

# **Social Capital and Climate Change Adaptation**

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## **Summary**

Anthropogenic climate change increasingly disrupts livelihoods, floods coastal urban cities and island nations, and exacerbates extreme weather events. There is near-universal consensus among scientists that in order to reverse or at least mitigate climate disruptions, limits must be imposed on anthropogenic sources of climate-forcing emissions and adaptation to changing global conditions will be necessary. Yet adaptation to current and future climate change at the individual, community, and national levels vary

widely from merely coping, to engaging in adaptive change, to transformative shifts. Some of those affected simply cope with lower crop yields, flooded streets, and higher cooling bills. Others incrementally adapt to new environmental conditions, for example, by raising seawalls or shifting from one crop to another better suited for a hotter environment. The highest—and perhaps least likely—type of change involves transformation, radically altering practices with an eye toward the future.

Transformative adaptation may involve a livelihood change or permanent migration; it might require shuttering whole industries and rethinking industrial policy at the national level. Entire island nations such as Fiji, for example, are considering relocating from vulnerable locations to areas better suited to rising sea levels.

A great deal of research has shown how social capital (the bonding, bridging, and linking connections to others) provides information on trustworthiness, facilitates collective action, and connects us to external resources during disasters and crises. We know far less about the relationship between social capital and adaptation behaviors in terms of the choices that people make to accommodate changing environmental conditions. A number of unanswered but critical questions remain: How precisely does social capital function in climate change adaptation? To what degree does strong bonding social capital substitute for successful adaptation behaviors for individuals or groups? Which combinations of social factors make coping, adapting, and transforming most likely? How can social capital help migrating populations maintain cultural identity under stress? How can local networks be integrated into higher-level policy interventions to improve adaptation? Which political and social networks contribute to transformative responses to climate change at local, regional, and international levels? This article serves as a comprehensive literature review, overview of empirical findings to date, and a research agenda for the future.

### **Keywords**

social capital, climate change adaptation, bonding, bridging, linking, transformative

## **Introduction: The Challenge of Climate Change**

Societies around the world have dealt with climate change for millennia. Indigenous peoples in the Middle East and South America, for example, used migration to cope with changing environments during the Holocene era (DeMenocal, 2001). Yet climate change in the current Anthropocene era, accelerated by human-created carbon dioxide emissions, has created broad-scale challenges, such as rising sea levels and shifting monsoons, beyond the ability of many populations to easily or inexpensively adapt. Under even moderate predictions and despite the voluntary pledges at the Conference Of Parties (COP) 21 held in Paris in December 2015, scientific consensus expects global average temperatures to rise more than 2°C with more frequent hot extremes (IPCC, 2014). Shifting and extreme precipitation patterns, sea level rise, and more severe weather events have increased due to climate change. In 2013 alone, 22 million people in 119 countries were displaced due to extreme weather events, a number three times that of those displaced due to conflict or violence (Weiss 2015, p. 53). There is general agreement that residents around the world will continue to face more frequent natural disasters such as floods as a result of climate change (IPCC, 2012).

Facing such threats, individuals, researchers, and policymakers alike are interested in the resilience of our social and natural systems to absorb shocks and “retain essential structures, processes, and feedbacks” (Adger, Hughes, Folke, Carpenter, & Rockström, 2005, p. 1036). We define resilience as the ability of a system to cope with a disturbance in ways that keeps up its functions and identity and maintains its capacity for adaptation and transformation (see IPCC, 2014). The need for resilience to the consequences of climate change has been driven home by the environmental changes already taking place around the world. Farmers and residents in Ethiopia’s Rift Valley, for example, have dealt with increasing dry periods and extended drought with a variety of mechanisms, including the use of high-yield, early-maturing seeds, crop rotation, and afforestation (Belachew, Godebo, Teshome, & Tesgaye, 2013, p. 17). Residents on Pacific island nations facing certain inundation have started applying for asylum under the status of climate change refugee. One citizen from the eroding island nation of Kiribati, Ioane Teitiota, applied to New Zealand as the world’s first climate change refugee trying to escape the routine flooding, high infant mortality rates, overcrowding, and skyrocketing unemployment

in his home country (Weiss, 2015). Although unsuccessful in his case, Teitiota's legal appeal could indicate an approach for thousands of others.

While some responses to climate change involve legal processes such as accommodation of refugees or compensatory payments, others involve collaboration between local communities, civil society, governments, international aid donors, and scientists. Regular threats to some 10 million Bangladeshi residents vulnerable to flooding and cyclones, for example, led in 2010 to the creation of a Bangladesh Climate Change Resilience Fund. The BCCRF has partnered with the World Bank and a variety of Western nations to implement disaster risk reduction and climate change adaptation measures such as livelihood diversification, disease risk surveillance, and new coastal infrastructure. Industrialized nations are not immune to the threats from climate change: New York City's Mayor Michael Bloomberg similarly started a \$20 billion project in 2013 to build seawalls and levees to insulate the city from future storms, as well as retrofitting hospitals and upgrading critical infrastructure to handle floods (Gregory & Santora, 2013).

As these examples illustrate, responses to climate change vary in terms of scope and intensity. While some individuals and communities may not change at all when confronted with new and rising risk, those who do may respond to climate and environment challenges on coping, adaptive, and transformative levels (Bernier & Meinzen-Dick, 2014; Davies et al., 2013; Frankenburger et al., 2013). The most basic response to a shock such as a drought or flood is the coping response involves a return to baseline behaviors and frameworks. After typhoon-induced flooding in rural communities in the Philippines, for example, residents may simply sweep out the mud and debris from their homes and go about their lives as usual. Such coping behaviors make communities and individuals no better prepared for future events. The next level up from coping is adaptive change, namely preventive actions that individuals or communities employ to learn from experience or to reduce the impact of predicted shocks (Bernier & Meinzen-Dick, 2014, p. 2). As adaptive activities, residents may shift livelihood patterns, elevate homes to avoid future flood damage, and pool resources to mitigate crop loss (Agrawal, 2008).

The highest level of response to climate change is transformation, or changing “the larger structures and systems in which they live, implying adaptation at larger scales and thus a more radical shift” (adapted from [Bernier & Meinzen-Dick, 2014](#), p. 2). Transformation involves a “larger intentional change that creates a fundamentally different system” ([Apgar, Allen, Moore, & Ataria, 2015](#), p. 44). A transformative response involves a fundamental change in technological and political regimes, such as building new energy-efficient, carbon-neutral cities, permanently curtailing carbon dioxide emissions, and forming new international agreements that will restrict greenhouse gas emissions ([Pelling, 2011](#)). This overview will bring examples of adaptive strategies at the local and national levels, but truly transformative approaches have been less visible at all levels.

While these coping, adaptive, and transformative responses can occur at multiple scales ([Rabe, 2004](#)), we build on research that “adaptation to climate change is inevitably local” ([Agrawal, 2008](#), p. 1). This is because local institutions filter the impact of livelihood challenges and hazards and also determine how residents respond. Through social learning and co-management, local institutions can connect with decision-makers at different levels ([Berkes, 2009](#)). A collective of sub-Saharan subsistence farmers in contact with an international non-governmental organization (NGO) based in Europe may be able to procure seeds able to grow in more arid conditions; well-organized rubber tappers in Indonesia may learn of new practices to handle shifting weather patterns through their connections with a village some distance away. The local context is tremendously important in determining responses to climate change, and thus so is the role of social factors ([Adger et al., 2005](#), p. 1038; [Brooks, Adger, & Kelly, 2005](#), p. 162).

Further, national and international agreements on the environment will have little real effect unless behavioral and cognitive shifts trickle down to the local level. The critical nature of local institutions is important as the spatial scales of climate change effects may differ from the relevant scale of response. Countries that produce the least climate-altering emissions nonetheless face prominent effects from them, such as soon-to-be-submerged Pacific islands. Yet linking social ties between islanders and

European decision-makers may help alter long-term industrial regulations, which will reduce the likelihood of other low-lying nations being submerged.

As we detail in the following sections, the connections between individuals, groups, and organizations—what we call social capital—play a critical role in driving responses (or lack thereof) to climate change. This is despite the relatively minimal coverage of the concept of social capital in the canonical documents on climate change (IPCC, 2012, 2014). This article reviews the literature, provides empirical examples of the role of social capital in community responses to the threat and realization of climate change, and illuminates the frontiers of the field through a research agenda.

## **Bonding, Bridging, and Linking Social Capital**

People in all societies across the world—developed and developing—live socially embedded lives in which they regularly interact with others, some of whom they know well, and others far less. Social science has recognized the importance of these ties and developed a number of theories and frameworks to better understand them. As scholars have pointed out, “family, friends, and associates constitute an important asset, one that can be called upon in a crisis, enjoyed for its own sake, and/or leveraged for material gain” (Woolcock & Narayan, 2000, p. 3). The term *social capital* captures these “networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit” (Putnam, 1995, p. 67). Social capital thus affects the ability to find people’s promises credible (trust), the attitudes and behavioral expectations group members have towards each other (norms), and the connections people have to one another (networks).

An educator in the 19th century provided one of the earliest definitions of social capital as “goodwill, fellowship, mutual sympathy and social intercourse among a group of individuals and families who make up a social unit, the rural community, whose logical center is the school” (Hanifan, 1920, p. 130). Scholars later broadened the concept to emphasize social capital’s role throughout societal structures that made members “productive, making possible the achievement of certain ends that

in its absence would not be possible” (Coleman, 1988, p. S98). Researchers later defined social capital more precisely as “features of social organization, such as trust, norms and networks that can improve the efficacy of society by facilitating coordinated actions” (Putnam, Leonardi, & Nanetti, 1993, p. 167). Others, though, saw social capital more cynically as a credential affecting status gained through relationships with elite. This view defined social capital as “the aggregate of the actual or potential resources which are linked to possession of a durable network or more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group” (Bourdieu, 1986). In this article we build on a functional definition of social capital as the norms, trustworthiness, and networks that tie people together.

Rather than envisioning all types of social connections as the same, researchers have categorized social capital into three main types: bonding, bridging, and linking social capital. Bonding social capital involves connections between individuals who share similar backgrounds, educational levels, nationalities, or religions. The most common example of bonding connections is that between family members. Members tied by bonding social capital often display homophily, grouping with and befriending those similar in terms of demographic or other characteristics (Mouw, 2006; Newman & Dale, 2007). Residents and friends linked by bonding social capital may attend the same schools, undertake the same religious rituals, and pursue similar career and life goals. Higher levels of bonding social capital are associated with positive social outcomes including civic engagement and collective efficacy (Collins, Neal, & Neal, 2014).

Bridging social capital brings together individuals who are only loosely connected. Such acquaintances may display obvious differences in terms of race, nationality, religion, and ethnicity and have broader diversity in norms and goals. These weak ties are useful in everyday situations such as resource and employment searches, when friends of friends and distant acquaintances can provide access to broader opportunities (Granovetter, 1983). While heterogeneous communities may inherently have lower social capital (Coffe & Geys, 2006), individuals from different backgrounds can connect through bridging ties using organizations and institutions such as schools, workplaces, and clubs (Small, 2010).

Bridging social capital may provide greater access to untapped resources by creating access from relationships in one forum, such as a religious group, to another sphere, such as a business (Wuthnow, 2002). Groups with strong internal cohesion benefit from these external networks when engaging in collective action across multiple regions (Dahal & Adhikari, 2008). In Indian communities split by conflicts between Hindu and Muslim groups, for example, higher levels of bridging social ties resulted in lower levels of riots and injuries (Varshney, 2001).

Linking social capital connects regular individuals to those with power and influence (Woolcock & Sweetser, 2002). For example, the connection between a resident and the head of a local civil society organization or government office involves relationships across different levels of power (Szreter & Woolcock, 2004). Linking social capital functions as a vertical connection, beyond the horizontal bonding and bridging in community relationships. Linking ties can be used to gain access to resources and administrative control that would not otherwise be available to communities at the local level (Dahal & Adhikari, 2008).

All types of social connections also impact levels of trust and trustworthiness. Trust is the expectation that others will act on commitments reliably, thus permitting cooperation and actions. Many scholars recognize trust as a primary feature, or mechanism, of social capital (Ostrom & Ahn, 2003). Bonding social capital in close relationships regularly relies on the fundamental levels of trust between in-group members. Bridging social capital provides a way for trustworthiness to be assessed across broader networks, permitting trust between those who may not immediately know each other. Bridging and linking social capital facilitates trust in institutions and information from vertical ties and allows for the dissemination of trust across levels of authority.

Social capital is an essential feature in daily life in developing and developed economies alike. Stronger ties help communities work cooperatively to solve collective action problems such as protecting against and responding to climate threats (Ostrom, 1994). The bonding, bridging, and linking forms of social capital all can improve social well-being. Higher levels of bonding and bridging social capital, for example, have a protective effect on health at the individual and community levels (Aldrich

& Sawada, 2015; Kim, Subramanian, & Kawachi, 2006). We next explore how social capital functions during and after extreme emergencies and catastrophes.

## Social Capital in Climate Change Disasters and Crises

Social capital plays a critical role during crises and environmental shocks such as those posed by climate change (Chamlee-Wright, 2010; Dynes, 2006; Prasad, Su, Altay, & Tata, 2014). Importantly, much of the actual impact of anthropogenic global warming to date has come in the form of extreme weather patterns, extended drought in arid locales, and more frequent flooding events along coasts such as extended monsoons and more severe typhoons (IPCC, 2012). In this context, deep reservoirs of social capital help residents survive climate-related catastrophe and accelerate recovery and long-term adaptation. Social capital motivates residents to return to flooded or damaged areas and to petition political leaders for assistance in handling challenges (Aldrich, 2010). Individuals with strong social ties to neighbors, feelings of attachment and place, and a vision for their neighborhood's future are more likely to return and restore a damaged neighborhood. They also connect to decision-makers and seek to make changes to political regimes which can change energy use and production policies, reduce greenhouse gases, and create more sustainable societal practices. Less socially connected residents instead see benefits of starting over in other communities where they can more easily begin life afresh (Aldrich, 2012). This is especially true because of the financial, psychological, and opportunity costs associated with rebuilding shattered lives and homes. As such, stronger bonding and bridging ties enhance a community's political "voice" while dampening the likelihood of "exit" (Hirschman, 1970).

Bonding social capital, a key element of social networks, is an important asset in climate change-related disaster settings (IPCC, 2014, p. 27). Research has shown that before slow-onset crises and environmental challenges, families and close social networks devise strategies in preparation, and these homophilous networks facilitate physical, emotional, and financial support during an event (Hurlbert, Haines, & Beggs, 2000). Local residents may pool their resources or store foodstuffs as mechanisms for

handling risks to their livelihoods caused by climate change (Agrawal, 2008, p. 2). Oral histories, such as those held by the Guna indigenous people in Panama, help affected communities recognize even slow-onset environmental and climatic changes through a shared knowledge of long-term history (Apgar et al., 2015). Beyond support and knowledge, bonding social capital can strongly influence decisions to evacuate or stay in hazardous areas; family members previously unwilling to leave a hazardous area may be persuaded by kin or friends to depart (Horney, MacDonald, van Willigen, & Kaufman, 2012). After disasters, these close networks can be likened to first responder units, providing immediate relief and triage to those within the network (Bullard & Wright, 2009; Dyson, 2006; Hawkins & Maurer, 2010, p. 1784).

Bridging social capital is also instrumental in helping people survive the aftermath of a disaster. In Hurricane Katrina, for example, “connections across geographical, social, cultural and economic lines provided access to essential resources for families” affected by flooding and the destruction of homes and businesses (Hawkins & Maurer 2010, p. 1789). Social capital serves as a public good in supporting whole communities through extreme events (Dussailant & Guzman, 2014). Communities with more connections can draw on the informal insurance they have created and borrow or acquire resources otherwise unavailable at a time of crisis. During flooding, extreme weather events, and other crises, standard providers of medical and child care and food and shelter may be out of service; at such times, one’s network must fill those gaps (Hurlbert et al., 2000). Residents in New Orleans after Hurricane Katrina, for example, used their social connections to remove water-damaged drywall, work through bureaucratic obstacles for assistance, and develop neighborhood recovery plans (Chamlee-Wright, 2010). Linking social capital, which connects residents to decision-makers, can facilitate access to extra-local resources and speed up political transformation. Following a crisis, links between a peripheral community and central government officials can facilitate access to resources and speed up recovery (Aldrich, 2015). Further, meetings between community members and insulated public officials may help create shared norms for handling broadscale issues like climate change.

Communities able to combine all three forms of social ties maximize the benefits during a crisis (Aldrich, 2012; Nakagawa & Shaw, 2004). In the case of a disaster, bonding social capital may be the most important in terms of immediate support (Aldrich & Sawada, 2015). In the longer term, bridging and linking social capital provide for economic recovery and opportunity (Hawkins & Maurer, 2010). After Hurricane Katrina, the Vietnamese community of Mary Queen of Viet Nam harnessed their local, extra-local, regional, and even national ties to aid their community in the enterprise of evacuation, relocation, and recovery following the storm (Airriess, Li, Leong, Chen, and Keith, 2008). In the next section, we apply what is known about social capital in disaster and crisis situations to the large set of potential disasters and strains from environmental and climatic change.

## Adaptation and Social Capital

When environmental and societal conditions change, residents can respond by struggling to maintain behavioral patterns under the new conditions (coping behavior), shifting standard ways through new behaviors and norms to reduce vulnerability (adaptive change), or radically altering behaviors and societal structures to face the future (transformative change) (Bernier & Meinzen-Dick 2014; Davies et al., 2013; IPCC, 2014). For residents facing rockslides in mountainous parts of Nepal, for example, the “most important coping strategy has been individual households moving their houses when they become too cracked to new locations within the village” (Sudmeier-Rieux, Jacquet, Derron, & Jaboyedoff, 2011, p. 688). While this response reduces the vulnerability of households to future landslides, it does not deal with other longer-term concerns of deforestation, poor crop yield from climate change, or low-income livelihoods. Farmers who relocate within their villages for safety still face a variety of other consequences of livelihood choices, unless they make adaptive changes, and threats from climate change such as failure of water supplies, unless they make transformative changes.

We build on the finding that behavioral and norm change are “determined, in part, by the ability to act collectively” (Adger, 2003) and are influenced by local institutions (Agrawal, 2008). Broadly,

adaptation to climate change rests on a social component as individuals interact with other network members to gain information, share resources, create collective norms, and build new institutions in order to provide resilience to climate change. Bonding, bridging, and linking social capital provide access to other forms of capital, such as human and economic capital, thus providing a key process to buffer against current and future shocks (Bebbington & Perreault, 1999). Deep reservoirs of social capital can alter response to climate change in a variety of ways: they can increase shared local knowledge, heighten participation, and make corporate and political institutions more responsive to longer term concerns of communities.

Bonding social capital, the strongest type of connection between kin, friends, and neighbors, underpins the sharing of resources, information, and labor in adaptation behaviors (Ostrom and Ahn, 2003). Such connections ensure a similar vision and buy-in to the process. Members of a cohesive tribe, neighborhood, or village, for example, can more easily cooperate to alter behaviors and norms and create viable and sustainable responses to climate change. Japanese communities, for example, shared embedded knowledge about flood and tsunami safety through the location of local religious institutions. For hundreds of years, Tohoku communities have located shrines on higher ground, well above even the highest tsunami inundation elevations, to indicate safe areas for their descendants (Takase et al., 2012). This type of shared knowledge in this example of flood-vulnerable areas is invaluable in the face of rising sea levels. Bonding social capital between close group members is particularly important in socially excluded, low-income groups, as they by definition have few external links for support and fewer material resources (Adger, 2003). Such local social behaviors may indeed be more important for coping with immediate shocks—environmental, financial, psychological, etc.—than for getting ahead (Woolcock & Narayan, 2000).

Bridging social capital provides the means for gaining exposure to innovations and for managing extra-local resources in response to climate change. One NGO, for example, pioneered massive changes in the refrigeration industry and slowed damage to the ozone layer because of its bridging social capital, which connected it with a manufacturing firm in East Germany (Toke, 1999). In the 1980s Greenpeace

sought to develop alternative technologies to ozone destroying chlorofluorocarbons (CFCs), but most refrigerator manufacturers snubbed the possibility of affordable and effective alternatives (Stafford & Hartman, 2014). Few NGOs had connections into the sphere of industry, and little progress was made on pushing new climate-saving technologies into the commercial sphere. Greenpeace activist Wolfgang Lohbeck had links to the financially strapped East German company Foron, which agreed to serve as a test bed for more environmentally sustainable coolants that could then be adopted elsewhere. The success of Foron's Greenfreeze cooling agent convinced other manufacturers in Germany and eventually around the world to switch (Seitanidi & Crane, 2014). Without the unlikely ties between the NGO and an ailing East German factory, the industry would have likely stayed the course and maintained its use of ozone-damaging chemicals such as CFCs). Here, bridging ties shifted the direction of an industry and mitigated polluting industrial processes.

Linking social capital provides the opportunity for synergy with the decision-makers at the regional and national levels to improve adaptation resources and actions. Scholars have documented how, despite paralysis at the national level, many local and regional governments have undertaken innovative climate change policies. Often these are between middle-level bureaucrats, scientists, and industry and occur because of vertical, not just horizontal, connections (Rabe, 2004).

The most effective adaptation responses to climate change will be based on bottom-up, local-level components, facilitated by social capital, that are also coordinated across society (Bernier and Meinzen-Dick, 2014; Davies et al., 2013). Thus, the highest likelihood for transformation comes when communities and organizations hold high levels of bonding, bridging, and linking social capital (Adger, 2003). Bridging and linking social capital in communities in Trinidad and Tobago allowed for collaboration between communities and the public and private sectors to develop investments which would mitigate the effects of future extreme weather events (Adger et al., 2005, p. 1038). For households in Mozambique, social capital proved fundamental to those engaged in vulnerable livelihoods; households without ploughs, cattle, or other material resources used exchange relationships to acquire these items. Such community support based on "neighborhood, friendship, and kinship"

allowed villages like Tsokate and Hoyohoyo to be highly resilient to stresses such as drought and floods (Brouwer & Nhassengo, 2006, 251). One study of communities in southwest Bangladesh showed how webs of social capital provided a broad variety of resources to residents including credit and lending arrangements, informal monetary assistance, food lending, and government allocation and disaster relief (Jordan, 2015).

In the absence of strong state institutions, social capital may serve as the primary institution for local adaptation. One study in Burundi found that “social capital adaptations have the effect of changing livelihood policies, institutions, and processes,” especially in places with poor governance (Vervisch, Vlassenroot, & Braeckman, 2013, p. 267). An adversarial or dysfunctional state may force vulnerable communities to rely primarily on bonding social capital while others use bridging social capital as a substitute for state assistance (Adger, 2003, p. 394). Bridging social capital is therefore important links beyond kin and locality, and particularly in managing access to common resources (Ostrom, 1994, 1996). Local communities provide the appropriate scale for institutional learning and innovation to adapt to local conditions, in terms of determining both appropriate local resource management based on adaptive practices and development of new income activities (Rodima-Taylor, 2012).

Competent regional and national governments can have a key role in managing broad risks and providing tools and resources for adaptation to climate change, providing key mechanisms for translation of scientific information to on-the-ground practice (Tribbia & Moser, 2008). Higher-level formal institutions, including the state, can both promote social capital and facilitate adaptation (Adger, 2003). Well-functioning institutions, both formal and informal, provide the complementary features for economic development (Woolcock & Narayan, 2000) and the platforms for transformative change. In some cases, formal institutions can better allocate risk across communities threatened by climate change by “diversifying patterns of resource use” and encouraging communities to seek out alternative livelihoods that support a diversifying ecosystem (Adger et al., 2005, p. 1037). In a common example, while the state might provide irrigation infrastructure to reduce climate vulnerability, local democratic management determines the institutions relevant to the community. In an ideal setting, established best

practices can be combined with local or traditional knowledge. This represents a “synergy view” of social capital, in which communities linked to the state engage in coproduction of development, increasing capacity and resilience (Evans, 1996; Ostrom, 1996; Woolcock and Narayan, 2000, p. 392).

## Maladaptation: The Dark Side of Social Capital

While social capital typically provides benefits to in-group members, higher levels of homophily can bring several types of negative externalities. First, bonding social capital by itself may not be sufficient to help those in crisis. As many have underscored, bonding capital allows the vulnerable to “get by” during crisis but is insufficient to help them “get ahead” (Woolcock & Narayan, 2000). One study of first-generation immigrants in Germany showed that bridging, not bonding, social capital provided better economic benefits in terms of employment (Lancee, 2012). Because bonding social capital connections are often geographically constrained, all members of an affected network may be similarly resource deprived during or following a crisis. Neighborhoods with higher levels of homogeneous bonding social capital regularly have fewer bridging and linking social ties (Costa & Kahn, 2003; Hawkins & Maurer, 2010, p. 1789).

Given that all residents face resource constraints, they must make decisions about where to invest their time and effort in building and maintaining relationships. In this way, higher levels of bonding social capital may be accompanied by lower levels of bridging and linking ties. Bonding forms of civic engagement may be negatively associated with democratic responsiveness (Hill & Matsubayashi, 2005) and positively associated with exclusion and prejudice (Putnam, 2000). Higher levels of bonding social capital among co-religionists, for example, has been shown to create higher levels of intolerance (Rhodes, 2012). Following the Haiti earthquake in 2010, for example, social capital enhanced access to shelter-related resources for those with connections but created new inequalities among displaced residents who lacked such social resources (Rahill, Ganapati, Clerisme, & Mukherji, 2014). Close in-group bonds can lead to sectarianism, ethnocentrism, or corruption (Putnam, 2000, p. 350). Though

groups with high bonding social capital may experience benefits of coordination, over time groups often become less diverse, which reduces potential bridging social capital (Newman & Dale, 2007). A group may take up a harmful practice, such as fishing with dynamite, and the close relationships of the group promote a specific practice while excluding those uninterested or unwilling to engage (Ballet, Sirven, & Requier-Desjardins, 2007).

Social capital may reinforce other problematic norms, such as differential gender relations or social structures. For example, *uur* panchayats (caste councils) tasked with distributing aid in communities throughout Tamil Nadu after the Indian Ocean Tsunami excluded widows, Dalits, Muslims, and other marginal groups (Aldrich, 2012, p. 91). Social capital also does not take into account intra-household relationships: if social capital relevant to economic activities is built around relationships of males, then activities promoting social capital may reinforce such social structure and do little to support women, as demonstrated in a study of microcredit in Cameroon (Mayoux, 2001). In this instance, the social structures that influenced financial systems were driven by men, and the financial norms expected of women participants were not consistent with their ability to participate in the fiscal activities of the microcredit savings groups.

Social capital is generally a resource for those who have substantial access to it and a barrier for those excluded from it. Yet social capital may also be an impediment to adaptation in that high reliance on others may reduce incentives for individual action. For farmers in rural Ethiopia, for example, social capital indeed predicts participation in community adaptation, but social capital is also negatively related to individual-level adaptation activities (Paul et al., 2016). This could indicate farmers who are unable to adapt on their own rely upon their community for adaptation or, conversely, households which are able to adapt privately engage less with their community. In either case, social capital does not lead to universal improvements through adaptation to climate risks, but rather trade-offs between individuals and their communities.

Broadly, such negative outcomes of adaptation behaviors may be deemed “maladaptation” to climate change (Barnett & O’Neill, 2010). Understanding maladaptation in a social capital framework is

particularly important because of the ways in which social capital underpins shared experiences and behaviors, particularly in the case of rural communities where there are often fewer links to external networks. One study of response to heat waves in England, for example, showed how bonding social capital exacerbated rather than reduced elderly vulnerability to risks by reinforcing risky behavior of coping with a heat wave (Wolf, Adger, Lorenzoni, Abrahamson, & Raine, 2010). Information flow among the elderly, restricted to their close relations, often reduced their perception of potential health risks from extreme temperatures and made adaptive behaviors less likely. Bridging and linking social ties, however, may mitigate potential vulnerability created by bonding social capital. While the effects are not universally positive, social capital is influential across many settings and relationships in climate adaptation.

## **Case Studies in Social Capital and Climate Change Adaptation**

On the whole, social capital appears to be important for climate adaptation. We now turn to three short cases of climate change adaptation in three varied settings that highlight the potential positive role of horizontal and vertical social ties. These cases—from a city in Louisiana, a region in Senegal, and the international climate policymaking forum—show how understanding social relationships is valuable to understanding adaptation processes.

### ***Managing Flood Risk in Houma, Louisiana***

Our empirical examples of climate change adaptation begin in Houma, a city west of New Orleans and located within the Terrebonne Parish in the state of Louisiana “where life is measured in hurricanes” (Hansen, 2010). It is also a city that showcases how one community transitioned from coping strategies for dealing with climate change to active, transformative resilience. The “Morganza to the Gulf Project,” a federal coastal restoration project sponsored by the U.S. Army Corp of Engineers (ACE), was initiated in 1992 to extend existing levees and install a floodgate in the Houma Navigation Canal. Progress was

painfully slow, and a budget of \$550 million authorized by Congress in 2000 is now projected to cost taxpayers \$12.9 billion (Wold, 2013). Thus far, \$70 million in federal monies has been used to conduct field research, collect soil samples, and produce feasibility studies, with no money actually being spent on flood-control mechanisms.

With the threat of rising sea levels, subsiding land, little support from the federal government, and no sign of coastal resilience construction from the ACE, communities at the local level in Houma have stopped waiting and undertaken strategic planning for future disasters on their own terms. Local residents, church groups, and town council members worked together to tackle the reality of rising sea levels and more regular flood events. In talking about the need to raise funds to combat rising flood levels, local residents do not reference climate change but rather speak in terms of floods and rising tides. Strong social structures and networks throughout communities in the city of Houma mobilized to initiate self-funded levees and water projects that will protect 200,000 people from storm surges that are increasing in frequency and intensity (author site visit, November 2015; Gordon, 2015). Communities in and around Houma have engaged in local initiatives of marsh restoration, elevating existing homes, improving pump systems and canal drainage, and conducting local buyouts and relocations of repetitively damaged homes and businesses. The money for these projects has been raised through a self-imposed sales tax or paid for by individual households.

The community in Houma has moved ahead with its adaptation strategies despite a lack of federal government support. The ACE has not assisted with the Morganza to the Gulf Project, and no federal dollars have paid for the local flood-control mechanisms. There is also no guarantee that future work by the ACE will not conflict with these bottom-up adaptation measures; that is, the work carried out by the community may need to be altered or even removed should federal plans require it in the future. Here, despite a weak response from the federal government to the problem of climate change, a cohesive local community has been able to move more rapidly, serving as a leading example of transformative change. Scholars have documented such progressive, faster-than-the-government responses in other local communities across the United States to the problem of climate change (Rabe, 2004). Social networks

support urban and regional adaptation initiatives because they underscore the locus of action and impact for projects. Government interventions influence the behavior of individuals and communities in synergistic and countervailing ways, as in the case of public and private flood control activities (Milman & Warner, 2016). Local communities, cities, and regional initiatives will continue to serve as first movers in long-term responses to climate change.

## *Farming in Senegal*

Our second example of climate change adaptation similarly comes from a local-level strategy put in place by a cohesive community in a developing nation facing current and future economic and agricultural consequences (Quist-Arcton, 2015). In Senegal, which sits along the border of the semi-arid Sahel in Africa, farmers historically have been dependent on rain-fed agriculture. Researchers, local NGOs, and regional policymakers have long searched for ways to encourage climate resilience. This is especially the case because current predictions have Senegal losing up to 50% of current agricultural capacity should global temperature continue to rise (Hummel, Doevenspeck, & Samimi, 2012). Many coastal areas of Senegal continue to struggle with the impact of erosion from rising sea levels, which has already impacted tourism and coastal development.

The Senegal government sought to provide better access to water and food for its population and has set up subsidized “social connections” of water for the poor (Barron, Fox, & Koudeoukpo, 2007). These mechanisms allow those on the edge of subsistence farming and with few material resources to more easily benefit from critical public goods such as potable water. Yet government agencies were not the only ones recognizing the need to respond to higher temperatures and less rain. Interest in other ways to mitigate drier seasons induced a group of farmers to travel 125 miles to see the impact of an extended drought which was an outcome of increasing risk under climate change. The farmers, provided with meteorological and climatological information by local climate researchers and the national weather agency, recognized the need to identify other food and income sources in a hotter, drier setting. With a

combination of outside information, and community coordination, the farmers established “One Woman, One Fruit Tree” (Quist-Arcton, 2015).

The organization has taken advantage of indigenous fruit trees, which themselves are more resilient to climate change and, when managed and harvested, can provide new sources of food and income. Integrated conservation and intercropping efforts, combined with guidance and information from external agencies via text message and community radio, provide new tools of resilience to farming communities of Senegal. Here bridging and linking social ties provided the local residents, farmers, NGOs, and international organizations with the chance to share information and best practices. Without connections to other groups, farmers would not have had access to the information, norms, and resources that helped them move away from standard crop types into new ones.

### *International Climate Policymaking*

Our third and final example of the role of social connections in climate change is set within international institutions. Globally, a response to climate change demands both facilitation of adaptation to climate effects and mitigation of climate changing emissions. These international responses to climate change are political, but they also involve social relationships: those of the policymakers, experts, and advocates who make up the epistemic communities dealing with climate science and policy. Epistemic communities are networks of experts who coordinate and empower government learning; the relationships of individuals in these communities provide order to international policymaking (Haas, 1992). Despite solid scientific knowledge of climate change in the 1960s, observers saw few visible outcomes from voluntary, self-set frameworks regulating industrial behavior and attempts at creating international soft law.

Representatives of nation-states concerned about rising temperatures have been meeting since the early 1990s in a structure that would eventually become the United Nations Framework Convention on Climate Change (UNFCCC). Annual meetings for the UNFCCC in the Conference of the Parties (COP) have provided a continuous forum for dialogue and coordination. The COPs have resulted in some

visible, key outcomes in the 1997 Kyoto Protocol and the 2015 COP Paris agreement. Regular connections between participants and epistemic communities of climate change experts have helped solidify norms and industrial guidance for the countries involved and, perhaps most importantly, pushed their focus in the field of climate change beyond coping and mitigation strategies to adaptive and transformative ones.

The UNFCCC focused initially on actions by high-income countries to stabilize the greenhouse gas emission levels. For example, in an effort to meet its national emissions reduction goals, the German government offered a €4,000 (\$4,500) subsidy to buyers who purchased a purely electric vehicle (France-Presse, 2016). Over time, the dialogue between decision-makers, bureaucrats, and the epistemic community of scientific experts has shifted emphasis to promoting adaptation, especially in developing countries (UNFCCC, 2011). Azerbaijan, Bosnia and Herzegovina, Ghana, Namibia, and Tunisia were among a small group of developing countries who participated in the UN Climate Change Secretariat's "Facilitative Sharing of Views (FSV)" in May 2016, a session that provided a platform to least developed countries to report their triumphs and perils in confronting climate change as well as convey their needs to implement their climate change goals (NAMA, 2016).

Through repeated meetings and by connecting decision-makers with climate scientists and local NGOs, the UNFCCC has served as a bridge between communities and international organizations. These connections have succeeded because of reservoirs of bonding social capital (among participants), bridging social capital (across country levels and organizational barriers), and linking social ties (between local residents and international decision-makers). The UNFCCC has improved coordination and provided administrative, informational, and financial assistance for groups adapting to climate change.

These three examples—at the local and international levels—have illustrated how social capital promotes transformative adaptation. In the next section we discuss how technology catalyzes social transmission of new norms and adaptive strategies.

# Novel Roles of Communications Technology and Social Media

Communications technology has served as one of the most transformative technologies in the early 21st century. For individual citizens, policymakers, and researchers, communications and information technologies improve the ability to communicate, monitor situations and conditions, and even identify emerging events (Anttila-Hughes et al., 2015; Kavanaugh et al., 2012). Internet access as of 2015 has reached 3.2 billion people, or over 40% of the world's population, and 7 billion mobile subscriptions worldwide provide service to most of the world (ITU, 2015). With the advent of social media, the use of Internet communications to interact with others also has major reach. In December 2013, Facebook reported, on average, 757 million daily active users and 1.23 billion monthly active users (PR Newswire, 2014). In 2015, Twitter reported 320 million active monthly users, 80% of whom are mobile users.

Social media, which implicitly reflects social interactions in a virtual setting, can reflect, enhance, or perhaps detract from other forms of social relationships. Social networking sites can have a positive impact on an individual's civic and political engagement, suggesting that sites such as Facebook can facilitate the core functions of social capital (Gil de Zúñiga, Jung & Valenzuela, 2012). For example, in an experiment of 61 million Facebook users, a single election day Facebook message turned out an additional 340,000 votes in the 2010 congressional elections (Bond et al., 2012).

In crises, social media have a rapidly evolving role for communicating with people at risk and providing services for response and recovery (Lindsay, 2011). Communications technology can provide rapid, local, detailed updates, particularly with the use of mobile phones. Furthermore, these technologies allow for multi-directional communication. Google and Facebook have introduced safety checks for those users who appear to be located near a disaster—natural or man-made—which provides a simple way for friends and relatives to determine and share the status of each other (Breedon, 2015). Other companies such as Airbnb and Skype altered their services to specifically support disaster victims reaching their network and beyond for communications and assistance. Such information is not

controlled by authorities, yet this improvisation is central to resilience in the absence or in advance of an official response (Sutton, Palen, & Shklovski, 2008).

Among the elderly, the Internet has resulted in an increase of social capital and well-being and a reduction in loneliness (Sum, Matthews, Pourghasem, & Hughes, 2008). In rural communities, the Internet has become a medium for coordination of local events, generating bonding social capital. In online communities, similar outcomes are observed: online gaming can serve to generate bonding social capital and even result in offline support (Trepte, Reinecke, & Juechems, 2012). The Internet connects those with similar interests, connecting people with others outside of their local communities, generating bridging ties among neighboring communities (Stern & Adams, 2010). In short, research suggests that the Internet provides connections and allows the rapid spread of information, which could improve climate adaptation. Despite these findings, much remains to be done; we now turn to the research agenda which can further our understanding of social networks in adaptation.

## **Social Capital and Climate Adaptation: A Research Agenda**

Critics have argued that social capital and climate adaptation remain conceptually slippery and difficult to measure in academic and policy arenas. In this article we have described the breadth of existing work on these concepts, offering specific definitions of the bonding, bridging, and linking aspects of social capital along with their application to coping, adaptive, and transformative responses to climate change. Moving forward, more work must be done to integrate theory and practice of social capital and climate adaptation. Research programs should develop systematic evidence and evaluative frameworks. For social capital to be most effective, we must offer definitive frameworks in the context of policy recommendations and specific programs while clarifying the mechanisms for influencing adaptation (Pelling & High, 2005).

Specifically, future work must integrate multiple levels of analysis, including individual households, communities, and regional and national governments. Recognizing the community-specific

and place-based nature of both social capital and adaptation, further rigor must be brought to determining the external validity of specific implications of social capital in climate adaptation. A variety of methodological approaches can better identify systematic evidence and the ability to transfer or scale interventions based upon social capital. Among these are randomized study design (as used commonly by behavioral and development economists), quantitative analytical tools such as matching (for handling observational datasets that may be biased by selection issues), and field experiments (already heavily in use in the fields of behavioral psychology and economics) (Harrison & List, 2004; Hess, Eidson, Tlumak, Raab, & Luber, 2014). Better tools for measuring social capital are essential if rigor is to be applied in efforts to affect levels and effects of social capital. Finally, strengthening social capital in government–citizen interactions happens both directly through the linking relationships and indirectly when government and external programming acknowledges existing social relationships. We see several areas where researchers should focus their efforts, including measurements for social capital and resilience, repositories and datasets for collected information, and interventions to deepen the reservoirs of social capital.

### ***Measuring Social Capital and Resilience***

Scholars and organizations have operationalized social capital with a number of indicators. We have compiled some of the most common across the categories of bonding, bridging, and linking social capital in Table 1 (see Aldrich, 2012; Putnam 2000; Woolcock & Narayan, 2000; World Values Survey, 2014).

Measures of bonding social capital can include trust, reciprocity and exchange between neighbors, and levels of social cohesion and homogeneity in a community. Bonding social capital can also be measured based on an individual's account of the sense of community they feel, tenure in their current home, frequency of volunteer work in their immediate neighborhood (Brown & Ferris, 2007; Putnam, 2001; Richey, 2007), and how often they see family and friends. For example, a recent study of Superstorm Sandy (2013) victims in the greater New York area surveyed individuals on whether or not

they agreed with statements like “People around here are willing to help their neighborhoods,” “People in this neighborhood can be trusted,” and “This is a close-knit neighborhood.” Individuals who lived in communities where social exchanges were more likely to take place were more likely to report that their community would bounce back quickly after Sandy ([AP-NORC, 2014](#)).

An individual’s sense of community, trust, and reciprocity is often a result of informal social interactions that take place in homes, on sidewalks, or at third places ([Jacobs, 1961](#); [Oldenburg, 1999](#)). These informal settings, such as pubs or cafes, can unite a neighborhood with a setting and place to build and maintain relationships. In Japan, *Ibasho* was created to serve as a third place to host community events as well as empower elders in the community. Those who frequented *Ibasho* were reported as having more friends and deeper neighborhood ties than those who did not ([Kiyota et al., 2015](#)).

Measures of bridging social capital can include varying levels of trust individuals have in extra-local residents of community and in local decision-makers, the number of nonprofit organizations and nongovernmental organizations in the community, frequency of volunteer work for regional organizations, crime rates across communities, blood donation rates in communities, frequency of interactions with dissimilar residents, or individual participation in local religious groups, sports clubs, civic activities, and rotating credit associations.

The presence and activities of organizations in communities has been found to be the most rewarding in communities where levels of social capital are high and sustained ([Anirudh, 2002](#)). The connections these organizations can generate have led to unexpected positive externalities. In one case, mothers who enrolled their children in a child care center experienced a significant improvement in their overall well-being based on the new connections developed within the organization ([Small, 2010](#)). Following Hurricane Katrina, communities with higher rates of associational membership and collective efficacy experienced significantly higher return rates ([Weil & Rackin, 2015](#), p. 22).

When coupled with norms of civic engagement, the strong social fabric of a community can produce positive community outcomes like crime reduction ([Buoanno et al., 2009](#)). This kind of collective efficacy results in a community’s willingness to work together with diverse actors and groups

to serve as enforcers of the common good to quell local crime and violence (Sampson et al., 1997, p. 918); the pre-existing conditions of shared trust and expectations of civility empower communities to work together to reduce crime (Sampson, 2001). Blood donations have served as a measure of bridging social capital, as one study found that an increase in blood donations in a community led to a reduction of common thefts by 13% and car thefts by 15% (Buoanno et al., 2009).

Measuring social capital can include items such as varying levels of trust in regional, national, and international decision-makers; regularity of communication with authority figures (NGO heads, government agents, elected officials, etc.); voter turnout in regional and national elections (Aldrich, 2012; McKenzie, 2008; Putnam, 2001; Weil and Rackin, 2015); volunteer work for national or international organizations, participation in political rally, protest, demonstration, or march (Aldrich, 2012; Brune & Bossert, 2009); or belief that authority figures and elected officials have the community's best interests in mind. Following Hurricane Katrina (2005), repopulation (Weil & Rackin, 2015) and the exclusion of temporary housing (Aldrich, 2012) were driven primarily by engagement in public affairs, suggesting that communities with higher levels of linking social capital could thusly leverage it to achieve their goals.

<COMP: INSERT TABLE 1 NEAR HERE>

While these measures capture different categories of social capital, a number of datasets have begun to investigate social capital, climate change, and disaster outcomes. At the country level, The Notre Dame Global Adaptation Index (ND-GAIN), The Maplecroft Climate Vulnerability Index, World Values Survey (WVS), AfroBarometer, and the Hyogo Framework for Action (HFA) are examples of databases that offer measures relevant to resilience, vulnerability, values, risk reduction, public attitudes, and social and economic indicators. ND-GAIN Country Index offers a country score based on indicators of resiliency from and vulnerability to climate change for 177 countries (ND-GAIN, 2015). The WVS offers data for nearly 100 countries that possess 90% of the world's population. WVS survey responses have been used to measure the intensity of certain functions of social capital, such as civic norms of cooperation and trust (Knack, & Keefer 1997). AfroBarometer offers survey data for more than 30

countries in Africa. Survey responses, like the WVS, are aggregated to the country level to reflect overall trends in public opinion issues like support for democracy, approval of women as political leaders, or approval of the government's management of the economy, social factors relevant in climate responses ([Afrobarometer, 2016](#)). These surveys contain useful covariates, including social capital, for analysis with regard to climate change. Further, these surveys should consider including questions on climate and environment in future versions.

The United Nations International Strategy for Disaster Relief (UNISDR) sponsors the HFA, which has become the Sendai Framework for Disaster Risk Reduction. This international convention promotes institutionalization of disaster risk reduction policies, monitoring, public awareness and education, reduction of underlying risk factors, and strengthening overall preparedness ([UNISDR, 2007](#)). Since 2005, states have submitted biennial evaluations on progress made within the Framework, offering researchers 22 national-level indicators across the HFA's five disaster risk reduction priorities via the HFA National Progress Query Tool ([PreventionWeb, 2016](#)).

The Climate Adaptation Knowledge Exchange (CAKE), World Council on City Data (WCCD), and the Georgetown Climate Center offer additional resources to researchers, policymakers, and planners at the regional, state, and city level. CAKE offers more than 300 case studies of regional adaptation to climate change, as well as resources like the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH), tool planners can use to assess coastal vulnerability. Georgetown University's Climate Center offers a clearinghouse of state and federal environmental regulations and climate and energy profiles for each state with the State Energy Analysis Tool based on data from the U.S. Energy Information Administration. The World Council on City Data (WCCD) offers city-level data on 100 social, economic, and environmental indicators for 21 metropolitan areas from Boston to Shanghai.

The EM-DAT International Disaster Database managed by the Centre for Research on the Epidemiology of Disasters (CRED) at the Université catholique de Louvain offers key information researchers can utilize to measure the human, social, economic, and environmental devastation wrought by both human and natural disasters ([Guha-Sapir, Below, & Hoyois, 2016](#)). Researchers have skillfully

utilized the EM-DAT Disaster Database in attempts to assess national-level vulnerability (Brooks et al., 2005).

Public datasets on climate, disasters, and social capital are essential for understanding the global scope and processes of responses to climate change. The data sets described above cover many forms of data, from administrative data to longitudinal surveys. Data sharing from individual projects and through large databases is essential for replication and coordination in the development of research and in policy implementation. We encourage our colleagues to continue to work to make their data and analytical tools available for replication and testing.

### ***Designing Interventions to Enhance Social Capital***

Social capital can promote climate adaptation, as discussed above, by supporting social institutions and providing mechanisms for cooperation and mutual support. Social capital, like other forms of capital, can be modified or enhanced through interventions. In South Africa's rural Limpopo Province, for example, a team of researchers conducted a randomized trial to monitor intervention groups that offered women enhanced social capital, microfinance training, and health education for more than 2 years (Pronyk et al., 2008). Beyond the immediate gains, women in the program reported higher levels of solidarity in times of crisis, exhibited higher levels of collective action, were more likely to be members of social groups, and believed they had the support of the community to back them. Further, studies carried out in Nicaragua showed that locally tailored programs focused on building social capital can improve both local trust and civic participation even in areas with low incomes and little education, common characteristics of rural populations threatened by climate change (Brune & Bossert, 2009).

Beyond these interventions, community currency and time banking programs have proved effective at building ties. In Japan, for example, a local government program used a community currency capable to promote involvement and generate trust among participants (Richey, 2007). Such a local currency could be useful in incentivizing climate adaptation behaviors while simultaneously reinforcing local action.

Preparation and response to shocks and disasters, including those generated by climate change, are best built upon existing social systems. Recovery efforts should work to restore and maintain social relations, not try to establish new ones. The positive effects of social capital in improving adaptation and resilience can be strengthened by increasing community collective responsibility and involving existing organizations in planning (Dynes, 2006). As such, NGOs and local governments should promote community involvement and support existing social institutions, whether faith-based organizations, sports clubs, social events, or other formal and informal groups that could play a positive role in promoting adaptation and ideally transformative changes (see Aldrich & Meyer, 2015).

Finally, given the importance and limited research on social media in climate change adaptation, a research agenda and its linkages to other social processes should likely be at the core of innovative policy research. Potential research topics include the efficacy of climate information dissemination, based upon factors of peer endorsement or local relevancy; determination of who is excluded from social media-based efforts; and the role of peer-to-peer coordination for adaptation or disaster relief. In a more connected world, social and communications technologies are among the most transformative in how we coordinate with our communities, organizations, and governments.

## Conclusions

Tackling global climate change requires trying to solve many interconnected problems. Modeled as tragedies of the commons or a prisoner's dilemma, adaptive and transformative change will require programs and institutions that take social capital seriously. Currently, the private sector has few incentives to spend money to reduce long-term emissions from manufacturing, transportation, and other processes. Rather than impose demands on the private sector, politicians everywhere would prefer to invest in strategies with short-term electoral payoffs rather than long-term national or global ones (Healy & Malhotra, 2009). As such, the little money and effort being spent on climate change is often focused on protecting or rebuilding physical infrastructure, such as raising homes and businesses out of potential

floodwaters, creating or raising sea walls, and relocating communities and whole island nations.

Certainly, these investments are better than doing nothing. Yet, as we have reviewed, researchers and practitioners have begun to recognize the immense power of connections, collaboration, and social capital in developing resilience and strategies for transformation (Godschalk, 2003).

Beyond altering physical infrastructure, the private and public sectors alike should invest in strengthening social capital to provide sustainable changes and structures to support the individuals and communities affected by climate change (Adger et al., 2005). This is because, as much of the evidence reviewed here has indicated, “climate change adaptation is an inherently social process” (Wolf, 2011, p. 29). A variety of social cohesion and social capital strengthening programs have already been field tested and found to be effective, ranging from community currency to city planning to civic engagement. Communities and organizations alike should seek to “engage local people . . . , create organizational linkages, [and] boost and protect social supports” (Norris, Stevens, Pfefferbaum, Wuche, & Pfefferbaum, 2008). While many cities turn to engineers to solve their problems, such single-focus approaches miss the role of human factors. Social ecological systems must learn to live “with change and uncertainty” (Adger et al., 2005, p. 1039).

While, as detailed above, social capital has some negative externalities, on the whole the balance of outcomes remains positive. Experts should build on research findings suggesting that specific forms of social capital such as natural resource co-management linking government and community-led activities can facilitate transformative adaptation. Researchers, however, should also highlight how social capital may at times be detrimental to adaptation. Programs that integrate communications technology to promote bridging and linking connections are especially important. Moving forward, using approaches such as randomized control trials and the integration of social scientists into climate response panels, decision-makers at all levels should move to ensure that responses to climate change use the best scientific knowledge—social, natural, and applied—to develop policies and programs. Even though human society has already dramatically altered the global environment, we can also cooperate to protect

and strengthen our communities, livelihoods, and industries in ways that also mitigate our future impacts.

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Table 1 Examples of Social Capital Indicators Relevant to Climate Change

<b>Bonding social capital</b>	<b>Bridging social capital</b>	<b>Linking social capital</b>
Trust level in neighbors	Trust level in extra-local residents of community and in local decision-makers	Trust level in regional, national, and international decision-makers (e.g., EPA, UNFCCC)
Levels of reciprocity and exchange with nearby residents	Amount of interaction with dissimilar residents (e.g., climate change workshop)	Regularity of communication with authority figures (NGO)

		heads, government agents, elected officials, etc.)
Sense of community/place	Participation in local religious groups, sports clubs, civic activities, rotating credit associations	Voter turnout in regional and national elections
Tenure in current home	Number of nonprofit organizations and NGOs in the community (e.g., focused on smart cities and renewable energy)	Volunteer work for national or international organizations (e.g., Greenpeace)
Volunteer work in immediate neighborhood	Volunteer work for regional organizations	Participation in political rally, protest, demonstration, or march (e.g., against fossil fuels)
How often individual sees family and friends	Crime rates	Belief that authority figures and elected officials have best interests in mind (e.g., are working on climate change issues)