. doi:10.1007/s10584-011-0226-2
- Baudoin, M.-A., 2014. Enhancing climate change adaptation in Africa assessing the role of local institutions in Southern Benin. *Clim. Dev.* 6, 122–131. doi:10.1080/17565529.2013.844677

- Baudoin, M.-A.M., Cuni Sanchez, A., Fandohan, B., Baudoin, M.-A.M., Fellow, B., Sanchez, A.C., 2014. Small scale farmers' vulnerability to climatic changes in southern Benin: the importance of farmers' perceptions of existing institutions. *Mitig Adapt Strateg Glob Chang.* 19, 1195–1207. doi:10.1007/s11027-013-9468-9
- Baul, T.K., McDonald, M., 2015. Integration of Indigenous knowledge in addressing climate change. *Indian J. Tradit. Knowl.* 1, 20–27.
- Baul, T.K., Ullah, K.A.M.A., Tiwari, K.R., McDonald, M.A., Kumar Baul, T., Ullah, K.A.M.A., Tiwari, K.R., McDonald, M.A., 2013. People's local knowledge of climate change in the middle-hills of Nepal. *Indian J. Tradit. Knowl.* 12, 585–595.
- Below, T.B., Schmid, J.C., Sieber, S., 2014. Farmers' knowledge and perception of climatic risks and options for climate change adaptation: a case study from two Tanzanian villages. *Reg. Environ. Chang.* doi:10.1007/s10113-014-0620-1
- Bewket, W., 2012. Climate change perceptions and adaptive responses of smallholder farmers in central highlands of Ethiopia. *Int. J. Environ. Stud.* 69, 507–523. doi:10.1080/00207233.2012.683328
- Bojovic, D., Bonzanigo, L., Giupponi, C., 2012. Drivers of Change in Southern European Agriculture: Online Participatory Approaches for the Analysis of Planned and Autonomous Adaptation Strategies. *Int. Congr. Environ. Model. Softw.* 39.
- Bryan, E., Deressa, T.T., Gbetibouo, G.A., Ringler, C., 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environ. Sci. Policy* 12, 413–426. doi:10.1016/j.envsci.2008.11.002
- Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., Herrero, M., 2013. Adapting agriculture to climate change in Kenya: Household strategies and determinants. *J. Environ. Manage.* 114, 26–35. doi:10.1016/j.jenvman.2012.10.036
- Campbell Hibbs, A., Kahl, D., Pytlik Zillig, L., Champion, B., Abdel-Monem, T., Steffenmeister, T., Rice, C.W., Hubbard, K., 2014. Agricultural Producer Perceptions of Climate Change and Climate Education Needs for the Central Great Plains. *J. Ext.* 52.
- Chalise, S., Maraseni, T.N., Maroulis, J., 2015. Adapting to climate variability: the views of peasant farmers in Nepal. *Int. J. Glob. Warm.* 7, 380. doi:10.1504/IJGW.2015.069369
- Chérif, S., Filho, W.L., Azeiteiro, U., 2016. The role of farmers' perceptions in coping with climate change in Sub-Saharan Africa. *Int. J. Glob. Warm.* doi:10.1504/IJGW.2017.10005907
- Chingala, G., Mapiye, C., Raffrenato, E., Hoffman, L., Dzama, K., 2017. Determinants of smallholder farmers' perceptions of impact of climate change on beef production in Malawi. *Clim. Change* 142, 129–141. doi:10.1007/s10584-017-1924-1
- Coe, R., Stern, R.D., 2011. Assessing and addressing climate-induced risk in sub-Saharan rainfed agriculture: Lessons learned. *Exp. Agric.* 47, 395–410. doi:10.1017/S001447971100010X
- Comoé, H., Finger, R., Barjolle, D., 2014. Farm management decision and response to climate variability and change in Côte d'Ivoire. *Mitig Adapt Strateg Glob Chang.* 19, 123–142. doi:10.1007/s11027-012-9436-9
- de-Graft Acquah, H., Onumah, E.E., 2011. Perception and Adaptation to Climate Change: An Estimation of Willingness to Pay. *Agris on-line Pap. Econ. Informatics* 3.
- Deressa, T.T., Hassan, R.M., Ringler, C., 2011. Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *J. Agric. Sci.* 149, 23–31. doi:10.1017/S0021859610000687
- Dhanya P, Ramachandran A, 2016. Farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi arid region of south India. *J. Integr. Environ. Sci.* 13. doi:10.1080/1943815X.2015.1062031
- Diem, J.E., Hartter, J., Salerno, J., McIntyre, E., Grandy, @bullet A Stuart, 2017. Comparison of measured multi-decadal rainfall variability with farmers' perceptions of and responses to seasonal

- changes in western Uganda. *Reg. Environ. Chang.* 17, 1127–1140. doi:10.1007/s10113-016-0943-1
- Dubey, S.K., Trivedi, R.K., Chand, B.K., Mandal, B., Rout, S.K., 2017. Farmers' perceptions of climate change, impacts on freshwater aquaculture and adaptation strategies in climatic change hotspots: A case of the Indian Sundarban delta. *Environ. Dev.* 21, 38–51. doi:10.1016/j.envdev.2016.12.002
- Elgin-Stuczynski, I.R., Batterbury, S., 2014. Perceptions of climate variability and dairy farmer adaptations in Corangamite Shire, Victoria, Australia. *Int. J. Clim. Chang. Strateg. Manag.* 6, 85–107. doi:10.1108/IJCCSM-03-2013-0039
- Esham, M., Garforth, C., Esham, M., Garforth, C., 2013. Agricultural adaptation to climate change: insights from a farming community in Sri Lanka. *Mitig Adapt Strateg Glob Chang.* 18, 535–549. doi:10.1007/s11027-012-9374-6
- Fisher, M., Snapp, S., 2014. Smallholder farmers' perceptions of drought risk and adoption of modern maize in southern Malawi. *Exp. Agric.* 50, 533–548. doi:10.1017/S0014479714000027
- Fosu-Mensah, B.Y., Vlek, P.L.G., Maccarthy, @bullet D S, Maccarthy, D.S., 2012. Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. *Env. Dev Sustain* 14, 495–505. doi:10.1007/s10668-012-9339-7
- Galdies, C., Said, A., Camilleri, L., Caruana, M., 2016. Climate change trends in Malta and related beliefs, concerns and attitudes toward adaptation among Gozitan farmers. *Eur. J. Agron.* 74, 18–28. doi:10.1016/j.eja.2015.11.011
- Gamble, D.W., Campbell, D., Allen, T.L., Barker, D., Curtis, S., McGregor, D., Popke, J., Douglas, R., -Gamble, W., Campbell^, D., Barker^, D., 2010. Climate Change, Drought, and Jamaican Agriculture: Local Knowledge and the Climate. *Ann. Assoc. Am. Geogr. Clim. Chang.* 100, 880–893.
- Gandure, S., Walker, S., Botha, J.J., 2013. Farmers' perceptions of adaptation to climate change and water stress in a South African rural community. *Environ. Dev.* 5, 39–53. doi:10.1016/j.envdev.2012.11.004
- Gebrehiwot, T., Van Der Veen, A., 2013. Farm level adaptation to climate change: The case of farmer's in the ethiopian highlands. *Environ. Manage.* 52, 29–44. doi:10.1007/s00267-013-0039-3
- Glenk, K., Eory, V., Colombo, S., Barnes, A., 2014. Adoption of greenhouse gas mitigation in agriculture: An analysis of dairy farmers' perceptions and adoption behaviour. *Ecol. Econ.* 108, 49–58. doi:10.1016/j.ecolecon.2014.09.027
- Hernandez, V., Fossa Riglos, F., Muzi, E., Moron, V., Riglos, F.F., Muzi, E., Fossa Riglos, F., Muzi, E., 2015. Confronting Farmers' Perceptions of Climatic Vulnerability with Observed Relationships between Yields and Climate Variability in Central Argentina. *Weather. Clim. Soc.* 7, 39–59. doi:10.1175/WCAS-D-13-00062.1
- Hitayezu, P., Wale, E., Ortmann, G., 2017. Assessing farmers' perceptions about climate change: A double-hurdle approach. *Clim. Risk Manag.* 17, 123–138. doi:10.1016/j.crm.2017.07.001
- Hou, L., Huang, J., Wang, J., 2015. Farmers' perceptions of climate change in China: the influence of social networks and farm assets. *Clim. Res.* 63, 191–201.
- Hyland, J.J., Davey Jones, B.L., Karen Parkhill, B.A., Andrew Barnes, B.P., Prysor Williams, B.A., 2016. Farmers' perceptions of climate change: identifying types. *Agric. Human Values* 33, 323–339. doi:10.1007/s10460-015-9608-9
- Jacobi, J., Schneider, M., Bottazzi, P., Pillco, M., Calizaya, P., Rist, S., 2013. Agroecosystem resilience and farmers' perceptions of climate change impacts on cocoa farms in Alto Beni, Bolivia. *Renew. Agric. Food Syst.* 30, 170–183. doi:10.1017/S174217051300029X

- Jha, C.K., Gupta, V., Chattopadhyay, U., Amarayil Sreeraman, B., 2017. Migration as adaptation strategy to cope with climate change. *Int. J. Clim. Chang. Strateg. Manag. IJCCSM-03-2017-0059*. doi:10.1108/IJCCSM-03-2017-0059
- Kabir, M.J., Cramb, R., Alauddin, M., Roth, C., Crimp, S., 2017. Farmers' perceptions of and responses to environmental change in southwest coastal Bangladesh. *Asia Pac. Viewp.* doi:10.1111/apv.12165
- Khanal, U., Clevo Wilson, B., Viet-Ngu Hoang, B., Boon Lee, B., Wilson, C., Hoang, V.-N., Lee, B., 2017. Impact of community-based organizations on climate change adaptation in agriculture: empirical evidence from Nepal. *Environ. Dev. Sustain.* doi:10.1007/s10668-017-0050-6
- Kichamu, E.A., Ziro, J.S., Palaniappan, G., Ross, H., 2017. Climate change perceptions and adaptations of smallholder farmers in Eastern Kenya. *Env. Dev Sustain.* doi:10.1007/s10668-017-0010-1
- Kusakari, Y., Asubonteng, K.O., Jasaw, G.S., Dayour, F., Dzivenu, T., Lolig, V., Donkoh, S.A., Obeng, F.K., Gandaa, B., Kranjac-Berisavljevic, G., 2014. Farmer-perceived effects of climate change on livelihoods in WA west district, upper west region of Ghana. *J. Disaster Res.* 9, 516–528.
- Lam Nguyen, A., Truong, M.H., Verreth, J.A., Leemans, R., Bosma, R.H., De Silva, S.S., 2015. Exploring the climate change concerns of striped catfish producers in the Mekong Delta, Vietnam. *Springerplus* 4, 46. doi:10.1186/s40064-015-0822-0
- Lasco, R.D., Espaldon, M.L.O., Habito, C.M.D., 2016. Smallholder farmers' perceptions of climate change and the roles of trees and agroforestry in climate risk adaptation: evidence from Bohol, Philippines. *Agroforest Syst* 90, 521–540. doi:10.1007/s10457-015-9874-y
- Le Dang, H., Li, E., Bruwer, J., Nuberg, I., Le Dang, H., Li, E., Bruwer, J., Nuberg, I., 2014. Farmers' perceptions of climate variability and barriers to adaptation: lessons learned from an exploratory study in Vietnam. *Mitig Adapt Strateg Glob Chang.* 19, 531–548. doi:10.1007/s11027-012-9447-6
- Le Dang, H., Li, E., Nuberg, I., Bruwer, J., 2014. Farmers' assessments of private adaptive measures to climate change and influential factors: a study in the Mekong Delta, Vietnam. *Nat. Hazards* 71, 385–401. doi:10.1007/s11069-013-0931-4
- Legesse, S.A., 2013. Farmers perceptions and adaptation to climate change in Ethiopia. *IEEE Potentials* 32, 30–33.
- Li, C., Tang, Y., Luo, H., Baofeng, D., Zhang, L., 2013. Local Farmers' Perceptions of Climate Change and Local Adaptive Strategies: A Case Study from the Middle Yarlung Zangbo River Valley, Tibet, China. *Environ. Manage.* 52, 894–906. doi:10.1007/s00267-013-0139-0
- Limantol, A.M., Keith, B.E., Azabre, B.A., Lennartz, B., 2016. Farmers' perception and adaptation practice to climate variability and change: a case study of the Veia catchment in Ghana. *Springerplus* 5, 830. doi:10.1186/s40064-016-2433-9
- Liu, Z., James Smith Jr, W., Safi, A.S., 2014. Rancher and farmer perceptions of climate change in Nevada, USA. *Clim. Change* 122, 313–327.
- Mahmudul Alam, M., Siwar, C., Islam Molla, R., Talib, B., Ekhwan bin Toriman, M., 2012. Paddy farmers' adaptation practices to climatic vulnerabilities in Malaysia. *Mitig Adapt Strateg Glob Chang.* 17, 415–423. doi:10.1007/s11027-011-9333-7
- Makate, C., Makate, M., Mango, N., 2017. Smallholder Farmers' Perceptions on Climate Change and the Use of Sustainable Agricultural Practices in the Chinyanja Triangle, Southern Africa. *Soc. Sci.* 6, 30. doi:10.3390/socsci6010030
- Manandhar, S., Vogt, D.S., Perret, S.R., Kazama, F., 2011. Adapting cropping systems to climate change in Nepal: A cross-regional study of farmers' perception and practices. *Reg. Environ. Chang.* 11, 335–348. doi:10.1007/s10113-010-0137-1

- Mase, A.S., Gramig, B.M., Prokopy, L.S., 2017. Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. crop farmers. *Clim. Risk Manag.* 15, 8–17. doi:10.1016/j.crm.2016.11.004
- Meldrum, G., Mijatović, D., Rojas, W., Flores, J., Pinto, M., Mamani, G., Condori, E., Hilaquita, D., Gruberg, H., Padulosi, S., 2017. Climate change and crop diversity: farmers' perceptions and adaptation on the Bolivian Altiplano. *Environ. Dev. Sustain.* 1–28. doi:10.1007/s10668-016-9906-4
- Mertz, O., Mbow, C., Reenberg, A., Diouf, A., Cheikh, A., Ae, M., Reenberg, A., Diouf, A., 2009. Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environ. Manage.* 43, 804–816. doi:10.1007/s00267-008-9197-0
- Mhlanga-Ndlovu, B.F.N., Nhamo, G., 2016. Farmer perceptions of climate change impacts on Swaziland's sugar industry. *African J. Sci. Technol. Innov. Dev.* 8, 429–438. doi:10.1080/20421338.2016.1219503
- Mubaya, C.P., Njuki, J., Mutsvangwa, E.P., Mugabe, F.T., Nanja, D., 2012. Climate variability and change or multiple stressors? Farmer perceptions regarding threats to livelihoods in Zimbabwe and Zambia. *J. Environ. Manage.* 102, 9–17. doi:10.1016/j.jenvman.2012.02.005
- Mulenga, B.P., Wineman, A., Sitko, Nicholas J., 2017. Climate Trends and Farmers' Perceptions of Climate Change in Zambia. *Environ. Manage.* 59, 291–306. doi:10.1007/s00267-016-0780-5
- Ndamani, F., Watanabe, T., 2015. Farmers' Perceptions about Adaptation Practices to Climate Change and Barriers to Adaptation : A Micro - Level Study in Ghana. *Water* 7, 4593–4604. doi:10.3390/w7094593
- Nguyen, T., Mula, L., Cortignani, R., Seddaiu, G., Dono, G., Viridis, S., Pasqui, M., Roggero, P., 2016. Perceptions of Present and Future Climate Change Impacts on Water Availability for Agricultural Systems in the Western Mediterranean Region. *Water* 8, 523. doi:10.3390/w8110523
- Nguyen, V.K., Alexander, K., 2014. Farmers' perceptions of and responses to annual flood events in the Vietnamese Mekong River Delta: Adapting to climate change impacts, in: Stucker, D., Lopez-Gunn, E. (Eds.), *Adaptation to Climate Change through Water Resources Management: Capacity, Equity and Sustainability*. Earthscan.
- Niles, M.T., Mueller, N.D., 2016. Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. *Glob. Environ. Chang.* 39, 133–142. doi:10.1016/j.gloenvcha.2016.05.002
- Osbahe, H., Dorward, P., Stern, R., Cooper, S., 2011. Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variable with farmer perceptions. *Exp. Agric.* 47, 293–316. doi:10.1017/S0014479710000785
- Paudel, B., Acharya, B.S., Ghimire, R., Dahal, K.R., Bista, P., 2014. Adapting Agriculture to Climate Change and Variability in Chitwan: Long-Term Trends and Farmers' Perceptions. *Agric. Res.* 3, 165–174. doi:10.1007/s40003-014-0103-0
- Phuoc, T., Nguyen, L., Seddaiu, G., Gonario, S., Viridis, P., Tidore, C., Pasqui, M., Roggero, P.P., 2016. Perceiving to learn or learning to perceive? Understanding farmers' perceptions and adaptation to climate uncertainties. *Agric. Syst.* 143, 205–216. doi:10.1016/j.agry.2016.01.001
- Poudel, D.D., Duex, T.W., 2017. Vanishing Springs in Nepalese Mountains: Assessment of Water Sources, Farmers' Perceptions, and Climate Change Adaptation. *Mt. Res. Dev.* 37, 35–46. doi:10.1659/MRD-JOURNAL-D-16-00039.1
- Poudel, D.D., 2015. Factors associated with farm-level variation, and farmers' perception and climate change adaptation in smallholder mixed-farming livestock production system in Nepal. *Int. J. Environ. Sustain. Dev.* 14, 231–257.

- PytlíkZillig, L.M., Hu, Q., Hubbard, K.G., Lynne, G.D., Bruning, R.H., 2010. Improving farmers' perception and use of climate predictions in farming decisions: A transition model. *J. Appl. Meteorol. Climatol.* 49, 1333–1340. doi:10.1175/2010JAMC2270.1
- Quiroga, S., Suárez, C., Solís, J.D., 2015. Exploring coffee farmers' awareness about climate change and water needs: Smallholders' perceptions of adaptive capacity. *Environ. Sci. Policy* 45, 53–66. doi:10.1016/j.envsci.2014.09.007
- Rakgase, M.A., Norris, D., 2015. Determinants of livestock farmers' perception of future droughts and adoption of mitigating plans. *Int. J. Clim. Chang. Strateg. Manag.* 7, 191–205. doi:10.1108/IJCCSM-01-2014-0011
- Ravi Shankar, K., Nagasree, K., Nirmala, G., 2014. Climate Change and Agricultural Adaptation in South Asia, in: *Handbook of Climate Change Adaptation*. Springer, Berlin. doi:10.1007/978-3-642-40455-9
- Rurinda, J., Mapfumo, P., van Wijk, M.T.T., Mtambanengwe, F., Rufino, M.C.C., Chikowo, R., Giller, K.E.E., 2013. Managing soil fertility to adapt to rainfall variability in smallholder cropping systems in Zimbabwe. *F. Crop. Res.* 154, 211–225. doi:10.1016/j.fcr.2013.08.012
- Sanogo, K., Binam, J., Bayala, J., Villamor, G., Kalinganire, A., Dodiomon, S., 2017. Farmers' perceptions of climate change impacts on ecosystem services delivery of parklands in southern Mali. *Agrofor. Syst.* 91, 345–361. doi:10.1007/s10457-016-9933-z
- Schattman, R.E., Conner, D., Méndez, V.E., 2016. Farmer perceptions of climate change risk and associated on-farm management strategies in Vermont, northeastern United States. *Elem. Sci. Anthr.* 4, 000131. doi:10.12952/journal.elementa.000131
- Schattman, R.E., Méndez, V.E., Merrill, S.C., Zia, A., 2017. Mixed methods approach to understanding farmer and agricultural advisor perceptions of climate change and adaptation in Vermont, United States. *Agroecol. Sustain. Food Syst.* doi:https://doi.org/10.1080/21683565.2017.1357667
- Shrestha Pradhan, N., Sijapati, S., Ratna Bajracharya, S., Pradhan, N.S., Sijapati, S., Bajracharya, S.R., 2015. Farmers' responses to climate change impact on water availability: insights from the Indrawati Basin in Nepal. *Int. J. Water Resour. Dev.* 31, 269–283. doi:10.1080/07900627.2015.1033514
- Shrestha, R., Chaweewan, N., Arunyawat, S., 2017. Adaptation to Climate Change by Rural Ethnic Communities of Northern Thailand. *Climate* 5, 57. doi:10.3390/cli5030057
- Simelton, E., Quinn, C.H., Batisani, N., Dougill, A.J., Dyer, J.C., Fraser, E.D.G., Mkwambisi, D., Sallu, S., Stringer, L.C., 2013. Climate and Development Is rainfall really changing? Farmers' perceptions, meteorological data, and policy implications. *Clim. Dev.* 5, 123–138. doi:10.1080/17565529.2012.751893
- Singh Rana, R., Bhagat, R., Kalia, V., Lal, H., Sen, V., 2013. Indigenous perceptions of Climate change vis-a-vis Mountain Agricultural activities in Himachal Pradesh, India. *Indian J. Tradit. Knowl.* 12, 596–604.
- Sjögersten, S., Atkin, C., Clarke, M.L.L., Mooney, S.J.J., Wu, B., West, H.M.M., 2013. Responses to climate change and farming policies by rural communities in northern China: A report on field observation and farmers' perception in dryland north Shaanxi and Ningxia. *Land use policy* 32, 125–133. doi:10.1016/j.landusepol.2012.09.014
- Sujakhu, N.M., Ranjitkar, S., Niraula, R.R., Pokharel, B.K., Schmidt-Vogt, D., Xu, J., 2016. Farmers' Perceptions of and Adaptations to Changing Climate in the Melamchi Valley of Nepal. *Mt. Res. Dev.* 361, 15–30. doi:10.1659/MRD-JOURNAL-D-15-00032.1
- Tambo, J.A., Abdoulaye, T., 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Reg. Environ. Chang.* 13, 375–388. doi:10.1007/s10113-012-0351-0

- Thi Lan Huong, N., Shun Bo, Y., Fahad, S., 2017. Farmers' perception, awareness and adaptation to climate change: evidence from northwest Vietnam. *Int. J. Clim. Chang. Strateg. Manag.* 9, 555–576. doi:10.1108/IJCCSM-02-2017-0032
- Thomas, D.S.G., Twyman, C., Osbahr, H., Hewitson, B., 2007. Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa. *Clim. Change* 83, 301–322. doi:10.1007/s10584-006-9205-4
- Traore, B., Van Wijk, M.T., Descheemaeker, K., Corbeels, M., Rufino, M.C., Giller, K.E., 2015. Climate variability and change in southern Mali: Learning from farmer perceptions and on-farm trials. *Exp. Agric.* 51, 615–634. doi:10.1017/S0014479714000507
- Tseganeh Kassie, B., Hengsdijk, H., Rötter, R., Kahiluoto, H., Asseng, S., Van Ittersum, M., Kassie, B.T., Van Ittersum, Á.M., Hengsdijk, H., 2013. Adapting to Climate Variability and Change: Experiences from Cereal-Based Farming in the Central Rift and Kobo Valleys, Ethiopia. *Environ. Manage.* 52, 1115–1131. doi:10.1007/s00267-013-0145-2
- Varadan, R.J., Kumar, P., 2014. Indigenous knowledge about climate change: Validating the perceptions of dryland farmers in Tamil Nadu. *Indian J. Tradit. Knowl.* 13, 390–397.
- Wanjiru Kibue, G., Xiaoyu Liu, B., Jufeng Zheng, B., Xuhui zhang, B., Genxing Pan, B., Lianqing Li, B., Xiaojun Han, B., 2016. Farmers' Perceptions of Climate Variability and Factors Influencing Adaptation: Evidence from Anhui and Jiangsu, China. *Environ. Manage.* 57, 976–986. doi:10.1007/s00267-016-0661-y
- Wiid, N., Ziervogel, G., 2012. Adapting to climate change in South Africa: commercial farmers' perception of and response to changing climate. *South African Geogr. J.* 94, 152–173. doi:10.1080/03736245.2012.742783
- Yegbemey, R.N., Yabi, J.A., Aïhounon, G.B., Paraïso, A., 2014. Modélisation simultanée de la perception et de l'adaptation au changement climatique: Cas des producteurs de maïs du Nord Bénin (Afrique de l'Ouest). *Cah. Agric.* 23, 177–187. doi:10.1684/agr.2014.0697
- Zake, J., Hauser, M., 2014. Farmers' perceptions of implementation of climate variability disaster preparedness strategies in Central Uganda. *Environ. Hazards* 248–266. doi:10.1080/17477891.2014.910491
- Zhao, X.-Y., 2014. [Review on farmer's climate change perception and adaptation]. *Ying yong sheng tai xue bao = J. Appl. Ecol.* 25, 2440–8.

10.6 How this thesis was impacted by the COVID-19 pandemic

As per the guidelines of the Social Sciences Division, what follows details the ways in which the COVID-19 pandemic impacted the completion of this thesis work.

Impacts on fieldwork prior to university closing:

The pandemic did not impact data collection or other fieldwork. All fieldwork took place before 2020.

Impacts on the final preparation of the thesis:

Though I have been lucky to avoid the worst within this pandemic—my loved ones and I are safe and healthy, and I live in a part of the world that has been spared the worst—it must be said that I wrote the final parts of this thesis under duress. Between the time the pandemic began and the moment I am writing these lines, I moved house five times for pandemic-related reasons; took up side jobs to keep subsisting; and spent a long, long time looking for postdoctoral work. I wish I could have spent that time writing more papers or revising the thesis. Alas. Given enough time, wouldn't everything strive toward, and fail to reach, perfection?