# Adaptation—Genuine and Spurious

## Demystifying Adaptation Processes in Relation to Climate Change

*Thomas F. Thornton and Nadia Manasfi*

**ABSTRACT:** In climate change discourse and policy, adaptation has become a critical byword and frame of reference. An implicit assumption in much of the strategizing is the notion that adaptation can be rationally planned, funded, and governed largely through existing frameworks. But can adaptation really be managed or engineered, especially given the significant unpredictability and severe impacts that are forecast in a range of climate scenarios? Over millennia, successful societies have adapted to climate shifts, but evidence suggests that this was often accomplished only through wide-ranging reorganization or the institution of new measures in the face of extreme environmental stress. This essay critically examines the concept of human adaptation by dividing it into eight fundamental processes and viewing each in a broad cultural, ecological, and evolutionary context. We focus our assessment especially on northern indigenous peoples, who exist at the edges of present-day climate governance frameworks but at the center of increasingly acute climate stress.

**KEYWORDS:** adaptation, Arctic, climate change, culture, development, indigenous peoples, vulnerability

Adaptation has become a key watchword and action frame in climate change discourse and policy. In 2009, prior to the Copenhagen climate summit, United Nations Secretary-General Ban Ki-moon referred to climate change as "the greatest collective challenge we face as a human family," in response to which it is "absolutely crucial that the world agrees on a comprehensive framework for adaptation." Yet adaptation is not clearly defined in the text of the landmark 1992 United Nations Framework Convention on Climate Change (UNFCCC). It is mentioned only in relation to stabilizing greenhouse gas emissions at a level where adaptation of ecosystems, food production, and sustainable economic development are all still possible (Article 2), committing parties to develop adaptation programs (Article 4.1[b]), and encouraging cooperation in adapting vulnerable areas to climate change (Article 4.1[e]) (see Ford et al. 2007; Schipper and Burton 2008; Smit et al. 2000).

But can adaptation really be managed or engineered, especially given the significant unpredictability, stress, and impacts forecast in various climate scenarios? Can infrastructure and development projects simply be 'climate-proofed' as a matter of planning or 'mainstreaming'

*Environment and Society: Advances in Research* 1 (2010): 132–155 © Berghahn Books
doi:10.3167/ares.2010.010107

adaptation into existing frameworks? While successful societies have adapted to climate shifts for millennia, often adaptation was achieved only through radical reorganization or innovation in the face of destabilizing environmental stress. Or, as per Romer's rule, new adaptations were enabled by evolutionary changes that initially were selected in order better to maintain existing patterns of life (Allaby 2004). In short, adaptation is often a blind process that can be viewed as 'rational' only in hindsight. As a participant in the 2009 15th UNFCCC Conference of Parties (COP15) in Copenhagen suggested, "In order to say something about adaptation, you need to have lived for 10,000 years."

In the emerging mainstream climate change literature on adaptation, recognition of the power of so-called autonomous adaptation has often been neglected in favor of what may be termed 'planned' adaptation, that is, what humans must rationally do in order to reduce risk and vulnerability. This perspective, perhaps fueled by a progressivist, 'techno-fix' bias, often leads to the downplaying of ongoing processes of autonomous adaptation at the local level. This point is made forcefully in a recent Commission on Climate Change and Development report, produced by the Swedish Ministry of Foreign Affairs, which seeks to counter this bias (Christoplos et al. 2009: 3):

> [A]daptation should be built on efforts to more effectively support individuals, households, and businesses as they struggle to adapt to climate change and … this should be done with a deeper awareness of the social, economic, cultural, and political factors that frame their actions, incentives, opportunities, and limitations for action … The poor adapt in ways that are usually unnoticed, uncoordinated, and unaided by national governments, development agencies, or international agencies. People draw on resources and support from these sources, but they do it in ways that are rarely reflected in the formal mechanisms designed for poverty reduction and climate adaptation.

This realization is perhaps the beginning of a potentially constructive 'retrofitting' (Head 2009) of the concept of adaptation (long a part of biological and anthropological studies) to the considerable challenges that human societies face in the context of present and future climate change and other drivers of cultural change, such as development and globalization (Liverman 2008).

This essay seeks to contribute to this constructive retrofitting by examining critically the concept of adaptation and related ideas such as mitigation, vulnerability, and adaptive capacity in a broad cultural-evolutionary context, focusing especially on northern indigenous peoples, who are at the margins of current climate governance frameworks but at the center of increasingly profound climate stress. We review key themes in the adaptation literature with an eye toward sharpening the conceptualization of adaptation as a process and, in the spirit of Sapir's (1924) critique of the culture concept, highlight some genuine and spurious assumptions about the nature of adaptation. The case of northern indigenous peoples is explored in detail because these groups are on the front lines of climate change. Moreover, they are active not only in autonomously adapting to profound climate stress and to rapidly changing and less predictable environmental conditions, but also in shaping more just and efficacious national and international climate policies based on diverse but comparable local knowledge, cultural practices, and adaptation processes.

## Defining Adaptation

Adaptation has been defined in many ways, and its meaning has evolved over time and as a result of consideration by scholars in different fields of study (Smithers and Smit 1997). In the biological sciences, adaptation refers to "genetic characteristics which allow individual organisms

to survive and reproduce in the environment they inhabit" (Smithers and Smit 1997: 133, after Winterhalder 1980; see also Abercrombie et al. 1977; Lawrence 1995). Critically, the process of adaptation requires variation or diversity in the fundamental building blocks of the organism—genes in biological evolution—in order for environmental selection to operate successfully, favoring some characteristics over others. As an aspect of evolution, adaptation also requires a process of transmission through which those genetic characteristics that compete successfully within a selective environmental context are passed on to future generations.

In the social sciences, cultural adaptation typically refers to the processes by which individuals and groups of people adjust their behavior and organization in response to changes in their environment (Denevan 1983; Hardesty 1986; Smit et al. 2000). Like biological adaptation, cultural adaptation requires diversity in the fundamental building blocks of culture (ideas, practices, etc.),[1] as well as a system of reproduction (imitation, learning, etc.) and inheritance (cultural transmission). At another level, human adaptation is strongly linked to environmental extensity and diversity in that humans not only adapt to their existing environments but, when not ring-fenced by environmental or political barriers, also seek new environments and niches when their existing ones become too stressed or stressful.

Putting the biological and the cultural together, the Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). This definition conveys the dynamism of adaptation in relation to both natural and human cultural systems. However, an awareness of the multi-scalar and coupled nature of human and biological networks as socio-ecological systems (Berkes and Folke 1998; Gallopín et al. 1989) is critical to understanding both stimuli and responses to processes such as climate change. When socio-ecological systems are linked through vast institutions (e.g., global markets) and environmental processes (e.g., climate change), the adage that 'all adaptation is local' proves false. Local adaptation may help a community-level socio-ecological system make minor improvements while neglecting major regional or global environmental forces and structural violence (Farmer 2003) that may be constraining or undermining it extra-locally. Although a useful heuristic, in reality few socio-ecological systems are discrete or simply joined; rather, they are nested and complexly linked. Young et al. (2006: 314) have particularly emphasized globalization as a phenomenon in which "linkages between biophysical and social systems across space and time produce surprising dynamics and novel emergent properties" across socio-ecological systems. Understanding these linkages presents a formidable challenge to researchers and policy makers in their efforts to assess resilience, reduce vulnerability, and build adaptive capacity.

Until recently, adaptation was neglected by the UNFCCC in international climate policy deliberations in favor of mitigation (Pielke et al. 2007; Schipper 2006). Reasons for this include (1) the fear that focusing on adaptation might give the impression of resignation and weaken the social will to mitigate; (2) the difficulty of incorporating and evaluating adaptation measures into negotiations, considering the uncertainty of climate change impacts (Burton 2008; Füssel 2007; Kates 2000; Pielke 1998); and (3) the notion that adaptation costs can be significantly compounded if mitigation is not attended to first (Stern 2007). However, the 2001 Marrakech Accords developed funding mechanisms to assist developing countries in adapting (Adger et al. 2003), and adaptation was included as one of the four pillars for any post-Kyoto Protocol agreement in the 2007 Bali Road Map and Action Plan (Schipper and Burton 2008). International financial commitments to adaptation continue to rise, most recently as a result of COP15 and COP16 agreements to boost funding for mitigation and adaptation by up to $100 billion a year by 2020, although which entities (including newly created ones) and initiatives will get the

money has not yet been determined. To make the best use of adaptation funding mechanisms, a better understanding of contemporary and historical processes of adaptation in relation to climate change and other stressors in existing socio-ecological systems must be developed.

Climate change can impact the way that individuals interact with their natural and social environments, possibly resulting in irreversible losses to a community's cultural heritage (Adger et al. 2009) or even the extinction of communities or segments of society. Alternatively, over time, cultural adjustments, innovations, and the transmission of key ideas and artifacts to younger generations may result in an enriched cultural repertoire with well-designed adaptations (Boyd and Richerson 2005; O'Brien and Holland 1992). Significantly, there is no guarantee that adaptation will happen on any level, or that adaptation at one level (e.g., community environmental management) might not be maladaptive at another level (e.g., national security). In essence, adaptation is a blind, complex, dynamic, and contingent process. While politics emphasizes the short-term view, human adaptation must be judged from a long-term perspective. Further, given the inherent uncertainty with respect to the future, a long-term view of past socio-ecological systems that have adapted to climate change is a critical, yet underutilized, tool in adaptation assessment and planning. Dearing (2008), for example, analyzes some 3,000 years of erosion and land use, what he terms 'slow' environmental change processes, relative to 'fast' changes, such as monsoon intensity and flooding, in Yunnan, China. Such 'historical profiling' of landscapes requires a mixed methods approach that involves anthropological, geographical, and environmental science investigations in order to map the 'adaptive cycle' on to the millennial record of climate, land, and resource changes.

In a recent critique of the climate change literature, Nelson et al. (2009: 272) note that "climate-change debates have historically focused on technologies and the elusive search for large-scale, cookie-cutter solutions, leaving aside the important role that individuals, cultures, and societies play in constructing and living out an adaptation dynamic" (see also Finan and Nelson 2009). Similar critiques have been leveled at the development literature (Escobar 1995; Ferguson 1994; Shiva 1989), and, as in the development case, a remedy is often seen in the advent of 'community-based' approaches in which local stakeholders take part in the process of determining their own futures. Yet existing national plans, whether promoting development or adaptation, typically have not paid sufficient attention to the critical role that local institutions play in these processes, or how they link populations and policies in practice. As Agrawal (2008: 50) observes concerning adaptation, "As a result, despite a stated commitment to grassroots involvement, the actual focus in national adaptation plans is on technical and infrastructure options for adaptation, with little attention to their social and institutional context."

Just as it is a mistake to reify techno-fix as the only viable mode of adaptation, it can be similarly wrongheaded to regard existing polities or institutions, be they states or local communities or civic organizations, as the critical units of adaptation. Communities themselves can be adaptive or maladaptive and even multi-scalar, given modern communication, transportation, and identity networks. Community-based approaches often neglect these dynamics. Similarly, states have been reified as a political unit for adaptation. As the principal actors under the UNFCCC, states are seen as the critical agents in mitigating and adapting to climate change. If one takes the long view, however, states generally have evolved not so much to adapt to environmental constraints but rather to transcend them—through expansion, military conquest, or trade. As Carneiro (1970) hypothesized decades ago, states tend to develop in order to overcome conditions of environmental circumscription that limit organic processes of expansion and increase resource competition, stress, and conflict among expanding populations.

In the circumpolar North, most sedentary communities today are the products of expanding or developing states that actively sought to demobilize hunting-gathering peoples in order

to exploit their territories and 'civilize' them through missionary work, education, collectivization, and other forms of economic rationalization and development. This process of state making enabled Arctic states to colonize the so-called Fourth World (Hall 1988) of marginal 'frontier' lands and indigenous peoples in order to exploit new sources of industrial wealth, such as minerals, oil, and gas, as well as to secure their borders during the Cold War through militarization in the interests of 'national security'. Similar processes have enclosed mobile hunter-gatherers, pastoralists, and swidden agriculturalists in other parts of the world. As a result, these communities typically have become more environmentally vulnerable, more economically dependent on the state and global economy, and less diverse and resilient in terms of their livelihoods and cultural repertoires. While growing states have invested heavily in infrastructure to create certain kinds of peripheral communities in order to facilitate national goals, these marginal areas are often the first to suffer from divestment during economic downturns. In the Far North, as in other 'frontier environments', this is manifest in the classic 'boom and bust' cycles of the natural resource economies, which bring not only short-term socio-economic vulnerabilities but often long-term environmental and politico-economic problems, or what is sometimes referred to as the 'resource curse'. This pattern is especially acute in Russia due to the sudden withdrawal of the state from rural collectivization projects beginning in the 1980s, combined with the aggressive industrial development of selective regions based on their natural resources (Crate 2006; Ziker 2002).

Anthropological studies suggest that the most resilient and adaptive social unit over long periods may be the household rather than the community or state (Netting 1993; Netting et al. 1984). In the past, households and extended families have been the critical units for responding to crises spawned by climate variability and cyclical environmental stresses, such as food and water shortages. Households continue to adapt in patterned yet diverse ways to the stresses of modern climate, food, water, and economic crises. Analyzing data over a 30-year period, West (2009: 286) reports in his study of Mossi household organization in Burkina Faso that extended households "persist because they are better adapted to conditions of heightened agro-climatic risk brought on by regional desiccation. They are also better able to take advantage of opportunities to intensify agriculture." A key to their adaptive capacity is the unique ability of households to engage in processes of 'extension' and 'fragmentation' according to ecological constraints. Modern communities and states often lack this flexibility, with the result that responses to environmental change can be more stressful, especially on the most marginal settlements and segments of the population. In the next section we look more closely at central adaptation processes adopted by households and other social groupings.

## Adaptation as Intersecting Processes

Cultural adaptation is an ongoing set of processes that must be viewed holistically over time. Smit et al. (2000) present a practical way of classifying aspects of cultural adaptation based on (1) who/what has to adapt (the system of interest), (2) what they have to adapt to (the stimulus), and (3) how they adapt (the processes and forms). The system of interest can vary from a whole system or country to individuals or species. It may be adapting to long-term mean climate variability, climate extremes, future climate change, or the risks and opportunities of climate stimuli, among other things. The adaptation process itself can vary in intent (autonomous, planned), timing (anticipatory, reactive), temporal and spatial scope, and form (technological, behavioral, institutional, etc.).

Given the dynamic and complex nature of adaptation and the bias of policy makers in favor of certain contemporary units (states, communities) and modes of adaptation (e.g., techno-fix)

over others, we favor a processual approach that revolves around eight key dimensions of human adaptation without preference for a single social unit or mode. These dimensions are mobility, exchange, rationing, pooling, diversification, intensification, innovation, and revitalization. While functional overlap may occur between these processes, each has a unique motivational core that distinguishes it from the others. In addition, we emphasize a long-term view of human adaptation that analyzes historical and contemporary processes at work and the convergence and disjuncture between forces of environmental change and human livelihoods over long time periods and multiple spatial scales. In the literature to date, the conceptual approach that most closely mirrors ours is that developed by Halstead and O'Shea (1989), on how cultures manage risk, and further refined by Agrawal (2008), in the context of rural institutional adaptation. However, here we have expanded the discourse beyond modes of adaptation in primarily rural contexts to a wider, more basic discussion of fundamental human adaptation processes.

We first define and characterize these adaptation processes and then assess how they are playing out in autonomous and planned contexts in response to climate change in northern indigenous communities and states. Table 1 provides an overview of the eight processes.

**Table 1:** Adaptation processes: Overview

| **Adaptation Process** | **Description** |
|---|---|
| Mobility | Seasonal movement or permanent migration to avoid risk or in search of better circumstances |
| Exchange | Flow of material and symbolic goods and services between people |
| Rationing | Controlling the circulation or consumption of limited or critical resources among members of a group |
| Pooling | Sharing or linking of assets (wealth, labor, knowledge) across social groups |
| Diversification | Increasing the variety of food, income production strategies, specialization, etc., to enhance livelihoods |
| Intensification | Increasing the availability of resources by boosting their yield within a certain space or time |
| Innovation | New, unplanned method or technique that arises to address a certain need |
| Revitalization | Organized reconfiguration of ideology and practices to reduce stress and create a more satisfying culture |

1. *Mobility*. Whether through seasonal movements or permanent migrations, humans have sought to avoid environmental risk and obtain better circumstances. Despite the development of agricultural and industrial states and the decline of more nomadic modes of subsistence, such as foraging and pastoralism, human migration has increased, largely as a response to economic and environmental stresses and perceived opportunities in alternative environments. Richerson and Boyd (2008: 877) observe that "migration has a profound effect on how societies evolve culturally because it is selective. People move to societies that provide a more attractive way of life and, all other things being equal, this process spreads ideas and institutions that promote economic efficiency, social order and equality."

Rather than being a source of conflict and instability, migration may act as an engine of social change. Of course, this assumes voluntary migration rather than forced relocation or situations that involve so-called climate and environmental refugees, who may lack choices about whether or where to move. It also assumes that host societies have the ecological capacity and adequate

ecosystem services to absorb migrants in sustainable ways, as well as the institutional means to adapt to potential socio-cultural 'organization of diversity' issues (Wallace 2009) posed by immigrants. Involuntary relocations especially can lead to incalculable cultural disruption, loss of livelihood, and increased dependency and stress (Oliver-Smith 2009). Presently, many such migrants are being absorbed into highly exploitive industries and urban slums, which are neither equitable nor sustainable. Unfortunately, under probabilistic scenarios generated in response to climate models, this is a process that is expected to intensify. As a result, conflict between migrants and residents in receiving areas may arise as a result of competition, ethnic tension, distrust, socio-economic fault lines, and political instability (Reuveny 2007).

In the modern industrial context, human mobility is intricately regulated by institutions and policies linked to immigration, transportation, and the enclosure of common lands into private space or property. A lack of sedentism can be confounding to states seeking to improve security or productivity through modernization, land use planning, and development. Nevertheless, it may be short-sighted to view mobility as maladaptation simply because it poses potential short-term social and political instabilities. As Agrawal (2008: 19) points out, mobility remains "a way of life for large groups of people in semi-arid regions, and a long standing mechanism to deal with spatio-temporal variations in rainfall and range productivity," especially among pastoralists (Niamir-Fuller 1999). Among northern indigenous pastoralists and foraging peoples, mobility remains a key dimension of economic production and adaptation (Rees et al. 2008).

2. *Exchange*. Like the flow of people, the flow of material and symbolic (knowledge) goods and services are a foundation not only of today's global economy but of every economy in history. Agrawal (2008: 21) observes that market exchange "is perhaps the most versatile of adaptation responses … to environmental risks but also … for specialization, trade, and welfare gains that result from specialization and trade at multiple scales." Agrawal cites a recent spate of insurance schemes to mitigate against weather-related damages among agricultural and pastoralist populations as an example of market exchange as a mode of adaptation.

A critique of the current dominant strategies of economic exchange is that the costs of exchange are being born disproportionately by the world's poor, underdeveloped, and thus most vulnerable communities, with negative consequences on their adaptive capacity. Their resources, natural and human, are being exploited at unsustainable rates in order to supply wealthier interests with resources, goods, and services. In its more extreme form, this inequitable, asymmetrical exchange (or negative reciprocity, as anthropologists refer to it) leads to a kind of 'eco-imperialist' expropriation, if not underdevelopment, of local environmental resources and ecosystem services (and even carbon) by well-financed (often distant) interests at the expense of the poorer local communities that depend on them for their livelihoods (Shiva 2008). The same is true of the knowledge economy, wherein intellectual property, even when based on local and traditional knowledge, can be captured as private property through patents and other legal regimes, or what Harvey (2005: 159) refers to as "accumulation by dispossession."

3. *Rationing*. All human societies have developed schemes and technologies for allocating provisions and other limited or critical resources among their members. The fundamental objective of rationing is to extend the supply of resources by controlling their circulation and consumption over time and space, and storage is among the most basic forms of rationing. The development of storage and preservation techniques has bolstered the resilience of households and communities enormously by allowing the consumption of otherwise perishable resources, such as fresh foods, over extended periods. Even among foraging societies with high mobility, these techniques have been instrumental in reducing risk due to climate and resource variability, as

evidenced by the widespread practice of caching foods among northern hunter-gatherers. The stockpiling of critical resources, such as energy, seeds, or even genetic material, is a modern means of utilizing storage to ration consumption (and conserve diversity) over time. In the case of genetic banking, it is a way of preserving biodiversity for the future by avoiding extinction due to present levels of consumption or destruction.

Rationing also can be applied to activities or elements that have a negative impact on critical resources or ecosystem services, such as pollution or overpopulation. Carbon capture and storage, for example, is seen as a potential technological solution to reducing the ill effects of carbon dioxide emissions into the atmosphere by rationing their release through sequestration. Cap-and-trade schemes are another potential means of controlling pollution (via the 'cap'), according to market-based principles. Rationing strategies are often productively linked with systems of exchange or pooling. Population control by limiting birth rates is among the most controversial of rationing programs, especially when it is applied coercively. Fortunately, there are many means available for promoting sustainable population growth at the family, ecosystem, regional, and national levels (Sachs 2008: 185).

Significantly, rationing does not by definition reduce consumption or pollution; rather, it may simply redistribute it. Similarly, rationing schemes do not necessarily result in greater equity among consumers or citizens. Population rationing programs, for example, may be nullified by increased per capita consumption of resources, or they may exacerbate existing inequalities due to differential values placed on children. Nevertheless, rationing remains among the most powerful adaptation tools that humans have developed for both limiting consumption and ensuring the equitable distribution of resources, including ecosystem services such as clean air and water.

4. *Pooling*. At base, pooling is a form of holding, sharing, or linking assets across social groups. Agrawal (2008: 20) defines it as "adaptation responses involving joint ownership of assets and resources; sharing of wealth, labor, or incomes from particular activities across households, or mobilization and use of resources that are held collectively during times of scarcity." Adaptive pooling assumes the ability to distribute or convert accumulated assets when needed in times of environmental stress (Moench 2007).

Perhaps the most important asset that can be pooled is credible knowledge. Credible knowledge is information that has been critically assessed by and rendered meaningful to members of a community. In the literature there is strong emphasis on improving the flows of information and scientific knowledge to communities. However, if the source of this information is not considered credible, or if the information is not considered relevant in terms of on-the-ground experience, such information pooling is unlikely to be successful. For example, regional weather forecasts or climate predictions may be judged as non-credible at a local level due to their higher incidence of error compared to local knowledge or monitoring techniques (cf. Strauss and Orlove 2003).

How communities pool resources is partly determined by tenure arrangements. Tenure systems are a means by which human societies hold prerogatives over key resources such as land, water, and knowledge. Tenure requires schemes for reckoning boundaries, access, and transfer. Such systems may facilitate or inhibit pooling, and globalization raises linkage potentials, as well as multi-level commons and tenure problems (Berkes 2007). Intellectual property tenure systems, for example, often seek to prevent pooling of information without formalized exchange or payment. As Brush (1999: 539) observes in the case of intellectual property patented through bio-prospecting in indigenous communities, "The monopoly privileges that one community can gain affect other communities that share the same knowledge and resources. If knowledge and genetic resources collected under contract lead to a patentable product, communities that

are not part of the contract but have the same resources can be deprived of the opportunity to commercialize their knowledge." The monopolization problem also exists for material resources and services, as evidenced by strategies to privatize access to critical adaptation resources such as public land, water supplies, and utilities. Such schemes of accumulation by dispossession undermine the pooling of common resources and, according to neoliberal critics, lead to the "escalating depletion of the global environmental commons (land, air, water) and proliferating habitat degradations … [resulting] from the wholesale commodification of nature in all its forms" (Harvey 2005: 160).

5. *Diversification*. Diversification is a form of risk management that typically refers to food and income production strategies. But at a more basic level, diversification is adaptive because it either introduces or maintains variations upon which future cultural adaptation processes can act. Significantly, diversification does not negate specialization, except perhaps at the level of the individual organism. Depending on the social unit, organic specialization may occur at various scales. For example, in a household there may be a division of labor whereby a grandmother specializes in child care or food preparation, or young males specialize in hunting mobile prey, and so on. As with the other strategies, diversification is a hedge against uncertainty and a means of maintaining the availability of critical resources, including money.

Too much diversification can be limiting or even maladaptive, especially if it means a loss of knowledge and skills. Denevan (1983: 402) suspects that most diverse techniques of environmental manipulation are long present within a culture, perhaps as marginal or secondary strategies, before widespread adoption occurs, as opposed to being introduced 'Eureka style' through radical innovation. When minority strategies are perceived to respond to an identified need, more widespread use of these already available techniques (or concepts) results. The development of agriculture may very well have evolved along these lines, initially as a marginal or subsidiary diversification strategy, subordinate to foraging, which was not adopted wholesale until it was perceived to be more adaptive due to changes in socio-ecological or environmental conditions (see Bellwood 2005; Richerson et al. 2001; Rindos 1984; Winterhalder and Kennett 2006).

Niche theory holds that diversification in terms of livelihood may reduce competition and resource stress within or between species inhabiting the same area or ecosystem. Due to mobility and cultural adaptation, humans are able to dwell in an extremely broad range of habitats and are thus able to exploit a wide spectrum of niches. Niches and cultures may be co-evolutionary and co-dependent, shaping each other in fundamental ways to the point that one cannot truly exist without the other. Historical and anthropological studies suggest that ethnic and linguistic diversification may be associated with niche specialization. For example, Barth (1956) shows how niche specialization through partitioning (to reduce livelihood overlap) among the inhabitants of the rugged mountains and river valleys of northern Pakistan led to the formation and co-existence of three distinct ethnic groups. As a result of climate change, fundamental niches may also change, and there may be significant lags in the formation of realized niches, which adaptation policies could address (Pidwirny 2006).

6. *Intensification*. Intensification is a means of increasing the utilization of resources by boosting their yield within a certain space or time. Its inverse process is extensification, which typically implies mobility (and is thus partially treated under that rubric above, rather than separately). Agricultural intensification, through the Green Revolution and other technological and organizational innovations, has been a favored adaptive strategy for increasing food yields in conjunction with expanding populations. However, the dominant strategy of increased dependence

on engineered seeds, irrigation, chemical fertilizers, pesticides, and mechanization has been criticized as maladaptive for its deleterious ecological consequences, such as soil erosion and compaction, pollution, and loss of biodiversity, which have brought harm to a range of species through habitat loss or degradation (see, e.g., Birdlife International 2008).

Intensification can also lead to centralization and reduced diversity. In the realm of food production, this can be seen in the reliance on fewer varieties of agricultural seeds, developed and patented by large multinational agribusinesses, which are considered more efficient in maximizing yields and can be co-engineered with supplementary inputs such as fertilizers and pesticides. Dependency on fewer seed varieties and their specific inputs can lead not only to increased environmental impacts but also to greater vulnerability for local groups if the price, supply, or efficacy of these non-local products is adversely affected.

These criticisms notwithstanding, intensification as a broad adaptive strategy need not, in theory, be a zero-sum game for humans at the expense of other species or local diversity. Intensification may be achieved simply by improving efficiencies and making resources more usable, for example, by reducing waste through consuming rather than discarding vegetable or animal parts, or by using 'waste' to enhance environmental habitats (e.g., through fertilization). Among northern reindeer-herding peoples, a flexible dynamic between intensification and extensification of grazing in relation to land and labor conditions has proven highly adaptive over time. However, this flexibility has recently been compromised by reindeer 'rationalization' schemes that trade flexibility for more rigid territorial regimes and greater dependency on state subsidies or economic diversification (Beach et al. 1992).

7. *Innovation*. Innovation is perhaps the most cited but least understood of adaptation processes. As noted in the discussion above on diversification, the seeds of adaptation are often born not of true innovation but rather of shifts from dominant to minority strategies in the context of environmental change. True innovation, akin to mutation in biological evolution and adaptation, is typically random and therefore very difficult to predict or plan. Thus, it is problematic to rely upon innovation, whether technological, ideological, or organizational, to build adaptive capacity. Still, there is no doubt about the significance of innovation in the history of adaptation. Among Arctic indigenous peoples, for example, the invention of the toggle harpoon and float had a major effect on the adaptation and successful spread of Inuit culture across the northern Arctic coast of North America in conjunction with marine mammal populations, such as seals, which could not be reliably secured with simple spears. While modern tools have replaced many traditional technologies, the toggle harpoon persists because it retains numerous advantages for landing large sea mammals from breathing holes or open water. Moreover, the tool itself continues to be adapted and refined (Arnold 1989: 81).

Selective forces perfected the toggle harpoon to the extent that it was adopted (and mechanized) by the whaling (oil) industry in the mid-nineteenth century. However, as with many technological innovations applied on an industrial scale, the mechanized whaling harpoon was overdeployed, leading to a worldwide decline in whale populations, the eventual collapse of the industry, and the whale rationing system that exists today through the International Whaling Commission.

Innovation within a system may affect vulnerability and resilience in unanticipated ways. In the Middle East, Jordan illustrates a case of low system resilience that resulted in an inadvertent transformation. An expansion of land use (extensification) combined with advancements in agricultural technology (innovation) allowed agricultural output to increase. However, a lack of proper resource management eventually resulted in land degradation and a weakening of the socio-ecological system. It has been suggested that the agricultural system in Jordan ultimately collapsed due to a period of climatic stress (Nelson et al. 2007).

8. *Revitalization*. Revitalization is a society's capacity to adapt to environmental stress through a structured reconfiguration of its ideologies, practices, and organization in order to reduce stress and create a more satisfying culture (Wallace 1956). Revitalization theory as applied to social movements has been criticized for, among other things, its reliance on the metaphor of society as an adaptive 'organism' with a 'homeostatic' state (Harkin 2004), as opposed to a complex 'panarchic' system with multiple states (see Gunderson and Holling 2002). Yet there is no questioning the power of social movements to produce adaptive social change and more sustainable livelihoods by redefining human priorities and codes for living. Wallace (1956) emphasizes that such revitalization requires both reformulating old 'mazeway' patterns of cognition and routinizing new adaptive 'codes' for living. Often the new codes are defined by charismatic leaders at the margins of society who can see beyond current cultural models. Obviously, this new vision ultimately must be grounded in the material exigencies of life and successfully institutionalized if it is to survive.

From the perspective of adaptation, revitalization is important because it allows humans to achieve rapid social change in response to environmental shifts or stresses without recourse to violence or competitive conflict. Frequently, revitalization involves syncretism wherein traditional knowledge and lifeways are constructively realigned to respond to contemporary socio-ecological constraints. For example, in Wallace's (1956) prototypical case for revitalization—that is, the Code of Handsome Lake movement among the Seneca Iroquois of New York—the prophetic leader's vision included sanction for men to shift their productive roles in society from hunting to agriculture (formerly dominated by women). This was consistent with evolving material conditions that had resulted in declining game resources, decreasing land base and access to traditional hunting areas, and the concomitant growth of sedentism and agriculture in that area in the late eighteenth century.

Beyond social change, revitalization is an important means of restoring ecosystems and reducing stress on human health. Civic agricultural and local food movements are examples of efforts to revitalize selective aspects of traditional agriculture within a modern context of valuing diversity, quality, sustainability, and connections to land, place, and community (Lyson 2004). Similarly, efforts to restore urban pedestrian and communal spaces for congress, passage, and exchange may be seen as an attempt to revitalize healthy and sustainable aspects of urban culture while at the same time reducing human stress brought on by poor design, short-sighted planning, and mechanical obeisance to automotive transport. Revitalization is also evident in a variety of ecosystems that range from forests to deserts. Also included are marine contexts with efforts to restore important coastal habitats, such as wetlands, lagoons, reefs, and mangroves (Berkes 2008), and critical ecosystem foundation species, such as herring, often using local and traditional knowledge (Thornton et al. 2010). The Convention on Biological Diversity (CBD) calls for the adoption of measures to revitalize threatened species through reintroduction, combining *ex situ* sources with *in situ* measures for reducing the forces that drove them toward extinction in the first place.[2] Such repair efforts require social change and adaptive (co-)management (Berkes et al. 2007) in order to be successful in the long run.[3] To the extent that they can be effectively institutionalized and remain responsive to objective conditions, revitalization processes are critical to socio-ecological adaptation.

All of the above adaptive processes involve technologies, learning, and institutions at various scales, from the most basic households, using their members' embodied technologies of ambulation and speech to navigate and communicate the lay of the land, to the most complex states or multinational entities, which use supercomputers and other specialized tools to coordinate international transportation, model changes in climates, monitor trading, and optimize commodity

exchange. The mixture of adaptive processes is complex and constantly changing, not only in relation to environmental constraints, but also in relation to other adaptation responses. Thus, adaptive processes must be understood as both drivers of change and responses to change.

## Adaptation in Northern Indigenous Communities

The severity and disproportionate effects of climate change on communities of the Far North are well known. In Alaska alone, a recent report by the US Government Accountability Office concludes that 31 villages "face imminent threats" from climate change, and that 12 have decided to "explore relocation options" (GAO 2009: 12). However, as the report's own title indicates, only "limited progress has been made," in part due to the fact that government bureaucracies remain uncoordinated and unable to reassess their institutional priorities in relation to climate change and adaptation needs. Instead, "In the absence of a lead entity, federal agencies individually prioritize assistance to villages on the basis of their programs' criteria, which do not necessarily ensure that the villages in greatest peril get the highest priority for assistance" (ibid.: 36). The magnitude of accelerated climate change impacts on Arctic communities has made them the focus of intense scrutiny by national and global media, seeking to personalize and ground the effects of climate change in real life (Henshaw 2009; Marino and Schweitzer 2009). Many see the Arctic as being on the threshold or tipping point of major systemic transformations.

Arctic climate change impacts are driven by key physical and biological processes that are increasingly well-documented (ACIA 2005; IPCC 2007; UNESCO 2009). The most important of these are annual average temperature increases. In Alaska, the increase is 1.9 °C since the mid-twentieth century, about twice the rate of the rest of the US. Temperature increases, in turn, drive other environmental changes that include melting and retreating of snow cover and changing snowpack structure; melting of large glaciers and ice sheets; retreating sea ice; permafrost degradation; changing river and lake ice magnitude, timing, and stability; changes in precipitation; and increased exposure to ultraviolet radiation. Climatic changes and impacts of this magnitude have not been experienced in the Arctic for over 100,000 years.

As a result, Inuit and other northern peoples find themselves in the position of having to adapt to these unprecedented complex, interacting, and non-linear changes in short order. At COP15, we carried out interviews with 12 northern indigenous leaders and representatives, many of whom commented that their own households and communities were "already adapting," but that states and their governing institutions were not adapting or were not helping their communities to reduce climate vulnerabilities and build adaptive capacities rapidly enough.[4] The major literature on Arctic adaptation (e.g., Ford 2009; Ford and Furgal 2009; Furgal and Seguin 2006; Furgal and Prowse 2008; Krupnik and Jolly 2002; UNESCO 2009) supports this perspective, as do the major indigenous organizations, such as the Alaska Federation of Natives (AFN 2008), the Inuit Circumpolar Council (ICC 2005; Watt-Cloutier et al. 2004), and the Russian Association of Indigenous Peoples of the North (RAIPON). The following statements are representative of recent indigenous peoples' climate change adaptation and vulnerability assessments in the Far North.

> *Canada*
> Interviews conducted [for an Inuit Circumpolar Council] indicate that despite the increased difficulty in finding and harvesting big game and sea mammals due to thinning and less predictable sea ice, Inuit communities are persistent in maintaining their traditional diets. When asked whether changes in ice conditions were affecting their traditional diets, respondents spoke of having to travel farther or in a different month than usual; they spoke of dietary substitutions such as hunting more musk-oxen when the caribou migration shifted away from

their area, or they explained how melting permafrost has made the natural ice cellars used to age and store meat less effective. (Smith 2009: 17)
A buddy of mine is into making little sleds out of aluminum, which you can use as a little kayak or boat. If you're out on the ice and you have to cross an open lead or something you can use that … It's combined as a little sleigh and, if you have to, you can use it as a boat. That's one way I can adapt. (John Keogak, interview in Smith 2009: 19)

And because the permafrost is melting, infrastructure is starting to become damaged … The roads are starting to be … wobbly…

We're also starting to see different insects and blackberries that never came up to our communities. Polar bears are starting to wander closer into the communities [and] wolves …

[T]he fact that lakes are starting to dry up a little bit is causing flora that used to grow to not grow anymore, so different animals that used to come feed on that, like the geese, are going farther away from the communities, so hunters have to travel farther. The moss that the caribou feed on is starting to grow in different places, so the migration patterns are changing, and again, hunters have to travel farther …

There needs to be a bridge between that gap [between scientific studies and traditional knowledge] for mitigation and adaptation to be successful …

I'm only 20 years old but already the world that I was born into has changed so much … I'm really not sure what will happen in the future. (Janice Grey, interview, 2009)

*Alaska*
In later years, my father noticed how the climate seemed to be changing, and he would comment on how spring came earlier and warmed up faster, making our whaling activities more hazardous. We hunt from the edge of the shorefast ice in spring, and changes in the ice pack have a big impact on our ability to participate in this traditional hunt. As time went on, even us young folks could see the changes. The ice pack was shrinking, and shorefast ice was rotting earlier in the year, and the ice retreated farther out during the summer and stayed out longer. It was almost like a rug was being pulled from under us. (Itta 2009: 207)

There are changes in sea ice conditions, changes in weather, changes in coastal erosion problems, river system anomalies.

Eighty percent of our communities in Alaska are living along the coast, and there are examples of villages that are literally washing away because of the many storm surges and erosion … There used to be a wall of ice that protected the villages, but now, because the ice has changed, that is no longer there …

[I]t's not the same as it used to be when we were much more nomadic communities than now. Now we have our schools, our roads, and all these other things, so we can't pack up our tents and move quite as quickly. This has made a real difference in our ability to adapt in that way …

Some areas are looking at new [plants], new species, new food sources. They are relying on new sources that are now available. In Alaska there is a whole industry now growing up around shark fishing, and certainly this has not been the case historically in that area. You learn to deal with species that were not there before or were in much smaller numbers …

The modern technologies are now also looking back at how our people used to live. For example, in my community the house used to be subterranean, and now people are understanding why the homes were built in this fashion—they are the most ecologically friendly, they are more energy-efficient … and all the things that modern technology is now looking for. (Patricia Cochrane, interview, 2009)

*Greenland*
In Greenland, our Sila Inuk project focuses on Inuit hunters, asking them to document what climate change effects they have seen over their lives and what information they have gleaned

from their grandparents … Hunters speak of thinning sea ice that makes hunting much more dangerous, changes to permafrost that alter spring run-off patterns, a northward shift in seal and fish species, and rising sea levels with more extreme tidal fluctuations. One hunter told us, 'The sea must be getting warmer because it doesn't freeze where it used to, even when the air is very cold.' Another said that the snow melts so quickly in the spring now that 'it is as if the earth just swallowed it!' Many say their traditional knowledge is not as reliable as it was in the past for predicting safe ice conditions. This is a great source of anxiety for Inuit hunters. (Lynge 2009: 106)

*Fennoscandia*

The sensitive nature of the Arctic environment cannot sustain large numbers of people or the wide-scale exploitation of energy resources … Changes in the flora, fauna and climate, combined with the loss of entire living territories, will force indigenous people to seek new ways of adapting …

In addition to climate change, indigenous peoples must accommodate other competing land uses, such as oil fields, forest felling, tourism and mining … In reindeer husbandry, it may lead to a reduction in herd sizes, the need to acquire additional food for the animals, and changes in reindeer husbandry models and cultures. Continuous feeding will transform nomadic reindeer herding, bringing it closer to domestic animal husbandry … If reindeer herders have fewer reasons to travel within their environment, the use of environmental, snow and climate terminology will become less important, along with the ability to navigate within and read the environment … When reindeer no longer have some 300 plants in their diet, the taste and fat content of reindeer meat will change and the fat will become unhealthy. Due to climate change, the terminology and practical knowledge of nature and reindeer husbandry will decline and partly disappear. (Lemet-Klemetti Näkkäläjärvi 2009: 132, 140)

*Russia*

We have seen changes in nature and the climate, but it's very different from one region to another … [M]y region, Sakha Republic, is one of the coldest places in the world, where temperatures can go down to -50, -60, -70 degrees centigrade … In the tundra … we've seen that in that place where a few years ago there were no trees or crops, now there are …

We've also seen variability in the temperature in the fall. Before in November there was no rain, but now there is rain and the autumn is longer. After it rains, it can get very cold and an ice layer develops, which makes it very difficult for the reindeer to get to the food below. Also in winter it can rain and then it freezes—this is not good for reindeer health. We also see that because of the warmer temperature, the rivers and lakes are open longer. Because we are nomadic people, we are always moving with the reindeer, so we have to change our routes and change the time of moving …

But when you try to change the route, there will be other reindeer herders, and you will have the conflict between the reindeer herders and state enterprises of reindeer herding and private reindeer herding, so there is no clear regulation of land use …

We have new legislation about land now which states that, as of next year, reindeer herders need to buy or rent the pastures. But that is impossible because for one reindeer you need 300 hectares per year; so if you need to pay, you will need billions to rent …

One of the [adaptation] strategies is … when you get an ice layer, if you have a castrated bull in the herd, it will be strong enough [to dig through the ice], whereas the rutting males spend a lot of energy on getting the females and are weak and tired … [C]astrated males … are strong and they can dig through the ice layer, and the females then have access to the food. So you need to have castrates …

When there is a hot summer, we use the permafrost areas where the ice is open. This keeps the insects from attacking the reindeer … because it's colder there. But now with climate change, the number of these places is falling. Other strategies include building shelters for the

> reindeer to stay under in warm temperatures. We also burn moss to get the smoke that keeps insects away, but there are new kinds of insects. (Mikhail Pogodaev, interview, 2009)
>
> In the local context … pollutants take the form of thousands of empty metal drums, pesticides, radioisotope thermoelectric generators from lighthouses, and scrap metals abandoned by industry and the military. Waste burial sites remain in the permafrost, and with the permafrost thawing, the danger from this waste increases.
>
> The main result of all these problems is the depopulation of the North by the aborigines, with the loss of the unique northern gene pool and circumpolar culture.
>
> The most convenient 'solution' supported by the government is the displacement of aboriginal peoples from traditional spheres of life and economic activity, moving them into inhabited areas, and thus giving them the opportunity to receive unemployment benefits or to become workers in modern industries. This is a painful process for northern aboriginal peoples … In traditional economic activities reside the life and the future of the peoples of the North … With the destruction of this way of life certain aboriginal peoples will disappear. (Abryutina 2009: 168–169, 172)

Although not always couched in the same general terms, these perspectives emphasize the key adaptation processes examined above. Table 2 illustrates how the perspectives map on to these processes.

**Table 2:** Adaptation processes as applied to northern indigenous communities

| Adaptation Process | Description |
|---|---|
| Mobility | • Traveling farther to hunt sea mammals, collect plants, feed reindeer<br>• Relocating or migrating away from land that is vulnerable to storms or melting permafrost |
| Exchange | • Transfer of traditional knowledge (related to hunting, building shelters, etc.) across generations |
| Rationing | • Reduction in the size of reindeer herds to accommodate competing land uses, such as oil fields, forest felling, and mining<br>• Caching food traditionally in ice cellar storage, but this faces disruptions because of melting permafrost |
| Pooling | • Sharing new scientific knowledge and skills |
| Diversification | • Altering prey choice and diet breadth, such as hunting musk oxen when caribou is not available, or shark fishing in Alaska<br>• Use of castrates in reindeer herds |
| Intensification | • Feeding reindeer on smaller areas |
| Innovation | • Development of the hybrid aluminum sled-kayak<br>• Invention of the toggle harpoon and float |
| Revitalization | • Return to traditional knowledge, organization, and technologies, such as semi-subterranean house structures and communal living arrangements for resilience, cost savings, energy efficiency, etc. |

Mobility is discussed in terms of increased risk to travel; increased need to travel farther due to dispersals of wildlife populations (such as sea mammals), plants, or feed (reindeer); and increased circumscription due to competition from other users (herders), dependence on infrastructure (schools, roads, etc.), competing land uses (resource extraction or other herders), and even

'solutions' to displacement, such as relocation or depopulation through outmigration. Exchange and pooling are emphasized in terms of sharing new scientific knowledge, the reliability of traditional knowledge and skills and their transfer among generations, and sharing and tenure security over pools of subsistence resources. Rationing disruptions are caused by melting permafrost, which renders ice cellar storage ineffective. Diversification is highlighted in the need to alter prey choice and diet breadth and the use of castrates in reindeer herds. Intensification is discussed in terms of reindeer feeding and corralling, rather than pasturing, and also in the ill effects of intensified resource exploitation, particularly hydrocarbon extraction from Arctic lands and waters, in contradistinction to what is needed to reduce global warming. Innovation is highlighted in the hybrid sled-kayak that allows for better navigation, given the expanding leads between ice floes. Finally, revitalization is framed in terms of a return to traditional forms of knowledge, organization, and technologies. This is seen as part of an effort to re-empower northern indigenous peoples to determine their own cultural path of adaptation and development in the context of climate change, with appropriate support from larger socio-economic systems. Climate change thus becomes a human rights and cultural sovereignty issue.

As this brief sample of Arctic indigenous perspectives makes clear in light of the eight processes of human adaptation presented above, households and communities are coping and adapting in myriad ways. However, when these key processes are blocked, vulnerability and exposure to risk are potentially increased. Obviously, it is too early to tell, in the dynamic Arctic context, the extent to which some of the strategies, especially as concerns subsistence activities, will prove to be viable means of adaptation in the long term. Davies (2008) emphasizes the difference between short-term coping strategies and adaptation strategies. Coping strategies entail immediate measures that may help to survive an unusual decline in resources but may not be sustainable in the long run. In contrast, adaptation strategies tend to spawn new cultural configurations that have evolved in response to changed conditions. Even still, as Romer's rule suggests, pathways toward the maintenance of existing patterns may eventually serve as catalysts for adaptation.

Indigenous peoples emphasize the disconnect between their own adaptation needs and the responses and priorities of the state and other non-Native institutions, such as multinational energy corporations and conservation organizations. Adaptive capacity could be enhanced through further research into how key indigenous adaptation processes may be complicated or put at risk by socio-economic policies or adaptation processes occurring at other scales. In Arctic Alaska, this means assessing the foundational importance of sea ice habitats and Inuit adaptations to marine mammals against the potential risks of policies that support (1) the intensification of offshore oil and gas development, (2) shipping opportunities to cope with dwindling domestic energy supplies or to exploit reduced transport costs through the Arctic seas, and (3) restrictions on sea mammal hunting as a means of conserving populations through rationing kills (see Itta 2009). Analyzing the nexus of climate and other socio-ecological impacts and adaptation responses at the household, community, state, and other institutional levels over time offers the best opportunity for reducing the so-called adaptation deficit and identifying opportunities for coordinating adaptation policy across scales in the Arctic and elsewhere.

## Conclusion

It has now become almost a cliché to point out that adaptation to climate change must happen in conjunction with mitigation in order to cope with increasing environmental change, and that adaptation should not be viewed as a stand-alone or single-sector, single-scale issue. Rather,

adaptation must be considered in the context of long-standing and evolving multi-scalar ecological, social, economic, political, and institutional circumstances (Adger et al. 2003; Nelson et al. 2007; Smit et al. 2000; Smithers and Smit 1997). However, to date, adaptation in climate policy has been poorly theorized and plagued by conceptual biases. We have emphasized critical weaknesses in the present approach to adaptation that, unless addressed, may hamper even the most progressive, multi-scalar institutional efforts to deal with escalating climate change.

We have stressed that human adaptation is not a single strategy but rather a set of diverse, intersecting processes that may evolve autonomously or through planning in response to the panoply of climatic and non-climatic stressors. Up to the present, conceptual work on fundamental human adaptation processes in the climate change context has been underdeveloped with a few notable exceptions. As a consequence, analysts and planners often ignore key findings from long-term anthropological and geographical studies of adaptation, focusing too much on too few institutions (modern states and communities) and processes (market exchange and innovation in the form of techno-fix) at the expense of other units (households) and methods (rationing and revitalization). Successful adaptation strategies may entail interconnected aspects of all of the eight major adaptation processes we have identified—and potentially more. Even with a broader set of conceptual tools, putting adaptation theory into practice will remain challenging because of the uncertainty of future climate change and its impacts and due to the difficulty of evaluating and linking adaptation measures across scales and against short-term and long-term costs and opportunities, as interpreted locally within the 'limits' of existing socio-political entities (Adger et al. 2009).

By enlarging the typology of adaptation processes and creating a metalanguage to characterize and analyze diverse modes of reorganizing across cultures, we have sought to broaden the discussion on adaptation processes as sources of resilience and adaptive capacity. Hopefully, such an effort will serve to expand the scope of climate impact assessment and adaptation planning to address a range of processes that are currently neglected, taken for granted, or irreflexively viewed as maladaptive from a status quo perspective. Furthermore, adaptation policy and funding should address not only future vulnerabilities to climate change but also past and current vulnerabilities and adaptive strategies to both climate variability and non-climatic stressors. If adaptation funding (under UNFCCC and elsewhere) fails to enlarge its framing of risks and adaptation processes, vulnerable groups, such as indigenous communities in the fast-warming Arctic, are unlikely to be able to adapt successfully to future climate change or will be forced to do so in ways that serve dominant interests rather than their own diverse and long-term needs (cf. Adger et al. 2006; Barnett 2008; Burton 2008; Handmer 2008; Pielke 1998; Ribot et al. 2008; Smithers and Smit 1997; UNDP 2002).

Some institutional innovations suggest that awareness of these links is improving, which is an important first step. Newly formed 'boundary organizations' are attempting to coordinate adaptation processes across present sectors and scales. It is beyond the scope of this article to review these institutional efforts in detail, but one example may suffice to illustrate the developments and challenges faced. The United Kingdom Climate Impacts Programme (UKCIP), which was already established in 1997, is one of the earliest examples of such a boundary organization (see Metcalf 2008). To date, the organization's efforts have focused largely on building adaptive capacity as a prelude to specific actions, and some links to critical adaptation processes are already apparent. For example, a major focus of the first phase of the UK's national Adapting to Climate Change Programme (2008–2011) has been on building adaptive capacity by developing a comprehensive evidence base of climate change impacts, raising awareness of the need for and benefits of early action, and embedding the consideration of climate change into policies and programs. UKCIP is playing a leading role by liaising between scientists, policy makers,

and various stakeholders. The organization is thus effectively pooling information from various sources and developing it into credible knowledge that is meaningful to businesses, local authorities, and other parties. Of course, it would be a mistake to assume that this capacity building will automatically lead to adaptation action. UKCIP's organizational and procedural approach shows potential for achieving adaptation action across scales, such as with strategic flood assessments, but it is still too early to tell how effective it will be in the long term.

Moreover, adaptation biases are evident. These include a reliance on bolstering existing infrastructure through techno-fix measures and a neglect of more socially transformative adaptation processes, such as revitalization and, to a certain extent, diversification. It can be argued that the greatest benefit would involve the introduction of new elements or significant restructurings to society, instead of merely 'shuffling around' with or within existing features or structures. Handmer and Dovers (1996) point out the human tendency to seek to maintain the status quo or to return to it after a disruption, as opposed to being more open to major changes. This is evident in the specific example of the UK's flood risk management option and in the country more generally, where alterations in physical structures (e.g., building the Thames Barrier to protect London and expanding the development ban in flood plains) are made rather than aiming for changes in human behavior.

It could be argued that in the UK the limiting factors to major adaptation reside in the willingness of the government to change its policies and the public's willingness to accept changes to its lifestyle or standard of living. This contrasts with northern indigenous people, whose resilience stems from being able and willing to change their lifestyle, depending on environmental conditions. In their case, the limiting factor is less their resistance to change than the barriers imposed by governments (e.g., development on herding or hunting lands or forced sedentism, etc.).

Climate change research reveals that the two groups' fates are inextricably linked, however, as a recent editorial in opposition to the expansion of the UK's Stansted airport, written by the president of Greenland's Inuit Circumpolar Council, Aqqaluk Lynge (2007), makes clear.

> What happens in Britain affects us in the north …
>
> Most flights from Stansted are not for an important purpose. They are mostly for holidays and leisure. Is it too much to ask for some moderation for the sake of my people today and your people tomorrow? For the sake also of our wildlife and everything else in the world's precious and fragile environment …
>
> Some might dismiss our concerns, saying: "The Arctic is far away and few people live there." That would be immensely short-sighted, as well as callous … [T]he Arctic is the barometer of the globe's environmental health. You can take the pulse of the world in the Arctic. Inuit, the people who live farther north than anyone else, are the canary in the global coal mine …
>
> We are not asking the world to take a backward economic step. All we are asking is that our neighbors in the south greatly reduce their emissions of greenhouse gases. This does not need big sacrifices, but it will need some change in people's lifestyles. Is that plane trip really necessary?

Lynge points out how the UK's short-term strategy for economic growth conflicts with its long-term strategy for greenhouse gas emissions reductions. His implicit suggestion that airplane travel must be rationed (or its deleterious effects as a mobility strategy otherwise reduced) is consistent with a framework that is willing to contemplate rationing or diversification as an adaptation strategy. Greenland itself is facing these contradictions in its own development and responses to climate change (Nuttall 2009).

Unfortunately, many national and local adaptation plans are not contemplating the full range of potential strategies or the implications of continued increases in consumption and emissions on others who may be disproportionally affected and whose vulnerability may be increased by such actions. Consequently, climate change is rapidly emerging as a human rights and environmental justice issue, as the statist framing of mitigation and adaptation measures often occludes crucial moral, livelihood, and entitlement considerations of minorities (Caney 2009), such as indigenous peoples of the Far North. However, gaining the moral and judicial high ground alone will not win the struggle against climate change impacts. Only genuine adaptation can do that. To transfer what Sapir (1924: 427–429) said about 'spurious' culture to adaptation:

> As long as [adaptation] is looked upon as a decorative appendage of large political units, one can plausibly argue that its [success] is bound up with the maintenance of the prestige of these units … The national-political unit tends to arrogate [adaptation] to itself and up to a certain point it succeeds in doing so, but only at the price of serious [adaptation] impoverishment of vast portions of its terrain …
>
> … The minute increment of individuality which alone makes [adaptation] in the self and eventually builds up [adaptation] in the community seems somehow overlooked. Canned [adaptation] is so much easier to administer.

## ACKNOWLEDGMENTS

We would like to thank Patricia Cochrane, Janice Grey, and Mikhail Pogodaev for agreeing to be interviewed during the UNFCCC's 15th Conference of Parties in Copenhagen, Denmark, in December 2009. Thanks also go to two anonymous reviewers and the editors for their helpful comments on early drafts of the article.

**THOMAS F. THORNTON** is Senior Research Fellow at the Environmental Change Institute, School of Geography and the Environment, University of Oxford, where he also directs the Environmental Change and Management MSc course. An anthropologist, he has written widely on human ecology, adaptation, local and traditional ecological knowledge, conservation, coastal and marine environments, conceptualizations of space and place, and the political ecology of resource management among the indigenous peoples of the Pacific Northwest and the circumpolar North. His most recent publications include "A Tale of Three Parks: Tlingit Conservation, Representation, and Repatriation in Southeast Alaska's National Parks" (2010) and *Being and Place among the Tlingit* (2008).

**NADIA MANASFI** completed her masters degree in Environmental Change and Management at the University of Oxford in 2009. A paper based on the results of her dissertation, "Finding the Balance: Challenges and Opportunities for Climate Change Adaptation in Different Levels of English Local Government," co-authored with Elizabeth Greenhalgh, is in press. Following graduation, she conducted research on adaptation in indigenous communities as part of an internship at the University of Oxford's Environmental Change Institute. Her more recent work with the German International Cooperation (GIZ, formerly GTZ) has focused on climate change adaptation in developing countries, and she plays an active role in advising partner countries on climate-robust development planning.

## NOTES

1. Dawkins (1989) proposes the term 'memes', an analogue of 'genes', as a fundamental unit of culture, although such discrete units have yet to be mapped (Benitez-Bribiesca 2001).
2. Initiated by the United Nations Environment Programme, the CBD entered into force on 29 December 1993. Its three main objectives are (1) the conservation of biological diversity, (2) the sustainable use of the components of biological diversity, and (3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. See http://www.cbd.int/.
3. See Gorman (1999) about a failed attempt to revitalize a threatened species, the Arabian Oryx.
4. Seven northern indigenous representatives from Alaska, Canada, Siberia, and Norway were interviewed between 8–12 December 2009 at the COP15 in Copenhagen. Five of the interviews were held at the Bella Center and the other two at the World Wide Fund for Nature (WWF) Arctic Tent. The interviews were conducted in English and lasted approximately 15–30 minutes. With the exception of one interview that involved two interviewees, the interviews were conducted on a one-to-one basis, and five were audio-recorded. The interviews were intended to discover any changes in weather/climate that the interviewees have noticed in recent years, what the impact of those changes have been on their lifestyle and community, and what adaptation strategies, if any, the community has already put in place. In addition, the interviewees were asked about support or challenges they have faced in addressing climate change and what their hopes for COP15 were.
5. See Agrawal (2008) for recommendations regarding adapting institutions in poor, rural areas.

## REFERENCES

Abercrombie, Michael, C. J. Hickman, and Minnie Louie Johnson. 1977. *A Dictionary of Biology*. Harmondsworth, UK: Penguin Books.

Abryutina, Larisa. 2009. "Indigenous Peoples of the Russian North: Social and Climatic Changes." Pp. 164–173 in *Climate Change and Arctic Sustainable Development*, UNESCO. Paris: UNESCO.

ACIA (Arctic Climate Impact Assessment). 2005. *Arctic Climate Impact Assessment.* Cambridge: Cambridge University Press.

Adger, W. Neil, Suraje Dessai, Marisa Goulden, Mike Hulme, Irene Lorenzoni, Donald R. Nelson, Lars Otto Naess, Johanna Wolf, and Anita Wreford. 2009. "Are There Social Limits to Adaptation to Climate Change?" *Climatic Change* 93 (3–4): 335–354.

Adger, W. Neil, Saleemul Huq, Katrina Brown, Declan Conway, and Mike Hulme. 2003. "Adaptation to Climate Change in the Developing World." *Progress in Development Studies* 3 (3): 179–195.

Adger, W. Neil, Jouni Paavola, Saleemul Huq, and M. J. Mace, eds. 2006. *Fairness in Adaptation to Climate Change*. Cambridge, MA: MIT Press.

AFN (Alaska Federation of Natives). 2008. "Alaska Federation of Natives 2008 Political Platform." http://www.nativefederation.org/documents/2008_AFN_Political_Platform.pdf (accessed 15 January 2009).

Agrawal, Arun. 2008. "The Role of Local Institutions in Adaptation to Climate Change." Paper prepared for the "Social Dimensions of Climate Change" workshop, Social Development Department, World Bank, Washington DC, 5–6 March.

Allaby, Michael. 2004. "Romer's Rule." *A Dictionary of Ecology*. http://www.encyclopedia.com/doc/1O14-Romersrule.html (accessed 20 January 2010).

Arnold, Charles. 1989. "Arctic Harpoons." *Arctic* 42 (1): 80–81.

Barnett, Jon. 2008. "The Effect of Aid on Capacity to Adapt to Climate Change: Insights from Niue." *Political Science* 60 (1): 31–45

Barth, Fredrik. 1956. "Ecologic Relationships of Ethnic Groups in Swat, North Pakistan." *American Anthropologist* 58: 1079–1089.

Beach, Hugh, Mydrene Anderson, and Pekka Aikio. 1992. "Dynamics of Saami Territoriality within the Nation-States of Norway, Sweden and Finland." Pp. 55–90 in *Mobility and Territoriality: Social and Spatial Boundaries among Foragers, Fishers, Pastoralists and Peripatetics*, ed. M. Casimir and A. Rao. Oxford: Berg.

Bellwood, Peter. 2005. *First Farmers: The Origins of Agricultural Societies*. Oxford: Blackwell.

Benitez-Bribiesca, Luis. 2001. "Memetics: A Dangerous Idea." *Interciencia* 26: 29–31.

Berkes, Fikret. 2007. "Community-Based Conservation in a Globalized World." *Proceedings of the National Academy of Sciences of the United States* 104 (39): 15188–15193.

_____. 2008. *Sacred Ecology*. 2nd ed. London: Routledge.

Berkes, Fikret, Derek Armitage, and Nancy Doubleday. 2007. "Synthesis: Adapting, Innovating, Evolving." Pp. 308–327 in *Adaptive Co-Management: Collaboration, Learning, and Multi-Level Governance*. Seattle: University of Washington Press.

Berkes, Fikret, and Carl Folke, eds. 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press.

Birdlife International. 2008. "Agricultural Intensification Has Caused the Decline of Many Common Bird Species in Europe." http://www.birdlife.org/datazone/sowb/casestudy/141 (accessed 30 January 2011).

Boyd, Robert, and Peter J. Richerson. 2005. *The Origin and Evolution of Cultures*. Oxford: Oxford University Press.

Brush, Stephen B. 1999. "Bioprospecting the Public Domain." *Cultural Anthropology* 14 (4): 535–555.

Burton, Ian. 2008. "Climate Change and the Adaptation Deficit." Pp. 89–97 in *Earthscan Reader on Adaptation to Climate Change*, ed. E. L. F. Schipper and I. Burton. London: Earthscan. [Originally published in 2004.]

Caney, Simon. 2009. "Justice and the Distribution of Greenhouse Gas Emissions." *Journal of Global Ethics* 5 (2): 125–146.

Carneiro, Robert L. 1970. "A Theory of the Origin of the State." *Science* 169: 733–738.

Christoplos, I., S. Anderson, M. Arnold, V. Galaz, M. Hedger, R. J. T. Klein, and K. Le Goulven. 2009. *The Human Dimension of Climate Adaptation: The Importance of Local and Institutional Issues*. Report to the Commission on Climate Change and Development, Ministry for Foreign Affairs, Stockholm.

Crate, Susan A. 2006. *Cows, Kin, and Globalization: An Ethnography of Sustainability*. Plymouth, UK: AltaMira Press.

Davies, Susanna. 2008. "Are Coping Strategies a Cop-Out?" Pp. 99–116 in *Earthscan Reader on Adaptation to Climate Change*, ed. E. L. F. Schipper and I. Burton. London: Earthscan. [Originally published in 1993.]

Dawkins, Richard. 1989. *The Selfish Gene*. 2nd ed. Oxford: Oxford University Press.

Dearing, John A. 2008. "Landscape Change and Resilience Theory: A Palaeoenvironmental Assessment from Yunnan, SW China." *Holocene* 18 (1): 117–127.

Denevan, William M. 1983. "Adaptation, Variation, and Cultural Geography." *Professional Geographer* 35 (4): 399–407.

Escobar, Arturo. 1995. *Encountering Development: The Making and Unmaking of the Third World*. Princeton, NJ: Princeton University Press.

Farmer, Paul. 2003. *Pathologies of Power: Health, Human Rights, and the New War on the Poor*. Berkeley: University of California Press.

Ferguson, James. 1994. *The Anti-politics Machine: 'Development,' Depoliticization, and Bureaucratic Power in Lesotho.* Minneapolis, MN: University of Minnesota Press

Finan, Timothy J., and Donald R. Nelson. 2009. "Decentralized Planning and Climate Adaptation: Toward Transparent Governance." Pp. 335–349 in *Adapting to Climate Change: Thresholds, Values, Governance*, ed. W. N. Adger, I. Lorenzoni, and K. L. O'Brien. Cambridge: Cambridge University Press.

Ford, James D. 2009. "Dangerous Climate Change and the Importance of Adaptation for the Arctic's Inuit Population." *Environmental Research Letters* 4: 1–9.

Ford, James, and Chris Furgal. 2009. "Foreword to the Special Issue: Climate Change Impacts, Adaptation and Vulnerability in the Arctic." *Polar Research* 28: 1–9.

Ford, James, Tristan Pearce, Barry Smit, Johanna Wandel, Mishak Allurut, Kik Shappa, Harry Ittusujurat, and Kevin Qrunnut. 2007. "Reducing Vulnerability to Climate Change in the Arctic: The Case of Nunavut, Canada." *Arctic* 60 (2): 150–166.

Furgal, Chris, and Jacinthe Seguin. 2006. "Climate Change, Health, and Vulnerability in Canadian Northern Aboriginal Communities." *Environmental Health Perspectives* 114: 1964–1970.

Furgal, Chris, and Terry Prowse. 2008. "Northern Canada." Pp. 57–118 in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, ed. D. Lemmen, F. Warren, E. Bush, and J. Lacroix. Ottawa: Natural Resources Canada.

Füssel, Hans-Martin. 2007. "Adaptation Planning for Climate Change: Concepts, Assessment Approaches, and Key Lessons." *Sustainability Science* 2 (2): 265–275.

Gallopín, Gilberto C., Pablo Gutman, and Hector Maletta. 1989. "Global Impoverishment, Sustainable Development and the Environment: A Conceptual Approach." *International Social Science Journal* 121: 375–397.

GAO (Government Accountability Office). 2009. *Alaska Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion.* Report to Congressional Requesters. GAO-09-551. Washington, DC.

Gorman, Martyn. 1999. "Conservation: Oryx Go Back to the Brink." *Nature* 398: 190.

Gunderson, Lance H., and C. S. Holling, eds. 2002. *Panarchy: Understanding Transformations in Human and Natural Systems.* Covelo, CA: Island Press.

Hall, Sam. 1988. *The Fourth World: The Heritage of the Arctic and Its Destruction*. New York: Vintage Books.

Halstead, Paul, and John O'Shea. 1989. "Introduction: Cultural Responses to Risk and Uncertainty." Pp. 1–7 in *Bad Year Economics: Cultural Responses to Risk and Uncertainty,* ed. P. Halstead and J. O'Shea. Cambridge: Cambridge University Press.

Handmer, John W. 2008. "Adaptive Capacity: What Does It Mean in the Context of Natural Hazards?" Pp. 213–228 in *Earthscan Reader on Adaptation to Climate Change*, ed. E. L. F. Schipper and I. Burton. London: Earthscan. [Originally published in 2003.]

Handmer, John W., and Stephen R. Dovers. 1996. "A Typology of Resilience: Rethinking Institutions for Sustainable Development." *Organization and Environment* 9 (4): 482–511.

Hardesty, Donald L. 1986. "Rethinking Cultural Adaptation." *Professional Geographer* 38 (1): 11–18.

Harkin, Michael E., ed. 2004. *Reassessing Revitalization Movements: Perspectives from North America and the Pacific Islands*. Lincoln: University of Nebraska Press.

Harvey, David. 2005. *A Brief History of Neoliberalism*. Oxford: Oxford University Press.

Head, Lesley. 2009. "Cultural Ecology: Adaptation—Retrofitting a Concept?" *Progress in Human Geography* 34 (2): 234–242.

Henshaw, Anne. 2009. "Sea Ice: The Sociocultural Dimensions of a Melting Environment in the Arctic." Pp. 153–165 in *Anthropology and Climate Change: From Encounters to Actions*, ed. S. Crate and M. Nuttall. Walnut Creek, CA: Left Coast Press.

ICC (Inuit Circumpolar Conference). 2005. "Petition to the Inter-American Commission on Human Rights." Ottawa, Canada.

IPCC (Intergovernmental Panel on Climate Change). 2007. "Summary for Policymakers." Pp. 7–22 in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson. Cambridge: Cambridge University Press.

Itta, Edward S. 2009. "Uses of the Arctic Ocean and the Future of Indigenous Cultures." Pp. 206–211 in *Climate Change and Arctic Sustainable Development*, UNESCO. Paris: UNESCO.

Kates, Robert W. 2000. "Cautionary Tales: Adaptation and the Global Poor." *Climatic Change* 45 (1): 5–17.

Krupnik, Igor, and Dyanna Jolly, eds. 2002. *The Earth Is Faster Now: Indigenous Observations of Climate Change.* Fairbanks, AK: Arctic Research Consortium of the United States.

Lawrence, Eleanor. 1995. *Henderson's Dictionary of Biological Terms*. Harlow, Essex: Longman Scientific and Technical.

Lemet-Klemetti Näkkäläjärvi, Juvvá. 2009. "Perspective of Sami Reindeer Herders on the Impact of Climate Change and Related Research." Pp. 131–143 in *Climate Change and Arctic Sustainable Development*, UNESCO. Paris: UNESCO.

Liverman, Diana. 2008. "Assessing Impacts, Adaptation and Vulnerability: Reflections on the Working Group II Report of the Intergovernmental Panel on Climate Change." *Global Environmental Change* 18: 4–7.

Lynge, Aqqaluk. 2007. "Global Warming Is Not Just a Theory to Us." *Independent*, 30 May. http://www.independent.co.uk/opinion/commentators/aqqaluk-lynge-global-warming-is-not-just-a-theory-to-us-450941.html (accessed 18 January 2010).

_____. 2009. "Facing the Impact of Global Climate Change: Recommendations from the Arctic." Pp. 104–113 in *Climate Change and Arctic Sustainable Development*, UNESCO. Paris: UNESCO.

Lyson, Thomas A. 2004. *Civic Agriculture: Reconnecting Farm, Food, and Community*. Boston, MA: Tufts University Press.

Marino, Elizabeth, and Peter Schweitzer. 2009. "Talking and Not Talking about Climate Change in Northwestern Alaska." Pp. 197–208 in *Anthropology and Climate Change: From Encounters to Actions*, ed. S. Crate and M. Nuttall. Walnut Creek, CA: Left Coast Press

Metcalf, Gerry. 2008. "UKCIP Guidance Notes on NI188, etc." Presentation of Local Authority Support Programme, South West Regional Workshop on NI188, 9 October. http://www.oursouthwest.com/climate/registry/081009-ni188-workshop-gerry-metcalf-ukcip.pdf (accessed 28 January 2010).

Moench, Marcus. 2007. "Adapting to Climate Change and the Risks Associated with Other Natural Hazards: Methods for Moving from Concepts to Action." Pp. 13–48 in *Working with the Winds of Change*, 2nd ed., ed. M. Moench and A. Dixit. Kathmandu, Nepal: ProVention Consortium.

Nelson, Donald R., W. Neil Adger, and Katrina Brown. 2007. "Adaptation to Environmental Change: Contributions of a Resilience Framework." *Annual Review of Environment and Resources* 32: 395–419.

Nelson, Donald R., Colin T. West, and Timothy J. Finan. 2009. "Introduction to 'In Focus: Global Change and Adaptation in Local Places." *American Anthropologist* 111 (3): 271–274.

Netting, Robert. 1993. *Smallholders, Householders: Farm Families and the Ecology of Intensive Sustainable Agriculture*. Stanford, CA: Stanford University Press

Netting, Robert, Richard Wilk, and Eric J. Arnould. 1984. *Households: Comparative and Historical Studies of the Domestic Group.* Berkeley: University of California Press.

Niamir-Fuller, Maryam, ed. 1999. *Managing Mobility in African Rangelands: The Legitimization of Transhumance.* London: Intermediate Technology Publications.

Nuttall, Mark. 2009. "Living in a World of Movement: Human Resilience to Environmental Instability in Greenland." Pp. 292–310 in *Anthropology and Climate Change: From Encounters to Actions*, ed. S. Crate and M. Nuttall. Walnut Creek, CA: Left Coast Press.

O'Brien, Michael J., and Thomas D. Holland. 1992. "The Role of Adaptation in Archaeological Explanation." *American Antiquity* 57: 36–59

Oliver-Smith, Anthony. 2009. "Climate Change and Population Displacement: Disasters and Diasporas in the Twenty-First Century." Pp. 116–136 in *Anthropology and Climate Change: From Encounters to Actions*, ed. S. Crate and M. Nuttall. Walnut Creek, CA: Left Coast Press

Pidwirny, Michael. 2006. "Concept of Ecological Niche." *Fundamentals of Physical Geography*. 2nd ed. http://www.physicalgeography.net/fundamentals/9g.html (accessed 20 January 2010).

Pielke, Roger A., Jr. 1998. "Rethinking the Role of Adaptation in Climate Policy." *Global Environmental Change* 8 (2): 159–170.

Pielke, Roger A., Jr., Gwyn Prins, Steve Rayner, and Daniel Sarewitz. 2007. "Lifting the Taboo on Adaptation." *Nature* 445: 597–598.

Rees, W. Garreth, Florian M. Stammler, Fiona S. Danks, and Piers Vitebsky. 2008. "Vulnerability of European Reindeer Husbandry to Global Change." *Climatic Change* 87 (1–2): 199–217.

Reuveny, Rafael. 2007. Climate Change-Induced Migration and Violent Conflict." *Political Geography* 26 (6): 656–673.

Ribot, Jesse C., Adil Najam, and Gabrielle Watson. 2008. "Climate Variation, Vulnerability and Sustainable Development in the Semi-Arid Tropics." Pp. 117–160 in *Earthscan Reader on Adaptation to Climate Change*, ed. E. L. F. Schipper and I. Burton. London: Earthscan. [Originally published in 1996.]

Richerson, Peter J., and Robert Boyd. 2008. "Migration: An Engine for Social Change." *Nature* 456: 877.
Richerson, Peter J., Robert Boyd, and Robert L. Bettinger. 2001. "Was Agriculture Impossible during the Pleistocene but Mandatory during the Holocene? A Climate Change Hypothesis." *American Antiquity* 66 (3): 387–411.
Rindos, David. 1984. *The Origins of Agriculture: An Evolutionary Perspective*. New York: Academic Press.
Sachs, Jeffrey. 2008. *Common Wealth: Economics for a Crowded Planet*. London: Penguin Group.
Sapir, Edward. 1924. "Culture, Genuine and Spurious." *American Journal of Sociology* 29 (4): 401–429.
Schipper, E. Lisa F. 2006. "Conceptual History of Adaptation in the UNFCCC Process." *Review of European Community and International Environmental Law* 15 (1): 82–92.
Schipper, E. Lisa F., and Ian Burton, eds. 2008. *Earthscan Reader on Adaptation to Climate Change*. London: Earthscan.
Shiva, Vandana. 1989. *Staying Alive: Women, Ecology and Development.* London: Zed Books.
_____. 2008. *Soil Not Oil: Climate Change, Peak Oil, and Food Insecurity*. London: Zed Books.
Smit, Barry, Ian Burton, Richard T. J. Klein, and Johanna Wandel. 2000. "An Anatomy of Adaptation to Climate Change and Variability." *Climatic Change* 45 (1): 223–251.
Smith, Duane. 2009. "The Sea Ice Is Our Highway: The Importance of Sea Ice to the Inuit Way of Life." Pp. 17–25 in *Climate Change and Arctic Sustainable Development*, UNESCO. Paris: UNESCO.
Smithers, John, and Barry Smit. 1997. "Human Adaptation to Climatic Variability and Change." *Global Environmental Change* 7 (2): 129–146.
Stern, Nicholas. 2007. *The Economics of Climate Change: The Stern Review.* Cambridge, Cambridge University Press.
Strauss, Sarah, and Benjamin S. Orlove. 2003. *Weather, Climate, Culture*. Oxford: Berg.
Thornton, Thomas F., Virginia Butler, Fritz Funk, Madonna Moss, Jamie Hebert, J. Tait Elder, Robi Craig, Shingo Hamada, and Adela Maciejewski Scheer. 2010. *Herring Synthesis: Documenting and Modeling Herring Spawning Areas within Socio-Ecological Systems over Time in Southeast Alaska*. Report to North Pacific Research Board, Anchorage, Alaska.
UNDP (United Nations Development Programme). 2002. "A Climate Risk Management Approach to Disaster Reduction and Adaptation to Climate Change." UNDP Expert Group Meeting, Integrating Disaster Reduction with Adaptation to Climate Change, Havana, Cuba.
UNESCO (United Nations Educational, Scientific and Cultural Organization). 2009. *Climate Change and Arctic Sustainable Development: Scientific, Social, Cultural and Educational Challenges*. Paris: UNESCO.
Wallace, Anthony F. C. 1956. "Revitalization Movements." *American Anthropologist* 58: 264–281.
_____. 2009. "Epilogue: On the Organization of Diversity." *Ethos* 37 (2): 251–255.
Watt-Cloutier, Sheila, Terry Fenge, and Paul Crowley. 2004. "Responding to Global Climate Change: The Perspective of the Inuit Circumpolar Conference on The Arctic Climate Impact Assessment." Paper presented at the Inuit Circumpolar Conference. Ontario, Canada.
West, Colin T. 2009. "Domestic Transitions, Desiccation, Agricultural Intensification, and Livelihood Diversification among Rural Households on the Central Plateau, Burkina Faso." *American Anthropologist* 111 (3): 275–288.
Winterhalder, Bruce. 1980. "Environmental Analysis in Human Evolution and Adaptation Research." *Human Ecology* 8 (2): 135–170.
Winterhalder, Bruce, and Douglas J. Kennett. 2006. "Behavioral Ecology and the Transition from Hunting and Gathering to Agriculture." Pp. 1–21 in *Behavioral Ecology and the Transition to Agriculture*, ed. D. J. Kennett and B. Winterhalder. Berkeley: University of California Press.
Young, Oran R., Frans Berkhout, Gilberto C. Gallopín, Marco A. Janssen, Elinor Ostrom, and Sander van der Leeuw. 2006. "The Globalization of Socio-ecological Systems: An Agenda for Scientific Research." *Global Environmental Change* 16 (3): 304–316.
Ziker, John P. 2002. *Peoples of the Tundra Northern Siberians in the Post-Communist Transition*. Long Grove, IL: Waveland Press.