Global Environmental Change 45 (2017) 79–88

Contents lists available at ScienceDirect

Global Environmental Change

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

Operationalizing longitudinal approaches to climate change vulnerability assessment

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ARTICLE INFO

Keywords:
Adaptation
Longitudinal approaches
Arctic
Vulnerability
Climate change
Inuit

ABSTRACT

The past decade has seen a proliferation of community-scale climate change vulnerability assessments globally. Much of this work has employed frameworks informed by scholarship in the vulnerability field, which draws upon interviews with community members to identify and characterize climatic risks and adaptive responses. This scholarship has developed a baseline understanding of vulnerability in specific places and industries at particular times. However, given the dynamic nature of vulnerability new methodologies are needed to generate insights on how climate change is experienced and responded to over time. Longitudinal approaches have long been used in sociology and the health sciences to capture the dynamism of human processes, but their penetration into vulnerability research has been limited. In this article, we describe the application of two longitudinal approaches, cohort and trend studies, in climate change vulnerability assessment by analyzing three case studies from the Arctic where the authors applied these approaches. These case studies highlight how longitudinal approaches can be operationalized to capture the dynamism of vulnerability by identifying climate anomalies and trends, and how adaptations develop over time, including insights on themes such as social learning and adaptive pathways.

1. Introduction

Research on climate change impacts, adaptation, and vulnerability (IAV) has sought to improve our understanding of the adaptation challenge by examining how physical changes in the environment translate to affect the lives and livelihoods of people around the world and their adaptation options. Much of this research employs a vulnerability framework, which draws upon interviews with community members and other methods to identify and characterize climatic risks and adaptation responses that are relevant and important to communities (Ford and Smit, 2004; Smit and Wandel, 2006; McDowell et al., 2016). This research is grounded in space and time, often focuses on a specific locale (e.g. hamlet, town, city) or economic sector (e.g. mining, forestry, subsistence hunting), considers the influence of multiple climatic and non-climatic stressors on risk and response, and is based on informant recall of past climate events (e.g. Ford et al., 2006a,b; Hesselberg and Yaro, 2006; Tyler et al., 2007; Laidler et al., 2009; Gearheard et al., 2010; Pearce et al., 2010, 2012; Young et al., 2010; Andrachuk and Smit, 2012; Schilling et al., 2012; McCubbin et al., 2015; Statham et al., 2015; Clark et al., 2016). Vulnerability and other risk assessments have improved our understanding of climate change IAV globally, but being temporally discrete they are limited in their ability to capture the dynamics of vulnerability and adaptation processes over time (Ford and Pearce 2012; Archer et al., 2017). This has the potential to limit the efficacy of adaptation interventions, which often target direct climate change impacts (e.g. engineered responses to coastal erosion; new technologies for navigation and search and rescue, etc.), with limited understanding of longer-term climate trends and human processes that are likely to condition future risk and adaptation (Barnett and O'Neil, 2010; Birkenholtz, 2012; Bennett et al., 2016; Kelman et al., 2016). In some instances, adaptations in response to temporally discrete climate risks have been maladaptive. For example, for Inuit in the Canadian Arctic the spatial concentration of hunting in specific areas and/or on a certain species of wildlife as the climate changes has resulted in downstream effects, with more focused and accumulated pressure on that area and/or species actually reducing adaptive capacity over time (Ford et al., 2013).

Human adaptation to changing conditions is a dynamic process, involving the interaction of several interrelated factors operating across scales, of which human behaviour, climate, and environment are but

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http://dx.doi.org/10.1016/j.gloenvcha.2017.05.002
Received 12 March 2017; Accepted 15 May 2017

some (Smit and Wandel, 2006; Dilling et al., 2015). Assessing human vulnerability to climate change requires knowledge of underlying ecosystem attributes – biosphere, hydrosphere, geosphere, and atmosphere – and the linkages among them, and of humans themselves, their economies, institutions, infrastructure, cultures, temporal rhythms, and related land use (Turner et al., 2003; Sidle et al., 2013; Penn et al., 2016). The challenge is to understand how these attributes and their linkages – ecosystem and human – will be altered under a changing climate. How will ecosystem processes change over time? How will people experience and respond to these changes? What human attributes facilitate or constrain adaptation? How may these attributes change over time to deal with new conditions? How will effects accumulate temporally and interact synergistically? New methodologies are needed to expand current understanding of human vulnerability to climate change to include insights on the dynamism of human-environment interactions and the "dynamic construct [of vulnerability] that is constantly shifting as decisions are made and… conditions change" (Dilling et al., 2015; Heltberg et al., 2009; Ford and Pearce, 2012; McDowell et al., 2016; Penn et al., 2016; Jurgilevich et al., 2017).

This article builds upon a body of scholarship on the concept of vulnerability and its application in climate change adaptation research. Several authors have described vulnerability and its constituents, exposure-sensitivity and adaptive capacity, in detail (Timmerman, 1981; Bohle et al., 1994; Cutter, 1996; Adger and Kelly, 1999; Cutter et al., 2003; Smit and Pilifosova, 2003; Adger, 2006; Smit and Wandel, 2006; Fussel, 2007). Others, including Ford and Smit (2004) and Turner et al. (2003) have outlined empirical frameworks for assessing vulnerability. Multiple studies have applied these and other frameworks for assessing vulnerability to climate change in the Arctic (Ford et al., 2006a; Berkes and Jolly, 2002,b; Ford et al., 2006a,b; Pearce et al., 2010; Prno et al., 2011; Andrachuk and Smit, 2012; Statham et al., 2015; Clark et al., 2016), sub-Saharan Africa (Westerhoff and Smit, 2009; Berrang-Ford et al., 2012; Connolly-Boutin and Smit, 2016), Chile (Young et al., 2010), Tuvalu in the Pacific islands (McCubbin et al., 2015), southern Australia (Bardsley and Wiseman, 2012), coastal communities in southwest Africa (Cinner et al., 2012), rain-fed agriculture in northeast Brazil (Lemos et al., 2016), remote central Australia (Maru et al., 2014), and in several countries in southeast Asia (e.g. Mendoza et al., 2014). A common feature of these studies, while providing important information, is that their characterizations of climate sensitivities and adaptation processes are snapshots of the present, often failing to capture the dynamics of vulnerability as it evolves over time (Bennett et al., 2016).

In this article we describe the application of two longitudinal approaches, *cohort* and *trend studies*, in climate change vulnerability assessment. We focus on the application of these approaches, basing our discussion on our combined experience conducting longitudinal climate change vulnerability assessments with Inuit in the Canadian Arctic. We review three case studies: one case in which a cohort study is applied, and two cases in which a hybrid cohort-trend study is applied. This review includes an examination of the approach taken by each case study and a discussion on how the longitudinal approach advances understanding of vulnerability and adaptation processes. We discuss the key themes uncovered by these approaches, and the opportunities and challenges associated with them. While we focus on the Arctic and Inuit, our main contention is that new methodologies are needed to advance existing understanding of human vulnerability to climate change globally to capture the dynamic nature of vulnerability, and in doing so, support adaptations that take into consideration longer-term trends in climate and society.

2. Vulnerability assessments in the Canadian Arctic

The Arctic is a global hotspot for climate change, with an arctic-wide warming trend of 1.9 °C recorded over the past 30 years, a rate three times the global average (Comiso and Hall, 2014). Manifestations of warming include, but are not limited to, changes in sea ice extent, thickness and melt patterns, permafrost degradation, changes in precipitation, increased frequency and intensity of extreme weather events, and more unpredictable weather. These changes have implications for both ecosystems and the human communities who rely on them for their livelihoods (Larsen et al., 2014). Inuit have been identified as particularly sensitive to climate change, largely due to the importance of subsistence hunting for their livelihoods and culture, and the sensitivity of subsistence activities to climate change (Ford et al., 2008, 2016; Pearce et al., 2010). Research suggests that even under the most aggressive emission reduction efforts, current greenhouse gas levels in the atmosphere commit the Earth to some degree of change, necessitating human adaptation (IPCC, 2013; Moss et al., 2013).

Recognizing the effects of climate change on Inuit, research in the Arctic shifted in the early 2000s from studies focused solely on measuring the biophysical impacts of climate change (IPCC, 1997), to projects primarily documenting community observations of change (e.g. Fox, 2000; Krupnik and Jolly, 2002; Nichols et al., 2004), and then to vulnerability and resilience assessments (e.g. Berkes and Jolly 2002; Furgal and Seguin 2006; Ford et al., 2006a,b; Pearce et al., 2010). In the climate change field, the term *vulnerability* refers to the susceptibility of a system (community) to harm relative to a climate stimulus or stimuli, and relates both to sensitivity to climate exposures and capacity to adapt (Smit and Wandel, 2006). This conceptualization of vulnerability builds on the risks and natural hazards literature to consider the complex webs of economic, social, cultural, political, and environmental factors that influence sensitivity and adaptability at individual and community levels (Watts and Bohle, 1993; Adger and Kelly, 1999; Cutter et al., 2003; Turner et al., 2003; Adger, 2006; Folke, 2006; Smit and Wandel, 2006). Many studies in the Arctic and elsewhere have operationalized this conceptualization using the *vulnerability approach* (Belliveau et al., 2006; Ford et al., 2006a,b; Hesselberg and Yaro, 2006; Westerhoff and Smit, 2009; Pearce et al., 2010; Young et al., 2010; Berrang-Ford et al., 2012; Schilling et al., 2012; Bele et al., 2013; McCubbin et al., 2015; Connolly-Boutin and Smit, 2016).

The vulnerability approach seeks to describe the processes and forces that influence and structure vulnerabilities in specific places to help identify why vulnerability exists, and to identify opportunities for facilitating adaptation (Ribot, 2014). The vulnerability approach includes two stages of assessment. The first stage assesses current vulnerability by documenting how people are exposed and sensitive to climatic conditions, and the adaptive strategies employed to deal with these conditions (Ford and Smit, 2004; UNDP, 2005). The second stage assesses future vulnerability by incorporating future climate change and social probabilities to estimate directional changes in exposure-sensitivities and associated adaptive capacities (Ford and Smit, 2004). Exposure-sensitivity refers to the susceptibility of people and communities to variable conditions. It is a joint property of the community characteristics (location, livelihoods, economy, infrastructure, etc.) and the characteristics of climate related stimuli (magnitude, frequency, spatial dispersion, duration, speed of onset, etc.) (Cutter, 1996; Adger, 2006; Smit and Wandel, 2006). Adaptive capacity and adaptation are closely related. Adaptive capacity refers to the potential of a community to adapt to climate change (including variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Adger, 2006; Smit and Wandel, 2006; IPCC, 2007). Determinants of adaptive capacity include the availability and distribution of resources, available technology, structure and function of institutions, human capital including education, social capital including property rights, the ability of decision makers to manage information, and the public's perceived attribution of the source of stress (Yohe and Tol, 2002; IPCC, 2007). These attributes will differ among regions, communities, and individuals, and will vary over time, translating into different capacities to adapt (Duerden,