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Putting People at the Center of Climate Change Adaptation Plans: A Vulnerability Approach

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Abstract

The majority of research and writing on climate change and planning focuses on mitigation, reducing emissions and climate change impacts over long time cycles. However, the realization that human settlements will see immediate and near-term impacts, regardless of emissions reductions, has given urgency to questions about how communities will adapt. We are interested in municipal level adaptation plans: "incipient plans" where implementation has either just begun or not even started, and evaluation and rethinking belong to the future. Our intention is to inform this process. We reviewed more than a dozen municipal and regional climate change and adaptation planning processes, and selected six to examine further. Our case selection includes plans from coastal and inland cities, both large and small, and all but one are from counties amongst the most vulnerable in the U.S. We found that while mitigation of green house gases (GHGs), which is important and necessary, was central to all plans, adaptation strategies were not considered to the same extent or left out completely. We argue that an adaptation strategy that uses a vulnerability approach can be the most effective way to assess climate risk because it puts people and communities at the center of the analysis; helps planners and policy makers to design adaptation strategies that will reduce suffering in local areas while making effective use of scarce resources; and enables better coordination among different elements of planning. To be efficient and effective, adaptation plans must be generated at different scales and must downscale climate information to a local level. Most importantly, the first step in adaptation planning must be to understand vulnerability and the full range of variables that contribute to it. We conclude by suggesting that cities must integrate climate action strategies into their long-range Comprehensive Plans to take full advantage of the targeting and coordination possibilities that a vulnerability approach offers.

KEYWORDS: climate change, adaptation, vulnerability, resilience, planning

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Introduction

The central question about climate change is no longer whether it is real or ongoing, but how individuals, communities, and governments will respond to its present and future impacts.[1] Planning for climate change represents an unprecedented collective action problem that urban planning in the United States has only recently begun to tackle. However, some states, counties, and several municipalities are now in the process of developing climate plans.

Addressing a meeting of the Intergovernmental Panel on Climate Change (IPCC) in 2007, John Holdren, Director of the White House Office of Science and Technology Policy, argued that, when it comes to global climate change, "We basically have three choices: mitigation, adaptation, and suffering. We're going to do some of each. The question is what the mix is going to be" (Kanter and Revkin 2007, 1). Planners narrow this question by asking, "What effect can state, county, and local planning have on this eventual 'mix' of mitigation, adaptation, and suffering?"

Much of the research and writing on climate change and planning focuses on emissions reduction and effects over long time cycles (e.g., Andrews et al.2008; Boswell, Greve, and Seale 2010; Cambell 1996; Lubell, Feiock, and Handy 2009). However, the realization that human settlements will see immediate and near-term impacts, regardless of emissions reductions, has given urgency to questions about how communities will anticipate and respond to climate change impacts. In other words, how will, or should, communities *adapt*, and build cities that are resilient to inevitable change?

Our paper focuses on some of the many questions surrounding climate change adaptation and urban planning. We use a case study approach to make two arguments. First, while mitigation of green house gases (GHGs) is critical, adaptation strategies must be considered concurrently and be built into climate change plans in order to minimize the risk of suffering. Second, a vulnerability approach is the most effective way to assess climate risk because it puts people and communities at the center of the analysis, helps us to design adaptation strategies that will reduce suffering in local areas while making effective use of scarce resources, and enables better coordination among different elements of planning. Most of the plans we studied are "incipient plans" where

[1] As Donaghy (2008) notes, climate change is change in average atmospheric behavior, and change in the patterns of variation around this behavior. So climate change is "real, has been going on since the earth was formed, and is anticipated to continue for the foreseeable future" (p. i). Human induced or anthropogenic climate change, however, is a relatively recent phenomenon, its origins usually traced back to the start of the industrial revolution. For the remainder of this paper, when we refer to "climate change," we are referring to anthropogenic climate change.

implementation has either just begun or not even started; evaluation and revision are future activities. Our intention is to inform these processes.

We begin by briefly clarifying our use of terms. We then review some recent findings on the trajectory of global carbon emissions and likelihood of climate change impacts on the United States. Second, we present six brief case studies of current climate change plans to demonstrate how adaptation planning, central to building resilient communities, is getting short shrift.[2] Third, building on well-established approaches in the natural hazards and international development literatures, we describe how a vulnerability approach to building resilient cities will reduce risk in our communities.[3] Finally, drawing on the case studies and the literature on disaster planning, we outline major lessons for future adaptation planning.

Clarifying Terms

One difficulty in discussing planning and climate change is that participants often use core terminology differently. For example, in natural hazards research and disaster management, mitigation refers to actions taken before a hazard event that attempt to minimize or eliminate the impact on humans: building levees, restricting development in flood prone areas, and so on. In the burgeoning literature on climate change, however, *mitigation* is "an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases" over long time cycles, which is the definition used in this paper (IPCC 2007 379). *Adaptation*, on the other hand, refers to actions that will respond to immediate and near-term impacts of climate change that are the result of historical warming and accrued emissions debt. Adaptation strategies build the capacity of communities and regions to deal with the inevitable impacts of these changes.

Regardless of what planners and policy makers do, there will be some level of suffering due to climate change hazards. Suffering encapsulates a range of potential impacts on individuals and communities, including physical harm or loss of life, mental or emotional stress and anguish, economic loss, and/or social hardships, like the loss of social networks or attachment to a community (Marris

[2] Many of the climate change plans we present were not designed with adaptation in mind. Plan analysis and critique is a heuristic device that we use to make our argument on the importance of adaptation planning.

[3] Vulnerability approaches (or assessments) are also used in other fields and systems related to planning, including poverty analysis, food security, resource management, and sustainable livelihoods (Adger, 2005; Downing and Patwardhan 2002).

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1974).[4] A *hazard* is a natural, physical, or environmental element that has the potential to harm individuals or human systems; in this case, hazards are the various effects of climate change. Each city and region in the United States will be uniquely at-risk from a range of climate-change related hazards, including changes in precipitation and water availability; saltwater intrusion; elevated storm surges; dune and coastal erosion; changes in average temperatures, including more frequent and severe heat-waves; and many others. Some climate change hazards, like sea-level rise or increasing global temperatures, will be gradual. Others, like more severe tropical storms, heat waves, or droughts, will be episodic (U.S. Global Change Program 2009). The central goal of any climate change plan should be to minimize the risk of suffering from impacts.

A simple "pseudo-equation" represents the relationship between risk and vulnerability, as well as Holdren's argument that communities will do some mixture of mitigation, adaptation and suffering in response to climate change:

$$\text{(R)isk of Suffering} = \text{(H)azards x (V)ulnerability}^{5} \quad (1)$$

To reduce the risk of suffering, we can reduce the incidence, magnitude, or duration of the hazards (H), reduce vulnerability to those hazards (V), or reduce both in some combination. Stabilizing or reducing the concentration of GHGs in the atmosphere, whether through emissions reduction or carbon sequestration, is the only way to reduce or eliminate climate change hazards over the long term. The other variable that contributes to the risk of suffering is *vulnerability*, the "characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisneret al. 2004, 11).[6] Housing, infrastructure, agricultural land, and the natural environment are all at risk from climate change impacts, but vulnerability, as Wisner et al. (2004) use it, refers to the risk of suffering that is unique to people. A house may be *unsafe*, or the land it sits on *hazardous*, but only the people in the house are described as *vulnerable*. Vulnerability can be conceptualized at different scales, but planners and policy makers tend to focus on groups or communities (Gunderson 2009). We unpack the idea of climate change vulnerability in detail later.

Closely linked to vulnerability is *resilience*. In the context of climate change and natural hazards, resilience more often refers to the ability of a system

[4] We say "regardless" because climate change is already causing suffering in some communities. The world has already warmed a significant amount in the past 100 years and our accumulated "carbon debt" makes further warming inevitable. The goal of climate change plans is to reduce the risk of future suffering to the furthest extent possible.

[5] Modified from Wisner et al. (2004).

[6] Thanks to Ben Wisner for clarification. See Wisner et al. (2004) chapters 2-3.

to absorb, deflect, or recover from an external shock while staying within acceptable limits of functioning.[7] Both vulnerability and resilience are dynamic concepts reflecting social value systems. People are seen as having agency, as well as both strengths and limitations. If a person or group is likely to suffer from a hazard, they are vulnerable, but how they are able to cope with, resist, or swiftly recover from that hazard describes their resilience. Just because a person or a community is vulnerable does not mean they cannot be resilient (Cutter et al. 2008).

Broadly speaking, vulnerability to climate change is reduced, and resilience enhanced, through *adaptation*. Adaptation is *planned*, guided by policy, or *autonomous*, carried out by individuals or groups in response to hazards (IPCC 2007). The concept of planned adaptation can be further refined as either *anticipatory* or *reactive*. *Anticipatory adaptation* predicts and responds to vulnerability before hazards occur, while *reactive adaptation* only happens after the hazard has occurred, in order to try and limit further recurrence of suffering (Center for Clean Air Policy [CCAP] 2009; Repetto 2008). Our paper focuses on anticipatory, planned adaptation (Figure 1).

Current Debates and the Argument for Adaptation

Until recently, the vast majority of debate about climate change has been focused on reducing GHG emissions. Adaptation was often seen as a distraction from the more important and pressing work of mitigation (Wilbanks et al. 2003).[8] Several key uncertainties continue to make adaptation planning a difficult sell.

First, there is uncertainty over how much countries will actually emit. Various emissions scenarios, or "storylines," have been modeled and presented (IPCC 2001). Each scenario leads to a different set of impacts, and communities cannot be sure for which scenario they should prudently plan. Second, within each scenario there is uncertainty over the amount of warming that would be produced. While the IPCC provides a "best estimate" of temperature increases under different emissions scenarios, the "likely ranges" for warming are quite broad. Even if planners are relatively certain of the trajectory of GHG concentrations in the atmosphere over time, they cannot be as certain about the extent of subsequent warming. The difference of even two degrees of warming could have serious implications for the magnitude of climate hazards that will result (Stern 2007).

[7] For an overview of social scientific usages of the concept of resilience, see Bahadur, Ibrahim, and Tanner (2010).

[8] Internationally, many "less-developed" countries have purposively driven the climate debate towards mitigation, over concern that rich countries (who also tend to be the biggest emitters) might favor, because they have the resources and infrastructure to avoid the worst effects of climate change.

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Third, there is a disconnect between the scale of climate science and the scale of planning actions. While climate projections are usually done on a global or country scale, planners work in regions, counties, and communities. Fourth, climate scientists think there may be some thresholds in the warming process that, if crossed, would lead to rapid and extreme temperature increases. These low-probability, high impact "trigger" events, like the collapse of the arctic ice sheet or large-scale release of methane due to melting permafrost, would create a catastrophic feedback loop in the climate system (Weitzmen 2009). Under such extreme scenarios, where sea-levels might rise as much as 90 feet, planned adaptation would not be possible. For some, the threat of such trigger events compels planners and policy makers to focus exclusively on mitigation efforts to avoid global catastrophe.

Uncertainty is bound up in any planning or policy decision related to future environmental hazards. Mark Pelling (2003, 8), commenting on natural hazards generally, observed that "planners may well ask: 'how can we justify an investment in vulnerability reduction when we do not know beyond a reasonable doubt the magnitude and frequency of future natural hazards…?'". This is an important question, which may lead skeptics to argue that mitigation is the best course of action till more is known about the likelihood and character of future risks.

Advocates for adaptation respond with two arguments. First, human activity has already caused the earth to warm by ~1.4°F, and our accumulated 'carbon debt' will cause it to warm by another ~1.8°F in the next several decades, even if GHG levels were stabilized immediately (IPCC 2007). Second, there is considerable doubt whether the world will be able to reduce GHG emissions to a level necessary to avoid serious climate hazards. Even under the most restrictive emission regimes being considered, there is a "sizeable chance" that temperatures will surpass the 2°C (3.6°F) target (Parry, Lowe, and Hanson 2009).[9] Wallace Broecker, a geoscientist at Columbia University's Earth Institute, recently argued:

> …we'll be lucky if we can stop CO2 at 600 ppm [parts per million]. There's no way we're going to stop at 450. Impossible. If we're going to double CO2, we'd better prepare what we're going to do about it (Stutz 2009, para. 4).

Mastrandrea and Schneider (2008) warn that the world has *surpassed* the IPCC's worst-case 'business as usual' scenario since 2000, and that "social and political inertia" make rapid reductions in worldwide GHG emissions unlikely in

[9] The "2°C target" is a widely cited metric for avoiding "dangerous" climate change (The International Scientific Steering Committee 2005).

the near term. In 2010, global emissions of C02 rose by the largest amount on record, despite a global economic downturn and a series of national commitments to reduce emissions totals. China, the world's largest emitter of greenhouse gases, released nearly 2.2 billion tons of carbon into the atmosphere, 10% more than in 2009. The United States released an additional 1.5 billion tons, 4% more than in 2009 (Gillis 2011).

Viewing adaptation and mitigation as trade-offs is no longer possible. The near-term effects of rising sea levels, diminishing snow packs, spreading insect infestations, and increased severity of storms are already being felt. While planners and policy makers continue to explore the myriad ways that they can contribute to mitigation, they must also focus their energies on adaptation (Fulton 2009a; 2009b).

One way to improve the adaptation planning process is to incorporate a vulnerability approach, which is well established in the natural hazards and international development literatures. This approach conceptualizes people's vulnerability to climate change hazards as the product of their social and economic characteristics, their built and natural environments, and the interactions between them. Vulnerability and resilience are moderated by a range of plans, policies, organizations, and services (Table 1). By understanding *who* is most likely to suffer from climate change hazards, and the processes through which vulnerability is produced and reinforced, we can design more effective adaptation measures using a wide range of planning tools and policies. A vulnerability approach also helps guide the allocation of scarce resources towards measures that will have the greatest positive impact on reducing the risk of suffering.

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Table 1. Variables that Contribute to Climate Change Vulnerability

Variables	
Social and Economic Vulnerability	Age; Gender; Ethnicity and Race; Education; Social Class; Work and Occupational Status; Access to diverse economic sectors and range of livelihoods; Access to Services; Health Status; Familiarity With Local language; Residence Status; Involvement In Local Community; Ability To Engage Governance Structures; Special Needs
Built Environment	Quality of Housing Construction; Density of Housing; Quality of Commercial and Industrial Building Construction; Number and quality of Public Facilities; Transportation Infrastructure; Presence and Safety of Critical Infrastructure (Police and Fire Stations; Hospitals; Schools; Drainage and Sewer Systems; Energy Production Facilities); Parks and Open Space; Protection of Monuments and Historic Structures
Natural Environment and Exposure	Elevation and Flood Plains; Coastal and Dune Erosion; Wetlands and Wetlands Degradation; Erosion; Coastal Subsidence; Groundwater Sources; Natural Drainage and Drainage Basins; Impervious Surfaces; Urban Canopy; Heat Island Effect
Plans, Policies, and Resources	Hazards-sensitive Land-use Planning and Zoning Ordinances; Hazards Sensitive Building Codes and Enforcement; Emergency Plans and Services; Hazard Mitigation and Disaster Recovery Plans; Local Service Organizations; Communities of Worship; Social Services Agencies; Community linkages

Sources: Cutter et al. (2008); also, Burby et al. (2000); Mustafa et al. (2010); Tierney (2007); Wisner et al. (2004); Pelling (2003).

In the next section, we examine six climate change plans, all of which are in the early stages of study, discussion or implementation, as well as their approaches towards adaptation. They offer us important insights about how cities are failing to consider important facets of vulnerability and increased risk of suffering in their communities.

Planning for Climate Change Adaptation: Selected U.S. Cases

Our case selection includes climate plans from large and small coastal and inland cities; all but one (Boulder, Colorado) are from counties amongst the most vulnerable in the U.S.[10] Before selecting cases, we reviewed more than two dozen climate change plans often held up as exemplars, looking for cities or regions that had taken significant steps towards adaptation plans. Our findings paralleled those of Wheeler's (2008) far more comprehensive survey of 64 state and local climate change plans, where he found that only 11 mentioned adaptation, and almost always "simply as a topic for further research and planning" (Wheeler 2008, 484). We selected six plans from this group, representing a range of geographies and size.

Three common characteristics stand out in the plans we reviewed. First, they focus overwhelmingly on emissions reduction though a combination of land use principles (densification, transit-oriented development, setbacks, rolling easements); building retrofits (green technologies for energy efficiency, safety); reducing consumption and increasing recycling; increasing renewables in municipal energy portfolios; and pushing for increased use of public transportation and energy efficient fleets. A few plans note specific hazard mitigation actions, like setbacks or easements, which could also promote adaptation planning. Second, while most plans (especially those in coastal cities) draw attention to near term impacts like flooding, few outline specific approaches to deal with these impacts. Finally, most plans lack explicit methodologies to help focus planning attention on the most vulnerable communities and people, except for one notable exception: low-income owners and renters.

Earlier we noted that a central goal of any climate change plan should be to minimize suffering. As Neil Adger (2007, 273), a convening lead author of the 4th IPCC report, observed,

> The existing evidence suggests that climate change impacts will substantially increase burdens on those populations that are already vulnerable to climate extremes, and bear the brunt of projected

[10] "Vulnerable" means being ranked in the top 20% category according to the social vulnerability index (SoVI). The SoVI was developed by the Hazards and Vulnerability Research Institute at the University of Southern Carolina. Constructed using a factor analytic approach by which 42 variables (from county-level socio-economic and demographic data) were reduced to 11 independent factors that explained 78% of variance, the index places these factors in an additive model to compute a summary score. Factors change for each county, underscoring the importance of the interactive nature of social vulnerability (Cutter, Boruff and Shirley 2003; see also www.sovius.org).

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> (and increasingly observed) changes that are attributable to global climate change.

Yet, in the plans we reviewed, vulnerability is usually reduced to low income levels or location in a hazardous physical place, and does not reflect what substantial research has demonstrated: vulnerability results from complex interactions between humans and the built and natural environments. By simplifying the concept of vulnerability, plans lose a great deal of analytic power, and narrow the range of potential adaptation measures considered as well as how those measures could, and should, be targeted.

Planning for Climate Change in Coastal Cities

The U.S. has 22.8 million people living on land in low elevation coastal zones, defined as areas less than 10m (33 feet) above sea level (Beatley 2009). Coastal communities will experience some of the worst impacts of climate change, but many have a history of dealing with hazards like hurricanes, storms, or erosion, and some have emergency preparedness and hazard mitigation plans in place. These institutional structures and past experiences suggest that adaptation planning may be easier to launch in coastal communities than in areas where impacts seem distant and difficult to grasp.[11] Here, we focus on planning activities in the San Francisco Bay Area and New York City.

Issues of Scale, Coordination, Vulnerability, and Adaptation in the Bay Area.

The San Francisco Bay Area is one of the most urbanized estuaries in the world. Its approximately 7 million residents will see major impacts from climate change, in the near and distant future. Current models indicate a 16-inch rise in sea water levels in the region by mid-century, and a 55-inch rise by the end of the century. Using these models, the San Francisco Bay Conservation and Development Commission (BCDC) notes that in 40 years, the current 100-year flood plain will have become the mean daily high water mark, inundating 180,000 acres of Bay Shoreline, including 66,000 acres of residential development, major highways and 72% of the San Francisco and Oakland airports. Over half of all publicly accessible shorelines and recreational areas will disappear (along with substantive stretches of industrial and commercial acreage), and Bay ecology will undergo

[11] On the other hand, existing emergency management infrastructure has some drawbacks. See Burby et al. 1999 for examples of incentives for homeowners or communities to continue living or building on highly exposed land.

substantial stresses and shifts.[12] Warming oceans will also cause inland temperatures to rise, increasing the number of wildfires and droughts. Given the enormity of potential impacts on the Bay Area, and in California more broadly, planning for climate change has become a major priority at all levels.

Berkeley, California. In November 2006, Berkeley citizens voted to mandate an 80% reduction in GHG emissions by 2050, and directed the mayor's office to develop a climate action plan. The Third Draft Plan, which took two years to prepare, includes input from citizens, researchers, and students at the University of California, civil society groups, and other experts.[13] Around the same time, the Governor issued an executive order requiring all state agencies to prepare for climate change impacts by preparing the state's first comprehensive Climate Adaptation Strategy (CAS). The state thus took the lead in providing statewide scenarios on climate change impacts, establishing regulatory guidelines, and requiring climate change plans by local governments and regional entities.

As with all the plans we surveyed, the Draft Berkeley Climate Change Plan lays out the city's emissions inventory, targets, and trends. The plan also recognizes the need to link the city's preparedness doctrine to the risks associated with climate change (City of Berkeley 2009, ES 5). The chapter "Adaptation to a Changing Environment" tackles the issues of near-term impacts to meet citizens' visions of being "resilient and prepared for the impacts of climate change," and to be a city where the "social and economic benefits of the climate protection effort are shared across the community" (City of Berkeley 2009, ES 2). Four policies—all to be implemented in partnership with other jurisdictions and agencies at local, regional and state levels—are outlined: first, launch and sustain a collaborative process to assess the city and the region's vulnerability with which to develop a plan for adaptation; prepare a plan for water conservation, efficiency, and diversification of water supply; prepare to reduce property damage associated with flooding and coastal erosion as well as to enhance local capacity to manage storm water and coastal floods; and last, prepare for extreme heat events by increasing tree cover, which will also improve carbon sequestration.

Berkeley's plan falls short of considering what makes different people more or less vulnerable to climate change hazards. The implementing actions are broad-based, applicable to all residents equally, and do not mention the possibility of variation across groups and communities based on the vulnerability assessment. Important questions are left unanswered. For example, will the elderly or children be targeted differently for policies related to extreme heat

[12] The BCDC and the United States Geological Survey (USGS). See http://www.bcdc.ca.gov/planning/climate_change/index_map.shtml.
[13] Berkeley's draft plan is available at www.BerkeleyClimateAction.org/

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events? How will property damage be dealt with in the case of low-income renters in multifamily units?

In some ways, however, the plan is ahead of others in its intent to understand vulnerability. It notes the need for a vulnerability analysis, even if it then rushes into policy prescriptions without providing targeting, coordination, or implementation details. The plan also lays out some specific policies for short-term implementation in each target area, notably on expanding and implementing assistance programs for low-income households.

San Rafael, California. San Rafael's 16-page draft climate plan, which uses state and ICLEI GHG emissions projections, is organized by how policy recommendations would affect various facets of the community: lifestyles (which includes transportation, land use, and waste reduction areas); buildings (reducing energy consumption and increasing conservation); environment (forestry, food production, habitat protection, and adaptation to rising sea water levels); economy (green businesses and social equity); and community empowerment and education.[14] The recommendations are broad (e.g., "develop a program to achieve energy savings in existing buildings by decreasing energy use by 20% as of the year 2020"), and implementation strategies are not included. The plan does, however, have a social equity component, nested in the economy area, with recommendations for creating environmentally beneficial jobs for low-income residents, and more importantly, recommending that the supply of affordable housing be expanded to reduce commute times and congestion for lower-income workers, thereby reducing the city's GHG emissions.

San Rafael's 56,000 residents will see even greater impacts from rising sea-levels than Berkeley's; almost all of the central and eastern parts of the city will be inundated (City of San Rafael, 2009). Yet the plan is silent about who lives and works in these areas or how the city could plan for displacement or "managed retreat." Recommended instead are policies for structural shore protection such as building both private and public levees and supporting measures like installing sea-monitoring gauges to track changes over time (City of San Rafael 2009, 11, EN 7, 8). Like Berkeley, the plan recommends participating in a future County regional vulnerability assessment and preparing a local assessment while continuing to build community awareness and provide emergency planning. However, no details are provided.

The San Francisco Bay Conservation and Development Commission (BCDC).
The BCDC is the federally assigned coastal management agency for the San Francisco segment of the California coastal zone. Along with local governments,

[14] The Climate Change Action Plan for San Rafael is available at www.sustainablesanrafael.org/.

it is responsible for regulating the Bay, shoreline, and development in lands within 100 feet of the daily high water mark. The primary function of the BCDC's staff report, *Living with a Rising Bay,* is to create a climate change section in the Bay Plan and amend findings and policies on issues that are currently under BCDC jurisdiction in light of climate change impacts. The report also offers a blueprint for future adaptation plans, like those being planned in Berkeley and San Rafael.

The Report begins with a detailed analysis of impacts of sea-level rise and increased storm activity, and lays out various scenarios from the IPCC and the California Climate Action Team, before describing its approach to vulnerability assessments and discussing shoreline protection options. The vulnerability assessment, described as "the first and most important adaptation strategy," follows the methodology used by the Climate Project for King County in Washington (2007) to identify the degree of sensitivity, adaptive capacity, and vulnerability of three areas or systems: the shoreline environment, the Bay ecosystem, and governance (BCDC 2009, 6).

The shoreline environment includes residents, businesses, and other facilities, especially transportation and infrastructure, in the area. With the aid of GIS maps, *Living with a Rising Bay* tabulates acreage lost and the impacts of climate change on a range of land uses and infrastructure including ports, airports, highways, water-related industry, railways, parks and beaches, and public access shoreline. What it does not do as well, however, is analyze the range of factors that make shoreline residents vulnerable, instead focusing only on issues of income, similar to the Berkeley and San Rafael plans.

Not addressing the range of factors that can explain social and economic vulnerability (see Table 1) leads to several problems, especially with the report's analysis of the impacts of changing land use. If ports and water–related industry disappears, where do people's jobs go, and whose livelihoods are most impacted? If highways are inundated and have to be relocated, which neighborhoods will that relocation most likely impact?

The term "vulnerability" is further blurred in the report's second area focus, the Bay, where ecological impacts in four geographical shoreline areas most susceptible to flooding and erosion are considered. The Suisun Marsh in the North Bay, with its sensitive ecosystem, is assessed as most vulnerable. The Central Bay, with subtidal habitats that are home to eel grassbeds that are expected to disappear soon, is categorized as less vulnerable. Yet the Central Bay shoreline has intense human activity in a range of industrial uses. Would taking multiple vulnerabilities into account change the calculus regarding the Central Bay?

In the third area of focus, governance, the report points to the fact that adaptation planning brings new challenges and additional complexity to regional

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cooperation, an issue with which Bay Area jurisdictions and sectoral management agencies continually grapple. While the report's analytical focus brings up the important issue of institutional weakness at the regional level, and the need to find institutional mechanisms and incentives for cooperation and collaboration, it ignores a range of governance issues related to citizen participation: who asserts the right to participate, who actually does participate and is able to influence process, and how does power shape the collaboration process and outcomes?[15]

New York City. New York is one of the world's largest coastal cities, and one of the best protected against environmental hazards. Climate change, however, threatens the city with a higher risk of hurricanes, floods, and heat-waves, changes in precipitation patterns that will endanger the water supply, and sea-level rise that could inundate hundreds of thousands of coastal homes and businesses as well as a large portion of the city's critical infrastructure (The City of New York [CNY] 2007). Atlantic Ocean hurricanes, more likely as temperatures rise, could have a devastating impact. A Category III storm would produce a storm surge of 21-feet at the entrance to the Lincoln Tunnel and require the evacuation of more than 3 million residents (The New York City Panel on Climate Change [PCC] 2009).

New York's climate change plan is incorporated into the city's 25-year comprehensive plan, *PlaNYC 2030*, which is broadly focused on environmentally sustainable development.[16] New York's first step towards an adaptation strategy was to commission a local and regional climate impact study, *Climate Risk Information* (PCC 2009). The remainder of the strategy is brief, focusing on three major areas for future planning: protecting vital infrastructure, developing local adaptation plans in vulnerable communities, and developing a citywide strategic planning initiative for adaptation. Of all our examples, NYC stands out in its focus on developing local adaptation plans. In 2008, the city formed partnerships with several community-based organizations in vulnerable neighborhoods and conducted five "outreach" workshops, one in each borough. Feedback from these workshops is meant to inform a citywide effort to assist communities in developing local adaptation and mitigation plans (CNY 2009). The process is ongoing, and we had few details on outcomes as we were writing this paper.

[15] BCDC's reference to the success of the ABAG initiated Hazard Mitigation Plan (2009, 129) is worth noting. This plan has financial incentives in the form of grants for participating municipalities. An important contribution of the Plan has been to provide regionally based vulnerability analysis to enable analytic consistency across geographic areas, and to allow for constant and easy updating of data.

[16] A progress report on PlaNYC is available at www.nyc.gov/planyc2030.

Planning for Climate Change in Inland Cities

Adaptation planning is a harder 'sell' in inland cities where there is no easily graspable image of a climate change impact to rouse people and planners to action. The few cities that have created or implemented climate change plans have a community history of interest in urban planning issues, implementing open space planning and growth controls, and more broadly in issues related to sustainability.

Chicago, Illinois. . The Chicago Climate Action Plan (CCAP) was released in 2007 after a two-year long research and consultation process. As an inland city, Chicago will face a different set of hazards than many coastal communities. Chicago commissioned a study by leading climate researchers to "downscale" the national and international data in order to project impacts on the city and metropolitan region. Their projections took only two IPCC scenarios into account: where emissions continued unabated, and where they were reduced to moderate-low levels (Hayoe and Wuebbles 2008).

In both scenarios, the most pressing climate change hazard would be increased average temperature, especially worrisome in the summer months. Besides the threat posed to human health and well-being (described in detail in the next section), warmer temperatures also pose an economic threat by negatively impacting tourism, putting strain on energy and transportation infrastructure, and raising the cost of emergency services (Chicago Climate Task Force 2008; Parzen 2009). Other major hazards projected are increased yearly precipitation, with heavier rainstorms and longer periods of drought, and changes in disease vectors.

The CCAP lays out nine adaptation "actions," general goals that are much less developed than their mitigation counterparts: manage heat, manage storm-water, engage the public, and so on. The plan points to the need to identify "populations at-risk" during heat waves, but does not offer any further detail. Chicago commissioned a separate adaptation study by an international engineering consulting firm that focuses on the potential impacts on the city's infrastructure and businesses. Risk is scored according to infrastructure costs, but the study does not consider how human safety and well-being should be valued (Parzen 2008). It is also vague about ways to adapt to risks once they are identified, offering only general strategies like "reduce vulnerability to extreme heat events" or "manage the urban heat island effect." The report enumerates some specific tactics or actions that might be undertaken, but they are so generic as not to have any specific relevance to Chicago: e.g., "develop and share best practices with other organizations" (Parzen 2008, 22). The authors do not discuss

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which adaptation measures should be prioritized, to have the greatest impact, or where, or how adaptation decisions might be made given Chicago's unique context.

Boulder, Colorado. Located just 35-miles northwest of Denver, Boulder is home to both a major research University and several federal labs that focus on climate research. This wealthy city of about 100,000 has a reputation for being eco-friendly. Boulder was among the first communities in the nation to implement growth controls and open space acquisition policies starting in the 1970s, and to design and implement a climate action plan. In 2006, Boulder voters approved the first municipal carbon tax in the U.S.

In 2002, The Boulder City Council directed its staff to develop a plan that would envision a sustainable energy future for the city. The resulting Climate Action Plan, which includes baseline data and an emissions inventory generated by consultants, outlines three primary strategies and an implementation plan for reducing emissions: increase energy efficiency, switch to renewable energy and vehicle fuels, and reduce vehicle miles traveled. In March 2009, two years after the start of implementation, which encouraged voluntary compliance to meet emissions goals, the city prepared *A Community Guide to Boulder's Climate Action Plan (CAP)*. The 2009 guide included a progress report on meeting goals, new strategies and programs that mandate compliance, and a "social mobilization" strategy to help citizens reach the emissions goals set out in 2002.[17]

While Boulder's climate action plan is ahead of the curve in terms of tackling knotty implementation questions and focusing on assistance for low-income residents, it says very little about adaptation. The plan is focused entirely on mitigation strategies, and beyond identifying low-income residents as a group in need of assistance, the city has not seen the need to design or implement a vulnerability assessment. The Boulder planners we interviewed and corresponded with see two reasons for this: first, the plan's focus on mitigation, and second, the fact that near-term impacts are hard to make visible. The emphasis on "social mobilization" in the 2009 CAP, and the process underway to integrate the CAP into the 2010 update of the Comprehensive Plan is a response to these concerns. Planners acknowledge that a major challenge will be to incorporate adaptation strategies, possibly focusing on food security, energy localization, and promoting regional collaboration with area cities.

[17] For details on the original Climate Change Plan (2006) and the Community Guide to Boulders Climate Action Plan (2009) see http://www.beclimatesmart.com. Since the original draft of this article was prepared, the City of Boulder has moved forward aggressively on its climate action goals. In November 2011, voters passed two measures that raise funds to move the city towards municipalizing its energy supply and distribution.

A Vulnerability Approach to Adaptation: Building Resilient Cities

Our case studies represent some of the most comprehensive and clearly articulated climate plans in the country, and demonstrate just how underdeveloped adaptation planning currently is. While many of these plans do a good job describing the various types of hazards that may impact the city, its infrastructure and economy, none provide a framework for understanding how suffering will be experienced unequally across households and communities.

We use the case of the Chicago Climate Action Plan's (CCAP) response to heat waves to illustrate how a vulnerability approach would improve adaptation strategies. Chicago's adaptation plan is mostly concerned with the potential rise in heat waves, which have caused nearly 1,000 deaths in the past 20 years, including a single event in 1995 that killed more than 700 (Klinenberg 2003). The number of 90-degree days in the city is expected to increase by 40% in 30 years if mitigation efforts are successful, and by 220% if they are not (CCAP 2008, 15).

As Chicago's heat waves become more frequent and intense, how could a vulnerability approach inform adaptation plans? First, it would incorporate a wide range of information on a number of different variables that are known to contribute to suffering. Currently, the CCAP adaptation report contains information on the natural environment and exposure (satellite imagery shows variation in ambient temperatures at very high spatial resolution), and stresses the role of the built environment in the context of the heat island effect, but says little about social/economic vulnerability.

Who is most vulnerable to heat waves in Chicago? Eric Klinenberg's detailed study of the 1995 heat wave found that victims were disproportionately poor, old, and ill (2003). Middle-class and affluent residents suffered far less because most had air conditioning or were able to evacuate. Vulnerability, however, was not coterminous with poverty. The most important variable for predicting suffering was isolation. Klinenberg found that heat wave victims tended to live alone and be socially isolated, and to reside in neighborhoods that are economically depressed and have fewer vibrant public spaces (University of Chicago Press 2002). His findings were consistent with a study in the *New England Journal of Medicine*, which found that victims "were less likely to leave home frequently, to have friends in Chicago, to have pets, and to participate in group activities" (Semenza et al., 1996, 87).

The CCAP makes several recommendations for "reducing vulnerability," including tree planting, green roofing and green alleys for reducing the urban heat island effect, increasing the number of air conditioning units in residential buildings, and improving emergency response plans (Parzen 2008). These are all important adaptation measures, but many of them are not coordinated with information on exposure and social and economic vulnerability that would allow

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planners to target the most vulnerable communities (similar issues come up in other cases). With limited adaptation funds available, putting green roofs on expensive apartment buildings or planting trees in middle- and high-income neighborhoods does little to reduce the risk of suffering among the most vulnerable. Yet, under the CCAP plan, adaptation does not go beyond suggesting these activities.

A vulnerability approach, on the other hand, would point to a wide range of planning tools and policies that would reduce the risk of suffering. Research shows that parks, open space, and vegetation reduce the heat-island effect, as does higher density development (Stone and Rogers 2001). Vibrant open spaces reduce the isolation that typifies heat-wave vulnerability and increase neighbor-to-neighbor contacts, as does public transportation and economic development (Freeman 2001; Frumkin 2002) Affordable housing, where many of the most vulnerable seniors live, could be located near such vibrant places with resilience in mind. Participatory planning actions at the neighborhood level could build ties between neighbors while educating residents about vulnerability, risk, resilience, and adaptation, and improve the performance of emergency measures during heat wave events. Outside planning, neighborhood groups, and the city's social services agencies could help identify at-risk people. Such a strategy would work across different programmatic foci within planning and other city agencies. In order to be imagined, and later, implemented, it would need to be coordinated between a range of departments: housing, zoning and land use (all of which typically sit within the planning department), urban forestry, open space, parks and recreation, transportation, and social services,

This brief example cannot do full justice to the rich literature that has developed around vulnerability, hazards, development, and planning (e.g., Blaikie et al. 2004; Burby et al. 2000; Mileti 1999; Mustafa et al. 2010; Pelling 2003). It does, however, highlight the shortcomings of the adaptation plans we described earlier. It also demonstrates the core features of a vulnerability approach and points us in the right direction for designing better adaptation plans that keep people and communities at the center of planning efforts to reduce suffering and the negative impacts of climate change. The vulnerability approach also emphasizes the importance of coordinating across scale and planning functions.

Recommendations

Keeping vulnerability in mind, what are some lessons that these cases offer for adaptation policy and planning practice? First, climate change science and data must be "downscaled" to the community level. Downscaling information and specifying impacts allows communities and local governments to understand who and what is most likely to be exposed to climate hazards, and how severe the

impacts will be. Local impact studies are also important for "selling" adaptation, which could possibly initiate behavior changes, as Boulder's "social mobilization" strategies and BCDC's persuasive inundation maps intend.[18] As all our case studies reveal, the public and their representatives are understandably skeptical of investing scarce resources into adaptation when climate risk is not fully understood. Skepticism is higher in the inland cities. The NYC and Chicago plans, which are built around a detailed account of hazards at a relatively small scale, demonstrate to skeptics why *both* mitigation and adaptation measures are critical; the impact studies project catastrophic hazards if emissions are not reduced, but serious climate change related hazards even if GHGs are stabilized at a relatively low-level.

Second, planners and policy makers must generate climate change plans at different scales. Each scale allows for different kinds of actions to be taken. More importantly, it allows for analytic consistency at, and across, different scales, and permits easier maintenance of data sets and updates. In the California examples, the state's plan establishes broad authority and mandates to local governments for regulatory controls, while in the San Francisco Bay area, the BCDC plan promotes a coordinated effort in structural shore protection and managed retreat. This will impact where San Rafael may build levees, while having minimal impact on Bay ecology and on other communities that share the shoreline. Based on its own local vulnerability assessment, San Rafael can then create incentives and plan land use and development to allow displaced residents to be relocated equitably. A different approach is being tested in New York City: encourage community level plans by nonprofits in order to allow vulnerable communities to have voice in decisions made.

Third, planners and policy makers should consider the full range of variables that contribute to vulnerability, and use vulnerability assessment as a first step in adaptation planning. The plans in our study tended to equate vulnerability with poverty, or with location in a hazardous physical place, rather than as the result of complex interactions between human systems and the built and natural environments. While vulnerability is a complex phenomenon, it is not indecipherable, and much of the information and resources needed to inform a vulnerability approach to adaptation are already available. Climate change may be a relatively new challenge, but issues associated with vulnerability, hazards, and disasters are not. In several of our case studies, the cities plan to harness already existing tools and knowledge. Chicago, Berkeley, and San Rafael all point to the importance of bolstering their emergency planning and response systems for managing extreme weather events. Boulder is starting to connect emissions

[18] Issues related to how human behavior can be changed through social norms and persuasion is part of climate change planning, but outside the scope of this paper (Griskevicius, Cialdini and Goldstein 2008)

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regulation with public safety and health. New York plans to manage the risk of extreme weather and coastal inundation, in part, by revising flood plain maps, updating building codes, and bolstering community based planning in vulnerable communities. In addition to local resources, fifty years of research on disasters and development can guide planners who are trying to understand vulnerability to a particular hazard.

Conclusions

Taking a vulnerability approach to adaptation planning will yield substantial benefits for cities and communities. By identifying groups and communities most likely to suffer, limited adaptation resources can be efficiently directed towards projects or policies with the greatest potential impacts. Many adaptation measures will also benefit mitigation activities by reducing vulnerability as well as GHG emissions. These "win-win" measures receive considerable attention in our case study climate change plans, and rightly so; they should be stressed whenever possible in order to increase investment cost-effectiveness. Planners must be sure, however, to analyze "win-win" measures from the perspective of vulnerability and resilience; in several of the plans we reviewed, mitigation measures were touted as having adaptation benefits, without any reference to where and how those investments should be made, or to which groups of people were benefitting. This can be illustrated by drawing on our earlier example of planning for increased incidence of heat waves, which typically includes green roofs and tree-planting to reduce the urban heat island effect (adaptation) and reduced energy use (mitigation). To qualify as an effective adaptation measure by our standards, however, these investments should yield benefits in communities that are judged to be vulnerable. If subsidies encourage a green roof to be installed on a building in a wealthy neighborhood (where many such investments are being made), it will mitigate GHG emissions but do little to reduce the impact of heat-waves.

Adaptation plans that take a more narrow and simplified view of vulnerability will limit the effectiveness of adaptation actions. As our case studies have shown, adaptation measures can cut across virtually every programmatic focus in planning, from housing, transportation, and land-use to parks, public safety, and economic development. The only policy document that works across these programmatic foci is a city's or county's Comprehensive Plan (referred to outside the U.S. as the Master Plan, the Long Range Plan or the Comprehensive Development Plan). A good way to ensure that vulnerability is addressed in a coordinated effort among a wide range of elements within planning is to incorporate climate change adaptation into local comprehensive plans, as New York has done and Boulder plans to do.

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