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Differentiating capacities as a means to sustainable climate change adaptation

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ABSTRACT

There are two forms of capacity to adapt to global change: those associated with fundamental human development goals (generic capacity), and those necessary for managing and reducing specific climatic threats (specific). We argue that these two domains of capacity must be addressed explicitly, simultaneously and iteratively if climate change adaptation and sustainable development goals are to be attained. We propose a simple heuristic to understand the four main ways these two capacities interact, leading to more or less desirable outcomes. Drawing from three case studies of agricultural adaptation to climatic risk (Phoenix, AZ; Northeast Brazil; Chiapas, Mexico) we argue that the institutional context of adaptation can implicitly or explicitly undermine one form of capacity with repercussions for the development of the other. A better and more strategic balance of generic and specific capacities is needed if the promised synergies between sustainable development and adaptation are to be achieved.
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1. Introduction

The growing recognition of the need to respond to climate change impacts has placed adaptation at the forefront of societal and governmental agendas around the world. In the context of increased awareness of the threats that climate change may impose on human populations, ecological systems and built environments, two ideas have prominently informed both the science and practice of adaptation. First, while climate change must be understood as a global process, adaptation is contextual and local. Second, adaptation policy is a more salient concern for less developed regions than for more developed ones. In this paper, we argue that while context and place-specificity is critical, in order for this specificity to best inform policy, it must be mapped onto two dimensions of adaptive capacity – *generic* and *specific* capacity. Analytically, the disaggregation of capacity into these dimensions illustrates the salience of adaptation not only in the developing world, but also, crucially, for more economically developed regions.

Theoretically and empirically, three arguments inform our thinking. First there is a strong academic and political agreement that the human toll of climate impacts is disproportionally felt in less-developed regions (World Bank, 2010; Parks and Roberts, 2006; Dow and Kasperson, 2006). Vulnerable populations in these regions are typically exposed to numerous stressors – climate hazards, volatility in markets, unstable political regimes – which compound the levels of risk and the potential impacts of any given climate event. But vulnerability is not restricted to the developing world: as hurricanes Sandy and Katrina have painfully demonstrated for the United States, even in contexts where governments are stable, infrastructure is engineered according to robust standards, and early warnings are relatively reliable and accessible, losses can be extensive and devastating (Moss et al., 2013). The relationship between development and climate risk is thus twofold. On the one hand, in the developing world and among some populations in the Global North, the lack of capacity to manage stressors (climatic and non-climatic) has roots in structural underdevelopment and the constraints it imposes on the exercise of choice in pursuit of human needs (Sen, 1999; Lemos et al., 2007; Pelling, 2011). On the other hand, in more affluent societies, vulnerability may also be rooted in development processes that, paradoxically, have successfully buffered populations from having to manage climatic risk as part of their daily livelihood activities (O Brien et al., 2006).

Second, all regions, regardless of development conditions, have varying levels and types of adaptive capacity, that is, the preconditions that enable any adaptation. While researchers have made considerable progress in identifying which attributes of a

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population are indicative of its overall adaptive capacity (Moss et al., 2001; Yohe and Tol, 2001; Brooks et al., 2005; Eakin and Lemos, 2006), they are less sure about the role of and relationship among different attributes of capacity (Lemos et al., 2013). Here, we argue that, depending on the social and geographic context, some attributes of capacity may need more concerted attention than others, particularly if climate adaptation is to work synergistically with sustainable development objectives. Only through such synergies is there a possibility that the structural conditions that undergird vulnerability will be addressed, paving the way for socially and politically transformative development processes.

Third, we posit that capacity can be understood as being composed of two dimensions: *generic* capacities, addressing deficiencies in basic human development needs (e.g., health, education, livelihood security, mobility) and *specific* capacities, which we define as those capacities that address the tools and skills needed to anticipate and effectively respond to specific (climatic) threats (Sharma and Patwardhan, 2008; Lemos et al., 2013). These two dimensions of capacity exist to some degree in all populations and societies, but manifest at different levels of decision-making (individual to national or supra-national) and are not necessarily distributed uniformly in any given population. These capacities may be latent in a population, and difficult to identify prior to the population's response (or lack of response) to a climatic stressor or shock (Engle, 2011). Nevertheless, existing demographic and socioeconomic characteristics of a population (for generic capacities), as well as existing actions taken to confront risk (for specific capacities) can be indicative of latent capacities and the levels of decision-making at which these capacities are manifest (Table 1).

Normatively, we argue that these two domains of capacity must be addressed explicitly, simultaneously and iteratively if climate change adaptation and sustainable development goals are to be attained. To this end, we draw from the empirical literature on adaptation and development to create a heuristic for evaluating the relationship between adaptive capacity in face of climate change and the critical capacities necessary for transformative and adaptive development, which we define as development investments that fundamentally alter over time the structural conditions that circumscribe the choice sets of vulnerable populations. We then illustrate the application of this heuristic to our own empirical research in Brazil, Mexico and the United States. In the next sections, we use evidence from our research and from the work of other adaptation scholars to illustrate and ground our propositions in the empirical literature.

Table 1
Examples of the manifestation of different forms of capacity at different organizational levels.

	Individual actor	System-level
Generic	Income level and structure, savings	Economic productivity
	Material assets	Information infrastructure
	Health status	Poverty levels
	Education levels	Economic and social inequality
	Population mobility	Transparency in governance
	Participation in social organizations	Population-level education
		Sanitation
		Health care services
		Built environment integrity
Specific	Climatic information use	Insurance provisioning systems
	Protection of private property	Early warning systems
	Climate risk insurance	Scenario development
	Adoption of technologies (e.g., crop varieties) to reduce climate impacts	Infrastructure investment
	Cultural climate prediction	Disaster planning
	Traditional risk mitigation strategies	Disaster compensation funds
		Risk mitigation planning

2. Integrating development and climate policy

Climate adaptation and development policy both seek to offer solutions to identified social ills and challenges. Yet, as they are currently conceptualized and operationalized, they are typically directed toward different sets of social problems and often targeted at different time scales. Development practice focuses on strategies to address structural differences within a society: inequities in access or availability of health or education services, inadequate income opportunities or disparities in availability of food, water and shelter. Contemporary development theory tends to highlight the importance of long-term payoffs through *structural* investments in female education, health and governance (Sachs, 2005; Banerjee and Duflo, 2011). Such payoffs epitomize "generic capacities": they enable social actors to respond to stress by increasing the range of agency and expanding choice.

In contrast, the emergent domain of climate adaptation policy has tended to emphasize risk management and the ability of vulnerable populations to respond to identified climate risks and scenarios of change, such as drought or flooding. Adaptation policy, particularly as related to public sector investments, often focuses on infrastructure improvements, enhancing early warning systems, public awareness campaigns and technological solutions to climatic threats (Eakin and Patt, 2011; Bierbaum et al., 2013; Moss et al., 2013). Despite the potential for synergies, climate adaptation and development policy typically developed in isolation, by separate institutions and agencies, rather than in an integrated fashion (Frankhauser and Burton, 2011; Smith et al., 2011).

The differential policy emphasis on *generic* human development and the management of *specific* risks linked to climate change in different economic contexts has important implications for policy design and interventions (development), as well as for the funding and financing of adaptation (Pielke and Sarewitz, 2005). The complexity and costs of designing and implementing policies that are targeted to develop both specific and generic capacity inevitably pose hard choices for governments around the world (Frankhauser and Burton, 2011). It makes sense to implement cost-effective policy that takes into consideration positive synergies between building both generic and specific capacities. For example, social policy that increases household income may also reduce the risk of famine in case of drought, or rising education levels in households may make them more likely to benefit from early warnings (Adger et al., 2011; Lemos et al., 2013). However, demonstrating the effectiveness of investment in generic capacity for adaptation is complex and methodologically challenging. In the absence of such evidence, the legitimacy of such adaptation interventions may also be questioned (Engle, 2011). Moreover, irrespective of what approach individuals, communities and governments choose, there may be tradeoffs between building different kinds of capacities that need to respond to a multiplicity of stressors. Adaptation actions taken at one spatial scale or place may negatively affect another (Eriksen et al., 2011).

For example, over the last decade Haiti has received significant bilateral and multilateral investment in improving disaster preparedness and early warning systems. Nevertheless, while diminished human losses to hurricanes may be attributed to some of these investments, persistent poverty, chronic health deficiencies, political instability and high unemployment have repeatedly undermined these efforts (Herard, 2011). While in cases such as Haiti weak institutions and poverty can undermine effective disaster management, well-established institutions and conditions of apparent wealth can lead to complacency. In Norway, for example, researchers have identified a lack of motivation at the local level to implement and enforce new flood risk management schemes following significant flooding in 1995. Despite high levels of education, a stable economy, and a relatively wealthy population, the institutional environment provided little incentive locally to innovate in risk management (Næss et al., 2005). Similarly, in the United States, the availability of farm insurance may buffer corn producers in the Midwest from feeling at risk even in the context of severe meteorological drought (Mase and Prokopy, in preparation).

An integrated and consistent analysis of these types of tradeoffs and synergies across time, space, and scale is a daunting task, which can potentially lead to inaction in face of knowledge deficiencies. We propose that disaggregating capacity into *specific* and *generic* attributes and exploring their relationship across these given dimensions (space, time, scale) is an important step to design and implement adaptation policy and options, and can be effective even in conditions of high uncertainty. In some contexts, for example, interventions focused on mitigating specific risks without attention to generic capacities may ultimately be maladaptive. In others, targeted investments to alleviate the burden of risk management at the local level may be precisely what are needed for a population to attain a more desirable level of human development (Tanner and Mitchell, 2008). There is an opportunity now in the design of adaptation policy to explicitly enhance rather than undermine these types of synergies. In the next section, we outline some of the critical tensions between climate adaptation and development interventions in relation to generic and specific capacity.

3. The burden of adaptation

While the autonomous actions of individuals, households and firms are instrumental in adaptation, their decisions are made in the context of governance arrangements and institutional environments that both constrain and facilitate decision-making. In some areas of the world, formal public and commercial instruments for risk management are almost non-existent; households and communities tend to bear risk locally and rely more heavily on informal norms and rules to manage environmental variability. In many cases, these strategies have been remarkably successful: they have enabled survival in some of the more isolated and more difficult environmental conditions for human existence (Denevan, 1983). Andean indigenous farmers, for example, have adapted to highly variable agro-ecological conditions by stratifying their farming strategies by altitude (Brush, 1977). Historically, rural residents across the developing world have pursued flexible labor strategies, crop diversification and rely on kinship networks to cope with drought (Mortimore, 1989; Davies, 1996; Mertz et al., 2011). Well-documented and even celebrated by anthropologists, agro-ecologists, geographers and others as demonstrations of human *adaptability* to difficult environments, these strategies may nonetheless be insufficient to respond to accelerated environmental change (Valdivia et al., 2010; Ford and Pearce, 2012). These local and informal risk management strategies can also be undermined by the implementation of formal public policies and programs that ignore or misunderstand their adaptive function. Painful lessons were learned, for example, during the famines in the Sahel of the 1980s when aid organizations moved populations too quickly into refugee camps, increasing the risk of contagious disease and disrupting local organization and coping mechanisms (Corbett, 1988).

The same populations who practice these local, idiosyncratic risk management strategies also tend to be economically marginalized: they tend to have poor access to formal education, health services, markets and economic opportunities. As a result, their *generic* capacities are low. These same conditions of isolation and marginalization, however, can be the basis for self-reliance and innovation in risk management. For these populations, the challenge for development and adaptation policy is to provide the services and support that build generic capacities without undermining the existing endogenous capacities for risk management: i.e., their specific capacities.

In contrast, there are contexts where formal risk assessment and commercial risk management instruments have been designed to buffer populations and individuals from inordinate risk. Such polices and programs have contributed to the creation of a reliable and stable context for economic investment and capital accumulation. Yet there are also hidden costs in shielding people from risk, variability and shocks: individuals may feel less responsible for their own adaptation, and the very policies designed to protect individuals from loss may inadvertently undermine systemic, *generic* attributes that build resilience. In New Orleans, scholars have argued that the National Flood Insurance Program led to the conversion of wetlands into urban development, effectively exacerbating social vulnerability to storm surge (Burby, 2006). Parallel circumstances can be found in New Jersey following the recent Hurricane Sandy (Gillis and Barringer, 2012). With claims in the tens of billions of dollars, the National Flood Insurance Program is once again under scrutiny: does this tax payer-funded program perpetuate a moral hazard along the US seaboard? (Lipton and Steinhauer, 2012). The dangers of complacency are not just borne by individuals who suddenly, after such unprecedented events as Hurricane Katrina, find themselves let down by the institutions and programs they had relied on to buffer them from risk (Burby, 2006). They are also borne by society at large: following the unprecedented event, insurance costs rise, public budgets for schools, roads, health care are diverted to help restore normalcy. In effect, adaptation is postponed.

Thus the extent to which a household, for example, will make investments to reduce its sensitivity to flooding, or prepare for the possibility of a prolonged drought, is significantly influenced by whether or not the household has access to affordable financial instruments like property insurance or traditional adaptive strategies, or whether other, more immediate concerns, such as the lack of access to health care or food, supersede climatic risk considerations. Ultimately it is the interaction of the institutional context with individual decision-making and risk perception that defines the trajectory of vulnerability and adaptation over time.

4. Evaluating the interaction of generic and specific capacities

We propose a heuristic to analyze the relationship between current levels of capacity for risk management (specific) and levels of socioeconomic development (generic) in any social group. In this heuristic, we present specific and generic capacities as orthogonal properties; in reality the boundaries between these capacities are far more fluid and interactive than the model implies. We posit that the current state of a social system, as characterized in each quadrant of Fig. 1, is shaped by broader societal institutional arrangements (simplified here as "system-level" capacities) that address human development needs (generic capacities) and risk (specific capacity). Although we recognize that using two levels of organization to illustrate any given system is a gross simplification, we argue that it is useful as an initial assessment of society–individual interaction.

When both generic and specific capacities are low, it is likely that the society in question will be in a "poverty trap" (lower left

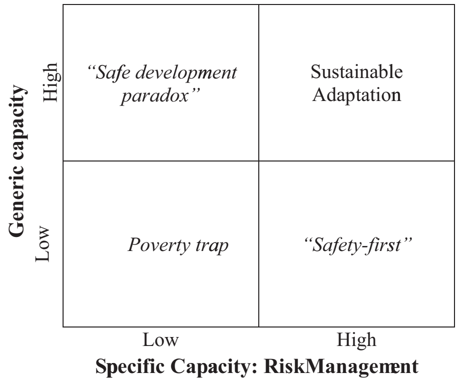

Fig. 1. Capacities matrix.

quadrant, Fig. 1). In this configuration, individuals and communities face chronic, intense stress that undermines human welfare and erodes the social fabric that is necessary to manage risk effectively (Maru et al., 2012). Lack of generic capacity across levels of organization creates a hurdle for both governments and individuals to invest in proactive, anticipatory strategies to mediate climatic risk, and repeated climatic shocks contribute to chronic problems in meeting basic needs. In essence, there is a positive feedback between specific and generic capacities at all scales, preventing constructive change.

Safety-first populations (lower right quadrant, Fig. 1) are characterized by low generic and high specific capacities at the individual level. Here we find individuals and households that tend to be asset-poor, but have developed relatively successful capacities to smooth their consumption needs in a highly variable environment. Their circumstances lead them to prioritize present-day safety and security over investments in the generic capacities that might enable future welfare gains. At the level of governance ("system-level"), there are typically only weak safety nets and capacities for investment to help such households manage risk or to build generic capacities.

The "safe development paradox" domain (upper left quadrant, Fig. 1) characterizes populations of high generic and low specific capacities at the individual level. We would expect to find populations with high levels of education, health, and economic productivity, yet with relatively limited ability to cope with and adapt to specific risks effectively at the individual or local level. In contrast, at the system-level, there may well be very strong safety nets and public investments in risk management, and programs to ensure socioeconomic stability. In his work on Hurricane Katrina, Burby (2006) describes these circumstances as illustrative of "the safe development paradox": federal policies intended to make development safe from hazard risk in fact increased local vulnerabilities by decreasing incentives for effective local risk management (in essence, creating a moral hazard). The irony in such cases is that that when federal "fail safe" measures fail, individuals are poorly prepared and tend to bear the brunt of hazard loss.

Finally, we call "sustainable adaptation" the domain of high generic and high specific capacities. This domain is characterized by conditions that would be most likely to lead to an outcome of sustainable and potentially transformative adaptation: a condition in which both generic and specific risks are high at both individual and system-levels, and development and adaptation policies are mutually reinforcing to the benefit of reduced overall vulnerability.

This heuristic provides a point of departure for thinking about which forms of capacity might already exist, could be strengthened, or may be absent entirely. It may also be used to evaluate the relative contribution of different policy interventions to overall vulnerability. While it may be that a given society does not fall precisely within any one of the four domains, the matrix highlights that there exist different relative levels of generic and specific capacity within a society at different organizational levels, and that the relationship between the two has implications for levels of current vulnerability and the ability to adapt to future change. In disaggregating capacity into the two dimensions, we also wish stimulate discussion about the contexts in which these capacities can work synergistically to enhance the potential for sustainable adaptation, rather than working at cross-purposes.

5. Illustrative cases: rural livelihoods and risk in the Americas

Research on rural adaptive capacity provides a rich domain to explore the utility of this heuristic. Rural households are often highly exposed to climatic variability and shocks; they are also often socioeconomically and geographically isolated, which poses challenges for public service provisioning and institutional development.

5.1. Chiapas, Mexico

Many smallholder farm populations in rural Latin America might be initially classified in the lower right quadrant of Fig. 1. Data from a 2009 survey of maize-producing households in Chiapas, Mexico (see Eakin et al. (2014), for survey details), illustrates the disparity in generic and specific capacities among smallholder maize producers in the highlands of Chiapas, Mexico. Here, *specific* capacity is illustrated in the reliance of households on traditional, household-level risk management strategies: income diversification, the use of local low-yielding but climatically robust maize varieties ("criollos") to counter frost and drought risk, and the spatial distribution of farm parcels (Table 2). In this sample, the persistence of low-yielding but climatically robust varieties of maize can in part be explained by the subsistence value of these seeds for households producing in uncertain and climatically variable environments (see also Eakin, 2005; Mercer et al., 2012). In the highlands of Chiapas, topography and climate conditions are less conducive to commercial varieties (Perales et al., 2003; Brush and Perales, 2007). Households tend to be economically diversified – although most of these income sources are low-skilled and

Table 2
Generic and specific capacities, maize-farming households, Chiapas, Mexico.

Household-level indicators[a]	
Generic capacities	
Education of household head	Primary incomplete
Poverty index[b]	19.74
Specific capacities	
Households planting local maize varieties	98.29
# income earning activities/household	3.37
State-level indicators ("System level")[c]	
Generic capacity	
% illiteracy 2010	17.8
< 5yr mortality rate (diarrheal disease) 2008	32.34/100,000
Specific capacity (agriculture)	
% farm units without insurance	99.7
% farm units reporting climate losses as primary agricultural challenge	75.3
% farm units with irrigation access	4.0

[a] Household survey implemented by H. Perales.Eakin et al. (2014) for details.
[b] Poverty index is based on a weighted sum of key assets.
[c] Data from the Instituto Nacional de Estadística y Geografía (www.inegi.gob.mx).

poorly paid – as a means of diffusing risk. Nevertheless, *generic* capacities are low, indicative of a history of lagging public investment in human development in the region. As reflected in the high poverty index in Table 2, these populations also tend to be among the poorest in Mexico, with high rates of illiteracy, poor access to health care and few alternative economic activities.

At the system-level, there is weak specific capacity (Table 2). There is little investment in risk management institutions (insurance, forecasting, appropriate agricultural technology and research), and climate events are a significant threat to production. The existing specific capacity at the local level is in part a response to this systemic deficiency; nevertheless, these local risk management strategies are not rewarded economically. Despite its subsistence and agro-climatic advantages in otherwise marginalized communities, local maize varieties have limited value in formal commercial supply chains, and their use has been discouraged Mexican rural development policy (Keleman, 2010). Public resources have been allocated to supporting private extension services, which typically focus on commercial seed and input adoption, and to subsidizing hybrid seed sales directly through private seed and input distributors (Keleman et al., 2009; Bellon and Hellin, 2011). This policy emphasis – designed in part to improve generic capacities of the farm population via improved income opportunities – may entail increased livelihood risk for smallholders who adopt such input recommendations because of their lack of formal insurance, or the capital necessary to make commercial investments viable (Eakin, 2005). Unable to take advantage of such varieties due to geographic isolation, cost and agro-climatic characteristics, smallholders have not widely adopted these in the highlands, preferring to rely on maize varieties that help mitigate the substantial livelihood risks they face on a daily basis. Only recently has a program been established recognizing the potential adaptive advantages of local seed varieties ("Masagro"), in part as a response to research on poverty and climatic risk undertaken in Chiapas by researchers from CIMMYT (Donnet et al., 2012). Nevertheless, this program represents only 138 million pesos (approximately US$ 11 million at current exchange rates), spent over 10 years, of the total agricultural budget for Mexico. In contexts such as this, the incongruence of local risk management institutions with national development priorities may contribute to an erosion of local specific capacity on the one hand, or lack of progress in generic capacities on the other.

5.2. Ceará, NE Brazil

Subsistence rainfed agriculture in Northeast Brazil is associated with the lower left quadrant – low generic and low specific capacities. Subsistence agriculture households have historically lacked both generic (income, access to education, health and safety, lack of political power) and specific (effective drought response) capacities. Rural populations have thus coped with repeated cycles of severe drought under conditions of limited flexibility and inadequate social and economic opportunity. The perennial high level of vulnerability of local populations to drought has is manifest in food insecurity, a chronic concern in this impoverished region. Because traditional patterns of clientelistic politics and rent-seeking fundamentally rely on drought vulnerability for its persistence (Nelson and Finan, 2009), there has been relatively low effort from local level political bosses to support the development of appropriate capacities. The "drought industry", or the private appropriation of public goods by local politicians, has created a resilient negative state that has challenged attempts to reform risk management (Tompkins et al., 2008; Nelson and Finan, 2009).

Historically, most adaptation efforts were designed to develop specific capacity. These included the dissemination of climate forecasts, drought-tolerant crop varieties and water storage activities. However, in the context of significant poverty and political marginalization, these activities have had limited success in reducing climate vulnerability (Lemos et al., 2002). More recently however, the generic capacities of households have significantly increased, in part due to the implementation of a national policy to eliminate extreme poverty (Family Allowance Program). This national program transfers cash to households meeting specific criteria (e.g. level of income and number of children of school age) and conditions participation on households' compliance with education and health requirements (e.g. children enrolled and attending school and following a state regulated vaccination and wellness visitations schedule and women enrolling in pre and post-natal care). The program also contributes to increased adaptive capacity by offering a separate, albeit small, income source for the poorest households.

Our study of subsistence rainfed farm households in six counties in the state of Ceará compared adaptive capacities and drought impacts during two drought events (1998 and 2012). Table 3 shows the changes in generic and specific capacities over the study period of 14 years. The variables listed are all positively correlated with an increased probability of a food secure household (Nelson et al., in preparation). Changes in generic capacities include increased ownership of transportation, critical in isolated rural areas for access to services and markets, higher levels of education, and a higher asset index. Although households demonstrate increased specific capacities, such as use of tractors and access to irrigation, the only measure statistically correlated with increased food security is an increase in the number of income earning activities per household, an increase associated with participation in the Family Allowance Program. The 2012 average of 2.5 activities per household drops to 1.8 if household participation in the poverty reduction program is not included in the calculation.

The level of food insecurity during the 2012 drought was considerably higher in than in 1998 (Table 3) (Nelson et al., in preparation). This is in part a function of the increased severity of the 2012 drought throughout the study region (Fig. 2). Nevertheless, these results suggest that while over the long-term this region may be moving toward a context of higher generic capacities, the level of investment in the specific capacities (risk management) at a system or household level is not yet sufficient to reduce drought risks for most of the studied households. Although increased generic capacity may be a necessary condition to reduce the drought vulnerability of rainfed farm households, in this context it is not sufficient to reduce vulnerability to drought measured through food security.

Table 3
Changes in generic and specific capacities associated with food security.

Household-level indicators	1998	2012
Generic capacities		
% Adults with high school education	4	15
% Households with car or motorcycle	24	61
Household asset index[a]	.02	.24
Specific capacities		
N income earning activities per household	2.0	2.5
Food security		
% households food insecure (insufficient quantity)	19	32

[a] Asset index is based on a weighted sum of key assets.

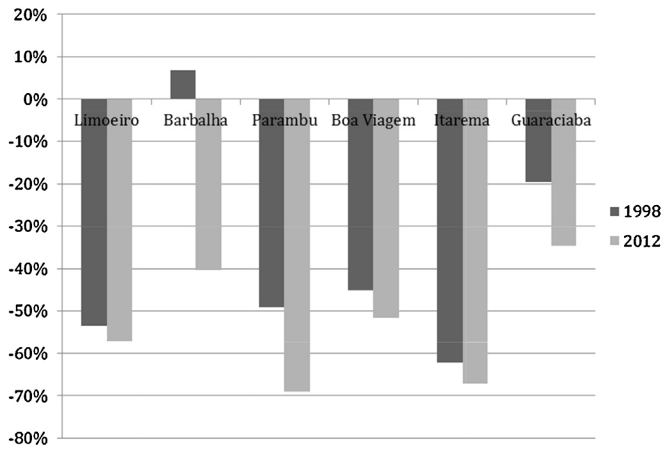

Fig. 2. County-level comparison of rainfall anomalies in 1998 and 2012.

5.3. Arizona, United States

In the safe development paradox domain of our heuristic, populations are described by development indicators that suggest high generic capacity, while, as individuals, they may be poorly prepared to autonomously cope with risk, uncertainty and change. Through a variety of public and private institutions, technology and infrastructure investments, such populations are shielded from risk, up to the point at which these institutions and technologies fail. In essence, the benefits of risk-buffering are privatized, while the costs of risk buffering institutions are subsidized in the public sphere. To some extent, irrigated farming in Central Arizona exemplifies this approach to risk management.

Irrigation (a specific capacity) has been a feature of human settlement in the region since the earliest Native American settlers, the Hohokam, established residency in the state (Anderies, 2006). Climate risk management has always been a core concern for populations in the region: drought and flooding, and access to reliable water, were continual threats to human existence. Today Central Arizona once again faces uncertain future in terms of water and climate (US Dept. of Interior, Bureau of Reclamation 2012). Pinal County, a primarily agricultural county surrounding the Phoenix metropolitan area, is relatively wealthy, with 14% of the population living below the poverty line (no greater than average for Arizona), and average household income of over $50,000. A recent survey (2012) of 52 farmers in the area found that 56% reported having a degree from a higher education institution, and many of these degrees were in agricultural-related disciplines (Eakin et al., in preparation). By almost all measures, the rural population has relatively high generic capacities.

The region has faced chronic and extensive drought conditions for the last decade (Hoerling et al., 2013). Climate change scenarios suggest declining flows in the rivers that feed the region (the Colorado River, Salt and Verde Rivers, and Gila Rivers) (Gober and Kirkwood, 2010). Irrigated agriculture still constitutes anywhere from 35% to 90% of total water demand. Nevertheless, there is little indication that individual farmers are acting autonomously to reduce per-acre water consumption or to alter production practices in face of declining future water resource availability (Needham and Wilson, 2005). In fact, recent research suggests that while farmers ranked future water availability as a top concern to farm viability, they also expressed uncertainty over their capacity to manage water scarcity (Eakin et al., in preparation). Furthermore, current institutional incentives motivate the continued production of high-water consumptive crops and maintenance of current water management practices (York et al., in review). Few farmers reported making use of available climate information, and many expressed doubts over their capacity to manage water scarcity effectively in the future. While the potential for dramatic collapse of the water resource system appears to be low, maintaining a reliable and stable supply for all users may become increasingly costly (Morrison Institute, 2011). At some point, individual water users and farmers may need to be incentivized to take on adaptive decisions on their own in order for both livelihoods and the region as a whole to remain viable. Yet, without a supporting institutional context in which policy encourages individuals to assume responsibilities for risk-management, specific capacities will remain low and risks of sectoral conflicts over water availability will continue to increase.

The sustainable adaptation domain of our heuristic remains at this point a conceptual and, as yet, empirically elusive ideal. Here, a population has high generic and high specific capacities, and these capacities are reinforced through the institutional environment, which reinforces local level capacities with flexible and supportive systemic capacity. It is not just the level of capacity that a population may have that matters, but rather how capacities combine to predict a desirable outcome. One conceptualization of sustainable adaptation is the extent to which adaptation interventions support sustainable development and vice versa (Eriksen and Brown, 2011). Another is the idea of development theory and practice that places climate-related risk front and center (Lemos et al., 2013).

Importantly, institutions supporting the development and maintenance of both domains of capacity must be functioning in both private and public spheres, and at multiple levels. There are now opportunities to revisit research findings of previous decades with the methodological and analytical advances in institutional analysis to evaluate how institutions working at one scale – for example, traditional local institutions for risk management – are enhanced or undermined by interventions to improved risk management at another level (see, for example, Anderies et al., 2004; Anderies, 2006). While high generic capacity is generally accepted as a desirable goal at all levels of analysis, it is conceivable that there may be some geographically and culturally circumscribed but nevertheless "optimal" balance between specific risk capacities at different levels. What that ideal balance would be, and how it should be determined, remains a challenge for development and sustainable adaptation policy. What is clear is that pathways to sustainable, transformative development must be those which enable all groups in society to build enough generic capacity to be able to take advantage of systemic resources, and to develop their own risk management capacities. Risk management without a strong basis of generic capacity ultimately is unsustainable. To be on such pathways, risk management interventions must be designed and implemented in a manner that avoids potential trade-offs: for example, over-reliance on infrastructure that may lead to complacency, or adaptation responses that compromise the ability of other regions or groups to successfully adapt.

6. Conclusion

The specific reality of particular, complex institutional and political contexts will necessarily define what combinations of capacities are desirable in order to support sustainable adaptation. Nevertheless, the idea that there is some appropriate balance between different forms of capacity at different levels of decision making is critical to inform thinking and action from governments, donors and agents in climate the adaptation arena. Adaptive capacity provides an intellectual link between adaptation research and development practice. There is a need, however, for empirical research that assesses generic and specific capacities in order to contribute to a nuanced understanding of how policy-makers might tailor interventions for a particular context. By analytically disaggregating capacity into the elements fundamental for general sustainable development, and those elements critical for effective risk management, investments in capacity building are likely to be more effective.

Importantly, high generic capacity does not necessarily translate into specific capacities for risk management at all levels of decision-making; the ways in which some capacities may strengthen or undermine others in different social contexts is poorly understood. In particular, we have little grasp of how institutions implemented at one level of governance and decision-making interacts with capacity development at another, and the implications of differences in individual and system-level capacities for vulnerability reduction over time. Finding a balance between appropriate investment in specific and generic capacities is challenging, not least because decisions of how best to manage risk across time and space are at their heart, political and cultural questions. Nevertheless, improving our understanding of the interplay among distinct capacities is critical if we are going to effectively address the emergent challenge of climate change while simultaneously meeting the chronic challenge of sustainable development.

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