Building Adaptive Capacity to Climate Change in Less Developed Countries

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Abstract This paper focuses on the relevance of adaptive capacity in the context of the increasing certainty that climate change impacts will affect human populations and different social groups substantially and differentially. Developing and building adaptive capacity requires a combination of interventions that address not only climate-related risks (specific capacities) but also the structural deficits (lack of income, education, health, political power, etc.—generic capacities) that shape vulnerability. We argue that bolstering both generic and specific adaptive capacities, with careful attention to minimizing the potential tensions between these two types of capacities, can help vulnerable groups maintain their ability to address risks in the long run at the same time as they respond effectively to short term climate impacts. We examine the relationship between generic and specific capacities, taking into consideration that they are not always positively related. We then propose a conceptual model describing positive and negative feedbacks between the two.

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1 Introduction

Around the world, the devastation of climate-related impacts has undermined livelihoods, threatened ecosystems, and stretched the capacity of sociopolitical institutions. Droughts, storms, and floods have often caused serious agricultural losses and human suffering: images of famines in Africa, human displacement in the Caribbean, and water-covered settlements in Bangladesh illustrate just some of the disastrous impacts of climate on vulnerable populations. In recent years, the possibility of more frequent and extreme events as a result of climate change has fueled new avenues of inquiry to understand and address the vulnerability of human and social systems to these events. As adaptation becomes prominent on the social and governmental agendas of both rich and poor countries, we need to understand better the factors that increase or constrain their adaptive capacity, or the ability of different socio-ecological systems and agents to respond and recover from climate impact. Such an improved understanding is particularly important for less developed regions where these negative impacts will likely interact with and exacerbate other stressors already affecting those most vulnerable (Eakin and Lemos 2006; Wilbanks and Kates 2010).

In these regions, although climate change poses a grave and emerging threat, vulnerabilities are generally symptomatic of deep socio-economic and political inequalities that have historically characterized their societies (Blaikie et al. 1994; Adger 2006; Eakin and Luers 2006). In other words, vulnerability is as much – or more – determined by the political economy of risk than by changing climate circumstances. Under these conditions, we argue that efforts to build adaptive capacity must simultaneously and iteratively address climate threats and longstanding development needs (Lemos et al. 2007).

In practice, building adaptive capacity means designing and implementing policy that both addresses: (a) structural deficits (which we call *generic* adaptive capacity) such as universal access to education and health, income and land distribution and redistribution (e.g. cash transfers and entitlements programs, land reform), political reform (e.g. increased accountability, democratic decision-making and transparency), and institutional and administrative capacity-building (e.g. greater enforcement of regulations and norms, investment in human capital, decreasing corruption and inefficiencies); and (b) risk management (which we call *specific* adaptive capacity) such as investment in adaptation technology (e.g. public works for water storage and distribution, coastal protection, development of drought resistant crops), social innovation (e.g. disaster response, insurance, alert systems) and specific interventions that either mitigate exposure of different groups to a particular climate threat (e.g. drought-related famine prevention, creation of early warning systems for storms, and relocation of vulnerable populations in the face of recurrent

and unmanageable floods). These interventions and policies will necessarily need to be carried out across different levels of government and across different sectors (Adger et al. 2005a; Wilbanks and Kates 2010) and are likely to be controversial and politically costly (Lemos 2007; Eakin and Patt 2011). However, the implications of the interaction between specific and generic capacities and the relative importance of each in affecting the overall ability to respond and recover from climate change impact have received relatively little empirical and theoretical attention (but see Adger and Vincent 2005; Lemos 2007).

In this article, we specifically discuss these interactions and theorize about different ways that generic and specific adaptive capacity intersect and shape each other in the context of building adaptive capacity in less developed regions. We hypothesize that in the best-case scenario, the combination of generic and specific adaptive capacity is synergistic, creating a virtuous cycle in which overall capacity is sustainably enhanced, fostering long-term adaptation (Lemos 2007; Lemos and Tompkins 2008). However, in less desirable scenarios, tensions in the relationship between generic and specific adaptive capacity may lead to negative feedbacks such as those that foster poverty and rigidity traps and resilient undesirable states such as those existing in clientelistic political situations. In these cases adaptation interventions can actually exacerbate inequalities or perpetuate maladaptation (Lemos 2007; Nelson and Finan 2009; Maru et al. 2012). For example, at the household level, the goal is to avoid an emphasis on interventions that focus on risk management without increasing the household's overall asset base because while these interventions may allow for short term coping, they fail to assure long-term adaptation (delNinno et al. 2003; Nelson and Finan 2009). In contrast, targeted capacity building for specific subpopulations or sectors may result either in complacency or rigidity traps in which endogenous efforts at specific risk management are thwarted (Eakin et al. 2011; Murtinho 2011).

Although there is growing consensus that adaptation policy must take into consideration structural deficits and long-term sustainability, addressing inequalities that create and sustain poverty and propagate vulnerabilities will likely require politically difficult policies that profoundly challenge the existing distribution of power and assets (Pelling 2009). At best, implementation of such structural changes has been slow and incremental in most countries, while virtually impossible in others. In this context, it is not surprising that adaptation interventions so far have mostly been technical and palliative (Lemos 2003). In some respect, linking progress on climate change adaptation to development goals can risk bogging adaptation policy down in the same politics of resource access and distribution that have impeded social development for decades (Eakin and Patt 2011). On the other hand, failing to integrate adaptation and development policy may result in distortions and inefficiencies that threaten sustainability in the long-run (Huq et al. 2003; Agrawala 2004; Bizikova et al. 2007).

To foster development that addresses climate change risk in the context of multiple stressors and enables adaptation, policy makers must decide whether it is more effective to invest in measures that will reduce vulnerability to a broad range of both climatic and non-climatic stressors, or whether it is best to focus on enhancing

specific capacities to manage particular hazards. At the level of individuals and households, policy makers may wish to build capacities for autonomous risk management and adaptation as part of social contracts to disadvantaged citizens. Yet deciding which of the diversity of assets and entitlements that constitute livelihoods need to be strengthened through public investment and support is complex and uncertain. Additionally, the implementation of interventions that positively interact with household and community level capacities rather than detracting from them by stifling or constraining local level ingenuity and resources (such as the mobilization of cultural and social capitals) should also be taken into account in the design and deployment of risk management. In this sense, understanding the relationship between generic and specific adaptive capacity at different scales of governance is a critical component of informing policy-making and planning to respond to climate change impact. In the next sections, we review the literature focusing on adaptive capacity and develop a conceptual model theorizing the relationship between generic and specific capacities across scales in the context of less developed regions (Box 1).

Box 1 Governance and Adaptive Capacity in the Brazilian Water Sector

Brazil's national reform of water management in 1997 brought changes to the water resources sector that have contributed to both better governance, including deeper democratic participation, and improvements in disaster risk response (Engle and Lemos 2010; Johns 2011). Results of the reform in the drought-prone Jaguaribe basin in NE state of Ceará reveal how governance factors at the institutional scale contribute to adaptive capacity and how generic improvements in institutional capacity interact with specific risk reduction interventions. However, challenges to inclusion and equality remain that may limit the potential synergies between governance and adaptive capacity (Johns 2011).

In Jaguaribe, state policy makers sought to design a new set of institutions to manage water resources based on emerging models (Integrated Water Resources Management – IWRM), which included participatory user commissions and basin-level committees to deliberate about water allocation (Lemos and De Oliveira 2004). These new institutions have contributed to generic adaptive capacity by giving water users greater access to decision-making and voice. Increased transparency and legitimacy have begun to erode the legacy of clientelistic power arrangements that benefitted elites in the distribution of drought aid by giving preference to irrigation and local elites. The negotiated allocation of water has reduced conflict among users and increased equality, thereby reflecting the positive relationship between generic governance factors in increasing the efficacy and accountability in specific risk reduction interventions (Johns 2011).

(continued)

Box 1 (continued)

However, there have been limitations in the quality and scope of democratization in which centralized institutions maintain high levels of power, attenuating the decision-making capacity of the new participatory institutions by exercising veto power over democratic decisions that run contrary to the official position. Within user commissions and committees, non-elite and poorer users, such as rural workers and small producers, are still marginalized in part due to their lack of resources, social and political capital (Taddei 2005). Alienation and continued exclusion is also a function of the control of knowledge in the form of technical climate information, which is not equally accessible to all participants (Lemos 2007). Thus, while the reform has improved governance and adaptive capacity, there are still constraints to risk response due to skewed power relationships.

The Jaguaribe case illustrates how integration and stakeholder participation contribute to limited gains in adaptive capacity in the case of a severe drought in 2001. The multiple agencies tasked with water management worked together to craft a solution to the water shortage by compensating water-intensive rice producers for foregoing their water allocation and thereby saving perennial fruit orchards. While the coordination enabled by the reform allowed for such a response, there were limitations in using this opportunity for installing bulk water charges in the agricultural sector, mainly due to the limited nature of democratic participation, which stalled a more nuanced and locally-informed implementation of water charges (Johns 2011).

The reform in Jaguaribe has led to increases in generic and specific adaptive capacity over time by allowing water users and small agriculturalists greater access to decision-making through participatory governance, but there are tradeoffs between centralization, knowledge access and participation that complicate the maturity of institutional changes. The reform has complemented wider national anti-poverty measures, such as Zero Hunger and Family Fund (conditional cash transfer schemes), and enhanced the effectiveness and equitable benefits derived from the historical reliance on measures to target specific drought risks. Despite these advances, making further gains in democratic participation is a continuing challenge.

2 Understanding Adaptive Capacity

The concept of adaptive capacity has existed for decades (Parsons 1964; Chakravarthy 1982; Staber and Sydow 2002). Current conceptual underpinnings of adaptive capacity are most closely associated with the Intergovernmental Panel on Climate Change's (IPCC) characterization of *adaptation* as an "adjustment in

Table 1 Determinants of AC

Determinant	Encompasses
Human Capital	Knowledge (scientific, "local", technical, political), education levels, health, individual risk perception, labor
Information & Technology	Communication networks, freedom of expression, technology transfer and data exchange, innovation capacity, early warning systems, technological relevance
Material Resources & Infrastructure	Transport, water infrastructure, buildings, sanitation, energy supply and management, environmental quality
Organization & Social Capital	State-civil society relations, local coping networks, social mobilization, density of institutional relationships
Political Capital	Modes of governance, leadership legitimacy, participation, decentralization, decision and management capacity, sovereignty
Wealth & Financial Capital	Income and wealth distribution, economic marginalization, accessibility and availability of financial instruments (e.g. insurance, credit), fiscal incentives for risk management
Institutions & Entitlements	Informal and formal rules for resource conservation, risk management, regional planning, participation, information dissemination, technological innovation property rights, risk sharing mechanisms

Source: Eakin and Lemos (2006) (Based on Smit et al. 2001 and Yohe and Tol 2002)

natural or human systems in response to actual or expected climatic stimuli or their effects" (Parry et al. 2007). Successful adaptation should result in an equal or improved situation when compared with the initial condition while less successful responses (such as coping) would allow for short term recovery but continued vulnerability. But what ultimately determines the success or failure of adaptation is a system's adaptive capacity, for it describes the ability of a socio-ecological system, group, or individual to mobilize resources to prepare for and respond to current or perceived stresses. Table 1 summarizes the determinants of adaptive capacity often found in the literature.

Understanding what influences adaptive capacity is rooted in the IPCC's categorization of the determinants of adaptive capacity: economic resources, technology, information and skills, infrastructure, institutions, and equity (Smit et al. 2001). A number of scholars have expanded on and redefined this initial list of six categories, and, depending on the analytical lens of the researcher, have emphasized the importance of some elements over others. For example, some research suggests that communities are limited in their capacity to adapt by their ability to act collectively. Here, social capital, trust, and organization greatly influence this capability (Adger and Neil 2003; Pelling and High 2005). Others narrow in on institutions, governance, and management as critical influences on the system or individual's capacity

adapt to climate change (Yohe and Tol 2002; Adger et al. 2005a; Eakin and Lemos 2006; Agrawal 2008; Brown et al. 2010; Engle and Lemos 2010; Gupta et al. 2010). In this emphasis, the degree to which governance is inclusive, just and participatory can have an important influence on what populations are able to effectively cope and adapt to stressors and which populations are most likely to suffer from harm (O'Brien and Leichenko 2003). Adaptive capacity is not equally distributed (Adger et al. 2007) and differential capacities among households, between different communities and even between nations can often be traced to histories of inequitable trajectories of development and differential access to power and resources (Dow et al. 2006).

Despite a long conceptual history and increasing emphasis in climate and sustainability literatures, adaptive capacity has yet to receive sustained empirical examination. In particular, analyses that move from a normative and theoretical understanding of adaptive capacity to test and unpack the theorized determinants of adaptive capacity are lacking. Moreover, it is increasingly evident that focusing on adaptive capacity can have practical and theoretical benefits. Not only is adaptive capacity an integral concept to both vulnerability and resilience studies uniquely positioned to draw from the benefits of both frameworks, but it also better resonates with practitioners and policy makers than concepts such as resilience and sensitivity (Engle 2011).

Adaptive capacity affects vulnerability by modulating exposure and sensitivity (Yohe and Tol 2002; Adger et al. 2007) and influencing both the biophysical and human elements of a socio-ecological system (Eakin and Luers 2006). Political-economy approaches to vulnerability analysis have particularly emphasized that adaptive capacity is socially and politically determined (Kelly and Adger 2000; Eakin 2005; Eakin and Bojorquez-Tapia 2008; Adger et al. 2009; Eriksen and Lind 2009). Adaptive capacity is thus both an aspect of vulnerability directly amenable to human influence and intervention, but particularly challenging to enhance because doing so may threaten existing power relations and resource distribution (Lemos 2003; Eakin and Patt 2011). In resilience studies, adaptive capacity, or adaptability, is the capacity of actors within the system to manage and influence resilience (Walker et al. 2004, 2006). Thus, the more adaptive capacity within a system, the greater the likelihood is that the system will be resilient in the face of climate stress. There is less attention in resilience studies, however, to how the capacities of individuals or groups – particularly those who are politically marginalized or disempowered – can be enhanced in order to effectively manage systemic resilience (but see Tschakert and Dietrich 2010; Brown and Westaway 2011).

These two perspectives, vulnerability and resilience, combine to suggest that there are two important temporal aspects of adaptive capacity. First, adaptive capacity is important for a system or for the actor(s) that constitute that system to cope in the short-term so as to maintain the status quo (i.e., resilience), recognizing that a return to the status quo without challenging existing power structures or resource allocation may not address underlying drivers of vulnerability (Lemos et al. 2007). Second, adaptive capacity is important to facilitate transitions and transformations – the

long-term adaptation directed to more desirable states (Nelson et al. 2007). Yet high adaptive capacity does not necessarily translate into long-term adaptation. Rather than being discrete processes, resilience, transitions and transformations are part of a continuum to which most adaptation action can contribute. What differentiates between them is the quality of the outcome, with transformation leading to highly desirable political, social and rights regimes (Pelling 2009). And while 'desirability' is usually defined by those human elements within a given system (i.e., as negotiated between actors and various interests), the greater the adaptive capacity, the more likely the system or actor(s) will wind up in a 'desirable' situation in the face of a climate variability and change. However, it is important to take into consideration that different actors within a system may have competing and even conflicting interests, and that these actors may have different levels of power to pursue their interests. Depending on the scale of the system in question and the structure of governance, the voices of the most vulnerable populations may not have influence over how "desirability" is defined and achieved. Moreover, there may be tradeoffs between these two elements of adaptive capacity (short-term coping and long-term adaptation) as well as with other aspects of adaptation implementation. For example, synergy between coping and adaptation for one population may mean failure in adaptation for others or enhancing resilience at one scale may exacerbate vulnerabilities at another (Eriksen and Brown 2011). Finally, adaptive capacity is a relative concept both in terms of spatial distribution and the way it is realized in different contexts. For example, within a given country or region there may be a great diversity of levels of adaptive capacity both generic and specific and first order interventions may lead to second and third order adaptations ("adaptations to the adaptations"). In this context, policy makers and decision makers should focus efforts on aligning development initiatives and goals in a manner that can make building adaptive capacity synergistic, rather than leading to competing or incompatible outcomes. In this pursuit, it is important that we improve understanding of what builds adaptive capacity and/or functions as barriers or limits to adaptation through more systematic empirical evaluations (Adger et al. 2009; Engle 2011). Identifying what has led successful and desirable adaptations can help to build empirical evidence for the factors necessary to facilitate these adaptations.

3 Generic and Specific Adaptive Capacity

As mentioned above, generic adaptive capacity is defined as those assets and entitlements that build the ability of different systems to cope with and respond to a range of stressors. Poor households are usually vulnerable to a number of overlapping and interdependent disturbances that shape their overall vulnerability. For example, in India, agricultural households are affected not only by climate impacts but also by globalization that shapes their access to markets and

incomes – that is, they are double exposed to climate impacts and globalization processes (O'Brien et al. 2004). Specific adaptive capacity refers to conditions that prepare systems to cope and recover from a particular event, in this case, a climate-related impact such as drought, flooding, or extreme weather (Sharma and Patwardhan 2008).

Based on case-study evidence, Lemos and her colleagues (Lemos 2007; Tompkins et al. 2008) have argued that building adaptive capacity is a dialectic, two-tiered process in which risk management (specific adaptive capacity) and deeper level socioeconomic and political reform (generic adaptive capacity) iterate to shape overall vulnerability. In principle, risk management approaches can create positive synergies across the state-society divide through participatory and transparent approaches (such as participatory vulnerability mapping or local disaster relief committees) that empower local households and institutions which in turn mobilize for further socio-political reform (Lemos 2007; Nelson et al. 2009). Similarly, by increasing households' overall adaptive capacity, anti-poverty programs (especially those that couple with education and health programs) may positively influence their ability to better take advantage of risk management mechanisms (e.g. access to social programs and insurance, identification of effective drought response).

Yet, empirically, the distinction between generic and specific adaptive capacity has received little attention despite widespread recognition of its critical implications for policy choice and design. These policy implications are twofold. First, policy makers in less developed regions and development scholars increasingly argue that it makes little sense to design policy to build adaptive capacity to climate stressors that ignores the multitude of other factors at the root of different systems' vulnerability. In this sense, this scholarship argues that adaptation policy needs to be *mainstreamed* into development policy to be effective (Huq et al. 2005; Jerneck and Olsson 2008; Kok et al. 2008). Second, some scholars argue that the concept of generic adaptive capacity can only take us so far. Some variables are not generalizable between different stresses and systems (Adger and Vincent 2005) and there is the suggestion that the prospect of adaptive capacity across a range of stresses is essentially a myth (Tol and Yohe 2007). In the next two sections we discuss the relationship between generic and specific adaptive capacity first at the national level, and second, at the household level. We use the concept of adaptive development to argue for a new approach to development that takes into consideration climate risk in policy-making and planning so as to enable national states to respond and recover from current and projected negative impacts of climate change. Formally integrating generic and specific capacity through an adaptive development approach at the national level could effectively balance climatic and developmental challenges. Using a livelihood approach at the household level (Scoones 1998; Ellis 2000), we theorize the relationship between generic and specific adaptive capacity and propose a simple conceptual model of potential synergies and trade-offs between the two.

4 Adaptive Development

Historically, the failure of economic growth alone to solve pressing societal problems has encouraged the emergence of new approaches to development. For example, dominant development paradigms over the past five decades have included human and sustainable development as attempts to address inequality and environmental degradation respectively (Parpart and Veltmeyer 2004). As unprecedented risks represented by climate change impacts become more palpable, the next frontier of developmental policy-making will have to take into account not only past concerns but also climate adaptation.

The effects of climate change will fall unequally and disproportionally on poor communities, and will create greater stress around issues of sustainability (Adger et al. 2005b; Parks and Roberts 2010). Impacts will also bring already stressed human and ecological systems closer to the thresholds of undesirable and irreversible changes (Rockstrom et al. 2009). Climate change also enhances uncertainty in development planning, such that intended economic and social outcomes of policy are potentially jeopardized if climate risks are not accounted for (Box 2).

Box 2 Disaster Risk Reduction in Bangladesh

Bangladesh lowland's exposure to climate-related disasters is well documented; between 1970 and 2004 around 0.7 million people have been killed and economic losses in excess of 5.5 billion dollars have been incurred as a result of cyclones and flooding (Chowdhury et al. 1993; delNinno et al. 2002). Perhaps the worst climate-related disaster was the 1970 Bhola cyclone that hit then East Pakistan (now Bangladesh), killing over half a million people. As recently as 1991, another cyclone, this one hitting at night, killed over 130,000 people and negatively affected other five million. Despite early warning (15 h ahead) and greater availability of shelters (built after the Bhola cyclone by public and private organizations), 67,000 died on impact and property worth US$ 2.4 billion was destroyed (Financial Indicators Bangladesh, 1991 cited by Chowdhury et al. 1993). Human-induced climate change is expected to exacerbate the problem; projected half-meter sea-level rise by 2050 is likely to permanently inundate about 11 % of Bangladesh territory (Khan and Rahman 2007). Bangladesh is the most densely populated country in the world with more than 1,000 people per sq. km (Khan and Rahman 2007). Agriculture, which provides about a quarter of the country's GDP, is largely nature-dependent due to heavy reliance on favorable seasonal conditions, particularly on monsoon rainfall.

Building adaptive capacity in Bangladesh has involved developing both generic and specific capacities. Over the past 30 years, Bangladesh has significantly reduced poverty. While the proportion of the population living below the poverty line was as high as 74 % in 1973–1974, between 1991 and 1992 and 2000, the incidence of national poverty declined from 50 to 40 %,

(continued)

Box 2 (continued)

indicating a reduction rate of 1 % per year (Sen 2003). However, a significant portion of the population remains vulnerable, especially in areas of low "geographic capital". In these locations, social and geographical disadvantages overlap and residents derive few benefits from the economic and social opportunities created by economic growth. Natural resources crises (including disasters) are especially threatening in these areas, being responsible for 15 % of the reason for increasing household poverty (Sen 2003). Specific AC has also been built through risk management programs, especially disaster response and anti-famine interventions. For example, since the 1970s a diverse network of shelters (including hundreds of one-story and two-stories concrete buildings, multi-purpose cyclone shelters and rehabilitating houses) has been built with the help of organizations such as the World Bank and NGOs. The government has also built 150 *killas* (artificial hills), mainly to protect household animals from flooding (Chowdhury et al. 1993). In the 1998 "flood of the century", the government was able to avoid a famine crisis like the one that killed tens of thousands of people in 1974 through a combination of trade liberalization, importation of food and aid (delNinno et al. 2003). Moreover, following the initial flood period, immediate relief was available through the Gratuitous Relief program which provided 35.7 % of severely flood-exposed households with direct relief. The overall handling of the crisis kept prices from rising despite larger losses in rice production than in 1974; indeed the government seems to have learned from successive droughts both in terms of preparedness (public stocks) and longer term planning (role of private markets) (delNinno et al. 2003).

However, vulnerability has persisted as households have remained sensitive (delNinno et al. 2003). After a successful response in 1998, long-term negative impacts included lower calorie consumption, damage to infrastructure (houses) and negative health impacts. Rather than adapting, most households coped with the shock of the flood in several major ways, including reducing expenditures, selling assets and borrowing. While immediate post-disaster relief programs facilitated coping, they were small relative to the needs of households (only one-sixth to one-eighth the size of household borrowing). Borrowing from the private sector to purchase food and to fund other expenses such as education, health, farming, business, repayment of loans, marriage and dowry, purchases and mortgage of land or agricultural equipment constituted the main coping strategy, leaving many households in debt even a year after the event. Fifteen months after the flood, household debts still averaged 146 % of 1 month's average consumption for the 64.2 % of flood-exposed households in the bottom 40 % of the expenditure distribution (delNinno et al. 2003). Although debt declined with time, it still constituted a great part of household hardship and left them vulnerable to future shocks. The Bangladesh case suggests that while focusing on risk management greatly reduces casualties and facilitates coping in the short run, it fails to foster long-term adaptation.

New approaches to help govern social and individual risks must explicitly consider the negative synergy between climate risks and structural deficits in its many forms. As mentioned above, poverty, lack of access to health and education, lack of political power, and social inequalities exacerbate vulnerability to climate impacts while recurrent impacts (drought, storms, etc.) increase vulnerability (Heltberg et al. 2009). By focusing on how risks can be reduced in the pursuit of development and vice-versa, it becomes possible to identify the essential difference between development in the face of climate change and development as growth, human development, and/or sustainable development. Yet, this distinction does not mean that we believe policy to address risk should not be to integrated and reconciled into other developmental policy; rather, we argue that adaptive development pays specific attention to how risk management intersects (positively and negatively) with policies aiming at economic growth, human and sustainable development. For example, in drought ravaged Northeast Brazil, risk management interventions such as crop insurance or emergency provision of drinking water can allow affected households to respond to short-term drought stress. However, the extent to which these interventions allow families to cope and also develop longer term adaptive capacity is likely to be predicated on the combination of specific risk management with generic anti-poverty programs such as the Zero Hunger or Family Fund initiative which provide households with fungible cash resources and long-term access to education and health. In NE Brazil, such programs may be fundamentally changing the relationship between exposure and sensitivity to drought and improving the ability of households to use monthly cash allowances for short-term survival while simultaneously engendering long-term resilience through better health and educational access.

When considered as a means to address risks faced by diverse populations, the concept of adaptive development provides a clear conceptual basis upon which to elaborate strategies aimed at improving the life chances of the poor and the long-term sustainability of ecosystems. Adaptive development strategies would work to reduce the riskiness of development choices, even as they attend to the criteria of equity and sustainability. The idea of adaptive development can help take into account the dynamic, non-incremental, synergistic and often surprising nature of climate change hazards that will need to be addressed in the future. Going back to the NE Brazil example above, it would be precisely in the positive synergy between short term risk interventions and long-term development programs that our ability as a society to prepare for both extreme events and long-term incremental change brought about by climate change lie. Adaptive development provides the social infrastructure that bridges individual actions to reduce personal vulnerability into a framework in which such actions contribute to collective capacity to manage risk. In addition, thinking about development through a risk and risk governance lens enables policy makers and scholars to draw upon a vast body of historical and emerging scholarly work that has sought to examine the nature of risks, and how risks can be and have been addressed in the past. Better understanding these responses leads us squarely to the scholarship focusing on the political economy of hazards, disaster risk and adaptation to climate-related impacts (especially climate variability) (Blaikie et al. 1994; Pelling and High 2005).

From a policy point of view, beyond conceptualizing the relationship between development and risk, there is a need to understand the dynamics of adaptive action, that is, how the practice of implementing risk management interplays with development policy negatively and positively. The adaptive nature of this implementation requires monitoring and experimentation that lead to evaluation and learning, aimed especially at increasing understanding of how positive synergies between more traditional development policies (i.e. those which aim to address structural deficits) interact and intersect with new ones designed to address climate-related risk. It also requires that we understand the direct and indirect effects of adaptation policy and make sure that the solutions pursued yield desirable outcomes for those populations who are particularly at risk and do not trade off negatively with sustainability and equity (Brown 2011; Eriksen and Brown 2011). Next, we look at specific and generic adaptive capacity at the household level and discuss their implications for mitigating vulnerability to climate change.

5 Livelihoods and Adaptation

At the household level, the combination of generic and specific adaptive capacity (or lack thereof) is associated with two kinds of actions: (1) those that enable households to maintain their level of assets even after the climate-related impact (defined as adaptations); and (2) those that allow households to respond to extreme events in the short term, but in ways that may erode their asset-base in the long-term (defined as coping). For example, when a household adapts in anticipation of drought, it might invest in water harvesting or the infrastructure for silage. When a drought hits this household it is less exposed and therefore able to 'ride the drought' relatively unscathed. In contrast, a household might otherwise sell some livestock to pay for fodder for the rest of the herd, subsequently losing part of its asset base forcing it to rebuild the herd in less than optimal circumstances (Carter et al. 2007). In this case, it copes rather than adapts because it fails to maintain or improve over its original state. In other words, while some extreme event-coping actions such as the sale of livestock or land might allow the household to recover in the short run, they will diminish its asset base in the long run, making the household more vulnerable. Broadly stated, households with enhanced adaptive capacity – and presumably more secure assets, entitlements and thus livelihood–may be more likely to engage in welfare-enhancing adaptations because they have the stock of capital from which to make these investments. Unlike asset-constrained households, they are less likely to rely on coping strategies that threaten their long-term welfare (Dercon 1998; Siegel and Alwang 1999; Carter et al. 2007). Typically there is a history to such differences in assets and entitlements: households are embedded in political structures that institutionalize resource access and distribution in ways that are often path dependent, creating poverty traps for those households who are excluded.

Livelihood analysis provides a pragmatic approach to assessing capacities and entitlements at the household level. Drawing from Sen's (1981) entitlement theory,

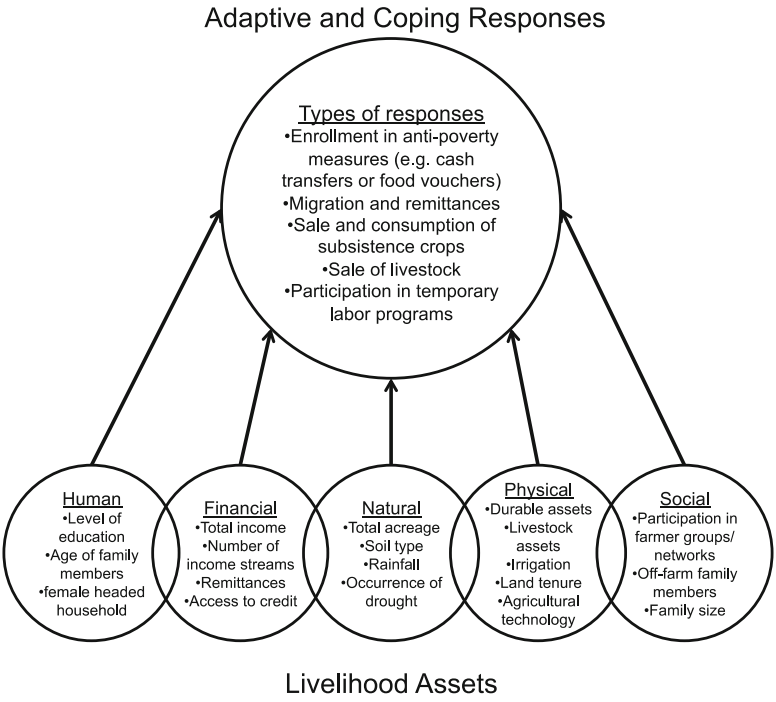

Fig. 1 Relationship between capitals, and adaptive and coping responses

sustainable livelihood research (Scoones 1998; Carney et al. 1999) addresses the relationships among a household's resource base (assets), its entitlements (the institutional context affecting rights and access to resources), and the result of these activities for aggregate household welfare (outcomes, or what we define as responses). Household capacity attributes can be categorized into five classes of livelihood capital: human capital (education, health, attitudes, belief systems); natural capital (soil quality, water endowments); physical capital (equipment, transport); social capital (connectivity in social or political networks); and financial capital (monetary savings, income composition) (Scoones 1998; Ellis 2000). Depending on the specific circumstances of the household and the political and economic structures in which the household exists, these different capitals play different functions in livelihood strategies and are differentially weighted in relation to risk management (Eakin and Bojorquez-Tapia 2008). These types of livelihood capital interact to engender coping and adaptation strategies (i.e. responses). Whether the strategies households engage in ultimately enhance (adaptation) or maintain/diminish their welfare over time (coping), such strategies typically can be classified as those that involve mobility, storage, diversification, communal pooling, and market exchange (Agrawal 2008). Figure 1 above depicts the five types of capital in relation to adaptive and coping responses.

As mentioned above, to support household adaptation in developing countries, adaptation policy makers must decide whether it is more effective to invest in

measures that will reduce vulnerability to a broad range of stressors (climatic and non-climatic), or whether it is best to focus on enhancing capacities to manage specific hazards. In terms of the livelihood framework, policy makers must decide not only which types of livelihood assets and risk management should be strengthened through public investment and support but also how their design and implementation positively synergize with rather than detract from existing desirable responses (e.g. local mobilization of social capital and risk pooling) (Box 3).

Box 3 Poverty Traps and Disaster in Ethiopia

Poverty traps are "self-reinforcing feedback loops that keep social-ecological systems in persistent poverty" (Azariaidis and Stachurski 2005, Dasgupta 2007) (Maru et al. 2012). Carter et al. (2007) define poverty traps as a "minimum asset threshold" below which dynamic accumulation and livelihood growth towards greater well-being, that is – in climate parlance – adaptation, is not feasible. In the context of climate vulnerability, poverty traps define poor households' coping capacity to respond to climate-driven impacts such as drought and flooding and ultimately shape their inability to adapt. In some areas of both the developed and less developed world, poverty traps represent undesirable resilient states that critically limit the asset base of poor communities (e.g. income, access to health and educational services, social and political capital, etc.) (Lemos and Tompkins 2008; Nelson and Finan 2009; Maru et al. 2012).

The Ethiopian drought-driven famine crisis of 1998–2000 exemplifies both the progress that LDCs have made in improving disaster response and the role poverty traps can play in staving long term adaptive capacity building (Hammond and Maxwell 2002; Carter et al. 2007). The crisis itself was the result of both the relative failure of three consecutive rainy seasons and the inability of Ethiopian policy makers and the international aid system to fully prevent and respond to post-disaster impacts on poor households, especially highlands pastoralists (Hammond and Maxwell 2002). While government response markedly improved in relation to the 1983 El Niño-driven drought famine, in these households poverty traps resulted in an asset smoothing function (i.e. when households hold on to their livestock assets rather than selling them at the expense of an increase in food consumption after the shock). However, despite trying to hold on to their animals many of these households soon reached a threshold – a lower equilibrium – at which they settle down and stop growing (Carter et al. 2007) or, in other words, they cope rather than adapt and, in consequence, position themselves poorly to respond to the next set of stressors coming their way. To break out of this undesirable state beyond disaster response, it is necessary to build and diversify the asset base of these households by tackling several types of their capital shortage including income, social networks, food security, political participation, etc.

At the household level, we theorize that the relationship between specific and generic adaptive capacity is twofold. First, the ability of households to benefit from risk management may be predicated on a minimum level of generic capacity. For example, some households may be so vulnerable that they lack the minimum level of resources to benefit from or engage in specific risk management interventions. This may be the case for households lacking basic education and enough financial resources to enroll and benefit from programs such as crop insurance or rural credit. In this case, their adaptive capacity may be enhanced by specific educational and social policies such as Oportunidades in Mexico or Zero Hunger in Brazil. It can also be enhanced by their membership in rural labor unions or cooperatives through which they pool risk or share resources. Another example relates to the usability of seasonal climate forecasting (SCF) information. Empirical research has repeatedly uncovered that certain communities of groups in least developed countries are severely limited in their ability to benefit from SCF because of their lack of minimum capacity to respond to the projections. In this case, even if farmers had access to SCF, their lack of financial capital constrains their ability either to change crops (to shorter or longer grains, for example) or engage in other forms of adaptation (Finan and Nelson 2001; Ingram et al. 2002; Lemos et al. 2002). In many cases, households with constrained entitlements have not benefited from development interventions adequately, or have been marginalized in national economic trajectories (Eakin 2005). Here, if households had the socioeconomic preconditions to change their crops or participate in seed distribution programs, there would be the possibility of a synergistic relationship between generic and specific adaptive capacity as climate information could be effectively employed to mitigate climate variability risk.

In contrast, reliance on cash transfers may erode households' long-term capacities through the issue of "lock-in", that is, when welfare programs create relationships and dependencies between state and society that are difficult to uproot and may create rigidity rather than flexibility to respond to multiple stressors. Saldaña-Zorilla (2008), for example, found that despite the decline in public investment and support for the rural sector, there was a persistent expectation among farmers in Mexico that the government should be responsible for disaster risk mitigation, contributing to enhanced vulnerability and passivity. Eakin and Bojorquez-Tapia (2008) found that larger-scale private sector farmers in northern Mexico who had historically benefited from preferential access to land, financial services and commercialization support were more sensitive and ultimately more vulnerable to climatic shocks than their relatively resource-poor *ejidal* (a form of collective tenure) neighbors. As public support for farmers of almost all types declined in the 1990s in Mexico, and the government no longer guaranteed insurance or provided financial support, the larger-scale and more privileged farm class found it lacked the crop and livelihood diversity to cope effectively with extreme events. The *ejidatarios*, having never relied on public support as a means of coping with shocks, were far more autonomous and self-reliant in terms of risk management, although also less commercially engaged and productive than their counterparts. In other cases in Mexico, larger-scale commercial producers moved quickly to secure public support

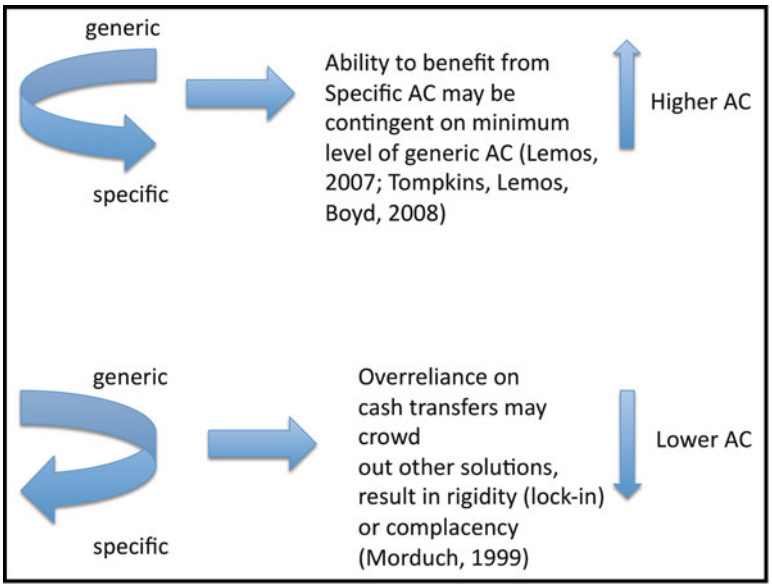

Fig. 2 Positive and negative feedbacks between generic and specific AC

following agricultural market liberalization in Mexico in the early 1990s. Their actions, designed to ensure that federal and state policy are closely aligned with their sectoral interests, resulted in a dangerous degree of complacency and neglect of risk such that famers require unprecedented federal support after their crops failed to frost in February 2011 (see Eakin et al. 2013).

Moreover, cash transfer programs may "crowd out" other initiatives (such as private investments) that may enhance adaptive capacity. For example, Murtinho (2011) found that in some rural Andean communities, autonomous adaptations to address problems of water scarcity were effectively "crowded out" by unsolicited public sector interventions. Rather than enhancing capacities to collectively manage current and future risk, the heavy-handed support of government was diminishing the probability that the community would take action. Figure 2 above shows a conceptual model of some of the relationships between generic and specific adaptive capacity.

6 Conclusions

This paper focuses on the relevance of adaptive capacity in the context of the increasing certainty that climate change impacts will affect human populations and different social groups substantially and differentially. The paper does so by arguing for greater attention to increasing climate risks in the design of development policies. The argument builds on two conceptual distinctions. The first is between

specific and general adaptive capacity where specific adaptive capacity refers to the ability of agents and systems to address the risks specific to a particular climate threat and generic adaptive capacity refers to household endowments and system characteristics that enable more flexible responses to a diverse range of climate threats and other stressors. While we recognize that building both kinds of capacity may require different strategies and face diverse levels of resistance, bolstering generic and specific adaptive capacities with careful attention to minimizing the potential tensions between these two types of adaptive capacity can help vulnerable groups maintain their ability to address risks in the long run at the same time as they respond effectively to short term climate impacts.

An analogous distinction that the paper advances concerns the idea of adaptive development and development as usual. Adaptive development focuses on how to address livelihoods and welfare in increasingly risky contexts compared to earlier variants of development that focused on growth, equity, and/or sustainability. The paper highlights how future development policies and interventions are likely to require greater attention to risk reduction to secure the objective of greater welfare because more frequent, intense, and widespread climate threats may otherwise undermine development gains.

The paper also emphasizes the fact that specific and generic adaptive capacity are not always positively related, just as development interventions and growth-focused development outcomes can sometimes reduce the ability to cope with risks. Using a number of case examples, the paper identifies how to enhance the potentially synergistic relationship between specific and generic adaptive capacity or between risk reduction and growth, equity, and sustainability.

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References

Adger WN (2006) Vulnerability. Glob Environ Chang-Hum Policy Dimens 16(3):268–281

Adger NW, Neil W (2003) Social capital, collective action, and adaptation to climate change. Econ Geogr 79(4):387–404

Adger WN, Vincent K (2005) Uncertainty in adaptive capacity. Compte Rendus Geosci 337(4):399–410

Adger NW, Arnell NW et al (2005a) Successful adaptation to climate change across scales. Glob Environ Chang 15:77–86

Adger WN, Brown K et al (2005b) The political economy of cross-scale networks in resource co-management. Ecol Soc 10:9

Adger WN, Agrawala S et al (2007) Assessment of adaptation practices, options, constraints and capacity. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, p.p717–743

Adger WN, Dessai S et al (2009) Are there social limits to adaptation to climate change? Clim Chang 93(3 – 4):335–354

Agrawal A (2008) The role of local institutions in adaptation to climate change. International Forestry Resources and Institutions Program, Working paper #W081-3, University of Michigan, Ann Arbor
Agrawala S (2004) Adaptation, development assistance and planning: challenges and opportunities. IDS Bull-Inst Dev Stud 35(3):50–54
Bizikova L, Robinson J et al (2007) Linking climate change and sustainable development at the local level. Clim Policy 7(4):271–277
Blaikie P, Cannon T et al (1994) At risk. Natural hazards, people's vulnerability and disasters. Routledge, London
Brown K (2011) Sustainable adaptation: an oxymoron? Clim Dev 3:21–31
Brown K, Westaway E (2011) Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. Annu Rev Environ Resour 36:321–342
Brown H, Nkem J et al (2010) Institutional adaptive capacity and climate change response in the Congo Basin forests of Cameroon. Mitig Adapt Strateg Glob Chang 15(3):263–282
Carney J, Drinkwater M et al (1999) Livelihood approaches compared. Department for International Development, London, p 19
Carter MR, Little PD et al (2007) Poverty traps and natural disasters in Ethiopia and Honduras. World Dev 35(5):835–856
Chakravarthy BS (1982) Adaptation: a promising metaphor for strategic management. Acad Manag Rev 7(1):35–44
Chowdhury AMR, Bhuyia AU et al (1993) The Bangladesh cyclone of 1991 – why so many people died. Disasters 17(4):291–304
delNinno C, Dorosh PA et al (2002) Reducing vulnerability to natural disasters – lessons from 1998 floods in Bangladesh. IDS Bull-Inst Dev Stud 33(4):98–107
delNinno C, Dorosh PA et al (2003) Public policy, markets and household coping strategies in Bangladesh: avoiding a food security crisis following the 1998 floods. World Dev 31(7): 1221–1238
Dercon S (1998) Wealth, risk and activity choice: cattle in Western Tanzania. J Dev Econ 55:1–42
Dow K, Kasperson R et al (2006) Exploring the social justice implications of adaptation and vulnerability. In: Adger N, Paavola J, Huq S, Mace MJ (eds) Fairness in adaptation to climatic change. MIT Press, Cambridge
Eakin H (2005) Institutional change, climate risk, and rural vulnerability: cases from central Mexico. World Dev 33(11):1923–1938
Eakin H, Bojorquez-Tapia LA (2008) Insights into the composition of household vulnerability from multicriteria decision analysis. Glob Environ Chang-Hum Policy Dimens 18(1):112–127
Eakin H, Lemos MC (2006) Adaptation and the state: Latin America and the challenge of capacity-building under globalization. Glob Environ Chang-Hum Policy Dimens 16(1):7–18
Eakin H, Luers AL (2006) Assessing the vulnerability of social-environmental systems. Annu Rev Environ Resour 31:365–394
Eakin HC, Patt A (2011) Are adaptation studies effective, and what can enhance their practical impact? Wiley Interdiscip Rev: Clim Chang 2(2):141–153
Eakin H, Perales H et al (2011) Between rigidity and lock-in traps: adaptability and the future of maize in Mexico. Paper presented at Resilience 2011, Tempe
Eakin H, Bausch JC, Sweeney S (2013) Agrarian winners of neoliberal reform: the 'Maize Boom' of Sinaloa, Mexico. J Agrarian Change. doi:10.1111/joac.12005
Ellis F (2000) Rural livelihoods and diversity in developing countries. Oxford University Press, Oxford
Engle NL (2011) Adaptive capacity and its assessment. Glob Environ Chang 21(2):647–656
Engle N, Lemos MC (2010) Unpacking governance: building adaptive capacity to climate change for river basins in Brazil. Glob Environ Chang 20(1):4–13
Eriksen S, Brown K (2011) Sustainable adaptation to climate change. Clim Dev 3
Eriksen S, Lind J (2009) Adaptation as a political process: adjusting to drought and conflict in Kenya's drylands. Environ Manag 43(5):817–835
Finan TJ, Nelson DR (2001) Making rain, making roads, making do: public and private adaptations to drought in Ceará, Northeast Brazi. Clim Res 19:97–108

Gupta J, Termeer C et al (2010) The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Environ Sci Policy 13(6):459–471

Hammond L, Maxwell D (2002) The Ethiopia crisis of 1999–2000: lessons learned, questions unanswered. Disasters 26(3):262–279

Heltberg R, Siegel PB et al (2009) Addressing human vulnerability to climate change: toward a 'no-regrets' approach. Glob Environ Chang 19(1):89–99

Huq S, Rahman A et al (2003) Mainstreaming adaptation to climate change in least developed countries (LDCs). Cambridge University Press, International Institute for Environment and Development: Climate Change Program. Intergovernmental Panel on Climate Change. Working group II, climate change 2001: impacts, adaptation and vulnerability, Chap 18

Huq S, Yamin F et al (2005) Linking climate adaptation and development: a synthesis of six case studies from Asia and Africa. IDS Bull-Inst Dev Stud 36(4):117–122

Ingram KT, Roncoli C et al (2002) Opportunities and constraints for farmers of west Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. Agric Syst 74(3):331–349

Jerneck A, Olsson L (2008) Adaptation and the poor: development, resilience and transition. Clim Policy 8(2):170–182

Johns O (2011) Climate and change in Brazilian water management: a case study of governance and adaptive capacity. MSc., University of Michigan, Practicum

Kelly PM, Adger WN (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Clim Chang 47:325–352

Khan MR, Rahman MA (2007) Partnership approach to disaster management in Bangladesh: a critical policy assessment. Nat Hazard 41(2):359–378

Kok M, Metz B et al (2008) Integrating development and climate policies: national and international benefits. Clim Policy 8(2):103–118

Lemos MC (2003) A tale of two policies: the politics of seasonal climate forecast use in Ceará, Brazil. Policy Sci 32(2):101–123

Lemos MC (2007) Drought, governance and adaptive capacity in North East Brazil: a case study of Ceará. Fighting climate change: human solidarity in a divided world, Human Development Report 2007/2008. H. D. R. O. O. paper, United Nations Development Program

Lemos MC, De Oliveira JLF (2004) Can water reform survive politics? Institutional change and river basin management in Cear Northeast Brazil. World Dev 32(12):2121–2137

Lemos MC, Tompkins EL (2008) Creating less disastrous disasters. IDS Bull-Inst Dev Stud 39(4):60–66

Lemos MC, Finan T et al (2002) The use of seasonal climate forecasting in policymaking: lessons from Northeast Brazil. Clim Chang 55(4):479–507

Lemos MC, Boyd E et al (2007) Developing adaptation and adapting development. Ecol Soc 12(2):26

Maru YT, Fletcher CS et al (2012) A synthesis of current approaches to traps is useful but needs rethinking for indigenous disadvantage and poverty research. Ecol Soc 17(2):7

Murtinho F (2011) Adaptation to environmental change among water user associations in the Colombian Andes. PhD, University of California, Santa Barbara

Nelson DR, Finan TJ (2009) Praying for drought: persistent vulnerability and the politics of patronage in Ceara, NE Brazil. Am Anthropol 11(3):302–316

Nelson DR, Adger WN et al (2007) Adaptation to environmental change: contributions of a resilience framework. Annu Rev Environ Resour 32:395–419

Nelson DR, Folhes MT et al (2009) Mapping the road to development: a methodology for inclusion and scaling-up of participation in policy processes. Dev Pract 19(3):386–395

O'Brien K, Leichenko RM (2003) Winners and losers in the context of global change. Ann Assoc Am Geogr 93(1):89–103

O'Brien K, Leichenko R et al (2004) Mapping vulnerability to multiple stressors: climate change and globalization in India. Glob Environ Chang 14:303–313

Parks BC, Roberts JT (2010) Climate change, social theory and justice. Theory Cult Soc 27(2–3):134–166
Parpart JL, Veltmeyer H (2004) The development project in theory and practice: a review of its shifting dynamics. Can J Dev Stud 25(1):39–59
Parry ML, Canziani OF et al (2007) Technical summary. In: Parry ML, Canziani OF, Palutikof JP, v. d. Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge
Parsons T (1964) Evolutionary universals in society. Am Sociol Rev 29(3):339–357
Pelling M (2009) Adaptation to climate change. From resilience to transformation. Routledge, Abingdon
Pelling M, High C (2005) Understanding adaptation: what can social capital offer assessments of adaptive capacity? Glob Environ Chang 15:308–319
Rockstrom J, Steffen W et al (2009) A safe operating space for humanity. Nature 461(7263): 472–475
Saldaña-Zorilla SO (2008) Stakeholders' views in reducing rural vulnerability to natural disasters in Southern Mexico: hazard exposure and coping and adaptive capacity. Glob Environ Chang 18:583–597
Scoones I (1998) Sustainable rural livelihoods: a framework for analysis. IDS working paper
Sen B (2003) Drivers of escape and descent: changing household fortunes in rural Bangladesh. World Dev 31(3):513–534
Sharma U, Patwardhan A (2008) An empirical approach to assessing generic adaptive capacity to tropical cyclone risk in coastal districts of India. Mitig Adapt Strateg Glob Chang 13(8):819–831
Siegel P, Alwang J (1999) An asset-based approach to social risk management: a conceptual framework. Social protection discussion paper series. Social Protection Unit, The World Bank, Washington, DC
Smit B, Pilifosova O et al (2001) Adaptation to climate change in the context of sustainable development and equity. In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (eds) Climate change 2001: impacts, adaptation and vulnerability. Contribution of working group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge
Staber U, Sydow J (2002) Organizational adaptive capacity: a structuration perspective. J Manag Inq 11(4):408–424
Taddei R (2005) Of clouds and streams, prophets and profits: the political semiotics of climate and water in the Brazilian Northeast. PhD dissertation, Columbia University
Tol RSJ, Yohe GW (2007) The weakest link hypothesis for adaptive capacity: an empirical test. Glob Environ Chang 17(2):218–227
Tompkins EL, Lemos MC, Boyd E (2008) A less disastrous disaster: managing response to climate-driven hazards in the Cayman Islands and NE Brazil. Glob Environ Chang 18(4):736–745
Tschakert P, Dietrich KA (2010) Anticipatory learning for climate change adaptation and resilience. Ecol Soc 15(2)
Walker B, Holling CS et al (2004) Resilience, adaptability and transformability in social–ecological systems. Ecol Soc 9(2):5. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5
Walker B, Gunderson L et al (2006) A handful of heuristics and some propositions for understanding resilience in social-ecological systems. Ecol Soc 11(1):13. [online] URL:http://www.ecologyandsociety.org/vol11/iss11/art13/
Wilbanks TJ, Kates RW (2010) Beyond adapting to climate change: embedding adaptation in responses to multiple threats and stresses. Ann Assoc Am Geogr 100(4):719–728
Yohe G, Tol RSJ (2002) Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. Glob Environ Chang-Hum Policy Dimens 12(1):25–40