Evidence Matters

Transforming Knowledge Into Housing and Community Development Policy

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The devastating consequences of Hurricane Katrina led to a sweeping reassessment of federal disaster policy. *FEMA / Liz Roll*

In This Issue

Federal Disaster Policy: Toward a More Resilient Future

In recent years, the concept of resilience has emerged as a centerpiece of federal disaster policy. As defined by Rockefeller Foundation president Judith Rodin, resilience is "the capacity of any entity — an individual, a community, an organization, or a natural system — to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience."[1] Resilience is relevant to a wide range of sudden disruptions, including terrorist attacks, epidemics, and financial crises, and of chronic stresses such as endemic poverty and unemployment. The concept has been applied to disasters — in particular, in response to several very destructive and costly recent events — and to the growing consensus that extreme weather events will become more severe and frequent in the future.[2] Broadly conceptualized, resilience applies to physical, social, and economic dimensions; people,

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Message from the Assistant Secretary

Although it isn't the first thing that comes to mind for most Americans when they think of HUD, our agency has long played an important part in helping communities recover from disasters and build resilience to reduce future risk. In fact, for a period in the 1970s, HUD hosted the Federal Disaster Assistance Administration, a precursor to the Federal Emergency Management Agency. Ever since, HUD staff have continued to support communities before, during, and after disasters, especially through the Community Development Block Grant Disaster Recovery Program.

Because disasters affect so many aspects of life and can strike communities of all sizes around the country, the federal response is comprehensive, with many agencies providing aid and expertise to support the state and local governments that are the first responders. As you'll see in the articles in this issue of *Evidence Matters*, HUD helps communities facing disasters through its assisted housing stock and more broadly through supplemental funding and technical assistance.

Within the agency's range of disaster response work, the Office of Policy Development and Research (PD&R) plays a key, multifaceted role. PD&R has a unique vantage point within the agency, providing expertise and research to support all of HUD's activities while also seeking best practices through partnerships with academics, think tanks, and other nongovernmental organizations. PD&R's staff have a range of skill sets such as program evaluation, geospatial data analysis, and local economic and housing market analysis, making the office especially well-suited to pitching in on the rapidly changing conditions typical of any disaster response effort.

Since the 1990s, PD&R staff have been especially engaged in three ways. First, by providing information on past disasters. Through a combination of staff member expertise and reports analyzing best practices and the agency's prior responses, PD&R serves as a clearinghouse for communities seeking information on how to prevent or respond to disasters. A selection of this research is available through HUD USER (huduser.org) in the PD&R Disaster Recovery Tool Kit.

Next, PD&R's efforts are critical to telling the early story on the extent of damage caused by disasters. Following Hurricane Sandy in 2013, for example, PD&R staff quickly mapped damage in the affected communities down to the block group level, allowing for better targeting of resources and making the case that the severity of damage necessitated additional funding.

Finally, when Congress provides disaster recovery funds through HUD, PD&R works with staff from the Office of Community Planning and Development to develop funding formulas that ensure that all affected communities receive assistance quickly, effectively, and equitably.

Through our American Housing Survey (AHS), PD&R played a critical role in understanding the effects of Hurricane Katrina on New Orleans and its citizens. Starting with the fortuitous baseline of the 2004 New Orleans metropolitan AHS, PD&R was able to foresee some of the difficulties of the recovery: a large stock of low-rent, single-family homes and low-income homeowners without mortgages, portending a lack of insurance coverage for recovery. In 2009, PD&R added a special metropolitan AHS of New Orleans to measure the progress of recovery, adding specific new questions on the housing path of residents who were displaced by the disaster. AHS returned to New Orleans again in 2011.

This highlights the important role of data and analysis in supporting disaster planning and relief. There is no substitute for the critical work on the ground, but those efforts need the type of knowledge infrastructure PD&R can provide to support work at all stages of disaster recovery.

— Katherine M. O'Regan, *Assistant Secretary for Policy Development and Research*

Editor's Note

This issue of *Evidence Matters* delves into HUD's role and responsibilities in assisting communities with disaster recovery and mitigation and describes how communities are rebuilding after a disaster to ensure long-term resilience. As with other community planning principles such as smart growth, local engagement must be central to disaster resilience and recovery planning, with HUD and other federal agencies playing an integral but supporting role by providing needed short- and long-term funding and technical assistance. Although federal agencies may be able to suggest best practices, such as developing land with multiple uses, only community residents can best decide how to manage complex local conditions and needs — for example, when a historic community facing repeated river flooding must decide whether to move its downtown to reduce the risk to residents.

The lead article in the issue, "Federal Disaster Policy: Toward a More Resilient Future," discusses the role of the federal government in supporting communities following natural disasters and in promoting resilience to reduce the financial and social toll of future disasters. The Research Spotlight piece, "The Research Basis for Disaster Resilience," presents information on the growing frequency and costs of disasters as well as the theory and practice underpinning the concept of resilience. Finally, the In Practice article, "Preparing for the Next Disaster: Three Models of Building Resilient Communities," examines how three communities have recovered from major disaster events with adaptations that have bolstered resilience and yielded economic benefits.

We hope this edition of *Evidence Matters* provides a useful overview of this critical topic. Our next issue will focus on housing in Indian Country. Please provide feedback on any of our issues at **www.huduser.org/forums**.

— Rachelle Levitt, *Director of Research Utilization Division*

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buildings, transportation systems, and social networks, for example, can all be more or less resilient to disruptions. Achieving greater resilience is a collective effort, as Susan Cutter writes in the preface to *Disaster Resilience: A National Imperative:* "Disaster resilience is everyone's business and is a shared responsibility among citizens, the private sector, and government."[3]

Highlights

- The need to promote resilience in federal disaster policies has become more urgent in the wake of increasingly frequent natural disasters, rapid urbanization, climate change, and globalization.
- The government's response to Hurricane Katrina and the recovery following the disaster offered important lessons for improving disaster resilience and have helped shift federal disaster policy toward a more proactive approach, as evidenced in the response to Superstorm Sandy.
- Disaster recovery offers people an opportunity to rebuild for resilience while they are still highly sensitive to their vulnerability. Programs such as the Rebuild by Design competition and the Rockefeller Foundation's 100 Resilient Cities promote promising resilience practices.

Disaster resilience is a matter of federal policy because communities call on the federal government to assist response and recovery efforts when major disasters and catastrophes strike. From 2010 to 2013, there were 289 presidential major disaster declarations and 59 emergency declarations — instances in which a state or tribal government requested federal aid and the president determined that the severity and magnitude of the disaster warranted federal assistance.[4] The declaration of a major disaster initiates long-term federal disaster aid programs, and the declaration of an emergency provides for a more limited intervention to meet a specific immediate need or to prevent a disaster from occurring, with each type of declaration helping communities in proportion to their needs.[5] These federal programs increasingly are designed not just to restore communities to predisaster conditions but to rebuild them better and stronger than before so that they can better withstand future disasters.

This article focuses on how the federal government has incorporated resilience into disaster policy and how it is fostering resilience at the regional, local, and individual levels. For individuals, federal programs promote an awareness of potential risks and encourage mitigation measures such as raising a home located in a floodplain. At the community and regional levels, federal policies provide funding for planning, mitigation, and reconstruction of

FEMA/U.S. Navy photo by Chief Mass Communication Specialist Ryan J. Courtade/Released

Hurricane Sandy caused widespread damage to the Northeast shoreline, highlighting the need to improve coastal resilience.

housing and infrastructure, primarily through the Community Development Block Grant Disaster Recovery (CDBG-DR) program. As communities recover from disasters, they have an opportunity to rebuild in ways that make them more resilient. Although the heightened sense of vulnerability and influx of funds (and, in some cases, the need for large-scale redevelopment) that follow a disaster may offer communities a unique opening for such rebuilding, communities that have not experienced a disaster also have an opportunity to incorporate resilience into everyday spending and land-use decisions. In recent years, federal policies have encouraged, incentivized, and facilitated the adoption of resilience principles into disaster recovery and local planning and development.

The Growing Need for Resilience

In the past decade, a number of factors — lessons learned in the aftermath of Hurricane Katrina, a cluster of severe natural disasters around the world, and emerging evidence regarding the implications of climate change — have contributed to broad reassessment and recasting of federal disaster policies. Among the current trends and themes in these policies are efforts of federal agencies to collaborate and coordinate their fragmented disaster programs and funding streams, an emphasis on aligning federal resources with local rebuilding visions based on inclusive community input, improved coordination among federal, state, and local governments as well as their private-sector and nonprofit partners, fostering innovative solutions through competition, and obtaining and using better disaster-related data. Federal, state, and local policies are also moving from reactive responses to proactive ones, ranging from stockpiling emergency supplies before a disaster strikes to predisaster mitigation planning, building local disaster response capacity, and improving disaster resilience.

Rodin writes that the need for resilience has become more pressing in light of rapid urbanization, climate change, and globalization. Although disaster resilience is a matter of concern for rural and urban populations alike, the concentrations of people and physical structures of cities are more vulnerable to hazards.[6] Hurricane Katrina, which struck New Orleans along with a wide swath of the Gulf Coast and caused an estimated 1,833 deaths and $125 billion in economic costs (in 2005 dollars), and Hurricane Sandy, which caused at least 159 deaths and damaged more than 650,000 homes and hundreds of thousands of businesses in several Northeast cities, raised public awareness of the need to improve resilience, especially in coastal cities.[7] Reviewing available evidence, the Hurricane Sandy Rebuilding Task Force concluded that "[w]hile scientific evidence does not yet tell us definitively whether storms like Sandy are growing more common, evidence indicates climate change is already altering environmental conditions in a way that suggests there may be changes in the frequency, intensity, duration, and timing of future extreme meteorological events, which may lead to unprecedented extreme weather events." Among the specific concerns is the rise in global sea levels, because it increases flood risk in highly populated coastal areas, but threats associated with climate change affect all areas of the country.[8] In addition to hurricanes, tornadoes, floods, and earthquakes, disasters that are less visible and dramatic but no less destructive, such as drought and prolonged heat

waves, threaten lives, damage property, and disrupt the normal social and economic functioning of communities.[9]

Resource scarcity adds further urgency to mitigation and resilience efforts. Public costs associated with disaster response and recovery are staggering; the Center for American Progress reports that the federal government spent $136 billion on disaster relief from fiscal year 2011 to 2013.[10] The potential exists, however, to reduce these costs through prudent investment in mitigation measures. The Multihazard Mitigation Council of the National Institute of Building Sciences estimates that for every $1 spent on mitigation, society saves $4 in future losses.[11] Another possible way to realize public savings is to encourage individuals to assume more responsibility for disaster-related risk. The challenge for policymakers is to provide needed assistance without creating a disincentive for households to take responsibility for planning, mitigation, and risk; even in high-risk areas, residents tend not to voluntarily invest in loss prevention.[12] For example, the National Flood Insurance Program (NFIP) was created in 1968 to encourage residents of flood-prone areas to purchase flood insurance. NFIP subsidized coverage to fill a gap in the private insurance market because private insurers feared that a single flood event could exceed their reserves.[13] NFIP itself has sustained substantial losses because premium rates did not accurately reflect risk. Ongoing reform of NFIP seeks to strike a balance between protecting taxpayers through risk-based pricing and keeping policies affordable for property owners.[14] Yet increasing the number of households that carry policies is critical to facilitating recovery; evidence shows that households with insurance coverage are more likely to be able to rebuild following a disaster and to do so more quickly than those without insurance.[15]

A Shift in Federal Disaster Policy: From Katrina to Sandy

The combination of the four hurricanes (Charley, Frances, Ivan, and Jeanne) that hit Florida and other states in 2004 and the three (Katrina, Rita, and Wilma) that struck the Gulf Coast the following year was a turning point in U.S. disaster policy, says Jan Opper, former HUD Associate Deputy Assistant Secretary for Disaster Policy and Management. Hurricane Katrina, in particular, became a focal point.[16]

FEMA / Calvin Tolleson

Homeowner mitigation efforts protected this Cameron Parish, Louisiana home from flooding associated with Hurricane Ike in 2008.

With the federal response widely considered to be a failure, Katrina spurred changes in law and practice. Aspects of the post-Katrina response and recovery, including the evacuation of New Orleans, the vulnerability of specific populations, and the effectiveness of housing recovery programs, offer important lessons for improving disaster resilience and have helped shift federal disaster policy toward a more proactive approach.

In some respects, the evacuation of New Orleans was a remarkable feat, with an estimated 1 to 1.2 million people leaving the city by car. The evacuation, however, was a glaring failure in one respect: 70,000 people, including some of the city's most vulnerable residents, were left behind.[17] Those who remained were endangered by the breakdown of the levee system, which caused massive flooding over large swaths of the city.[18] These experiences highlight the importance of physical infrastructure — in this case, transportation and flood mitigation systems — in helping cities withstand and recover from disaster.

Katrina and its resulting desperation, desolation, and dislocation also brought into stark relief the intersection of natural disasters, human social systems, and the built environment.[19] The storm and subsequent flooding dramatically and tragically exposed longstanding patterns of inequality that left some populations more vulnerable than others to the consequences of disaster.[20] Disparities in access to resources, social capital and networks, and political power, as well as cultural differences along race and class lines, resulted in inequities in residents' exposure to Katrina-related hazards and in their ability to withstand and recover from these hazards.[21] Race and class affected many response and recovery decisions and outcomes, from the ability or willingness of lower-income and minority residents to evacuate to their capacity to relocate or rebuild.[22] Elliot and Pais find, for example, that

FEMA/Rosanna Arias

Rebuilt following Hurricane Irene to meet base flood elevation standards, this West Creek, New Jersey home sustained very little damage from Hurricane Sandy.

"net of other factors, blacks outside the city [of New Orleans] were 1.5 times more likely than similar whites to evacuate after, rather than before, the storm," and Fussell et al. find that black residents returned to New Orleans more slowly than did white residents, largely because of disparities in housing damage.[23] A year after the storm, only 48.5 percent of black evacuees had returned to their residences compared with 73.2 percent of white evacuees.[24] Other especially vulnerable groups included domestic violence victims in shelters, children in foster care, and seniors in nursing homes and hospitals; approximately half of the people who died in Louisiana as a result of Katrina were aged 75 or older.[25] Among the lessons learned in response to such disparities is the need for greater understanding of the relationship between social vulnerability and disaster.[26] Another lesson evident in the recovery process was the importance of restoring social networks and incorporating community engagement. Widespread community involvement proved an important aspect of resilience; research finds that recovery from Katrina was faster and more effective in New Orleans neighborhoods that took initiative, mobilizing to shape and participate in recovery with broad inclusion of previously excluded or disadvantaged groups.[27]

Within the broader scope of recovery activities, University of California at Berkeley department of architecture professor Mary Comerio says that "housing recovery is critical," especially for "urban concentrations of housing loss" and especially for low- and moderate-income residents.[28] Research shows that attachment to place, and thus the ability to remain in or quickly return to one's home, is an essential component of community disaster resilience.[29] FEMA grants for home repairs, U.S. Small Business Administration loans of up to $200,000 for repair and rebuilding, and the state-designed programs funded by CDBG-DR, along with NFIP, constitute the core federal programs for permanent housing recovery.[30] After Katrina, the two major CDBG-DR programs were Louisiana's Road Home program and Mississippi's Homeowner Assistance Program. Some residents used the assistance to rebuild, whereas others relocated. Both rebuilding (when it incorporates structural mitigation) and relocation (when it removes residents from high-risk areas) can improve a community's resilience to future disasters.

Many of the lessons learned from Katrina have informed subsequent policy. The Post-Katrina Emergency Management Reform Act of 2006 directed the president to establish a national preparedness goal and a national preparedness system.[31] Since Katrina, the federal government has replaced the National Response Plan that guided the Katrina response with a National Response Framework. The framework, which was released in 2008 and revised in 2013, became one of the five National Planning Frameworks of the National Preparedness System.[32] Another of the five frameworks, the National Disaster Recovery Framework (NDRF), was released in September 2011 and also incorporates major lessons from Katrina into a revised approach. NDRF is sensitive to the need to ensure that recovery is equitable; does not discriminate; and addresses emotional, social, and financial needs in addition to physical restoration and rebuilding. NDRF encourages local predisaster planning and

preparedness and recommends that state and local governments designate Local Disaster Recovery Managers. Finally, NDRF explicitly recognizes "that there is opportunity within recovery," including the opportunity to enhance sustainability and resilience in pre- and postdisaster planning and recovery.[33]

The first large-scale test of NDRF, and an opportunity to implement the lessons of Katrina, was Hurricane Sandy. Soon after the storm, President Obama created the Hurricane Sandy Rebuilding Task Force by executive order, naming HUD's then-Secretary Shaun Donovan as its chair. Directed to provide cabinet-level leadership over rebuilding in conjunction with the NDRF, the task force was an acknowledgment of past deficiencies in interagency coordination and the need for resilient rebuilding immediately after the disaster.[34] The task force united the efforts of 24 executive departments, agencies, and offices to create the Hurricane Sandy Rebuilding Strategy, which included 69 recommendations aimed at aligning federal funding with local rebuilding priorities, fostering a regional approach to rebuilding, and improving resilience to accommodate climate change.

The Hurricane Sandy Rebuilding Task Force provided guidance on how best to spend federal funds (appropriated through the Disaster Relief Appropriations Act of 2013) to support effective long-term recovery for a more resilient future, "working hand-in-hand with communities to help them rebuild smarter and better by providing the best data about the risks they face, setting clear resilience standards to help protect against those risks, and bringing a wide range of stakeholders together to foster innovative ideas and ensure a comprehensive regional approach to rebuilding."[35] Among the task force's recommendations are the development of a sea level rise projection tool, a smarter electrical grid and liquid fuel supply chain, and reforms to NFIP.[36] The task force articulated two main infrastructure goals: coordinated efforts toward quick and effective recovery and investments in making systems more resilient against future disasters.[37] For housing, HUD used the Disaster Housing Assistance Program to issue rental payments to landlords to provide housing for displaced families and, through the Federal Housing Administration, worked with a New Jersey Community Development Financial Institution on a program that allows homeowners to remain in their homes while making repairs.[38]

In the year following Sandy's landfall, $10.4 billion in CDBG-DR funds had been allocated, with 26,000 households helped through housing programs; more than $74 million in FEMA Hazard Mitigation grants had been awarded; $7.9 billion had been paid on more than 143,000 NFIP claims (more than 99% of those filed); and 97 percent of public beaches from New Jersey through Connecticut reopened by Memorial Day 2013.[39] Department of Homeland Security Inspector General audits of FEMA's initial response to Sandy in New York and New Jersey concluded that the agency was effective and efficient, highlighting the agency's proactive preparation and effective coordination.[40] As response transitioned to recovery, the states of New York and New Jersey, New York City, and other grantees made resilience — "building back better and smarter" — a key principle guiding their CDBG-DR spending, including improvements to transportation infrastructure, a home buyout program to encourage the resilient redevelopment of high-risk coastal areas, and various homeowner assistance programs.[41] Despite lessons learned from Katrina, Grand Forks (see "Preparing for the Next Disaster: Three Models of Building Resilient Communities," p. 19), and other disasters, implementing these programs has presented new challenges and lessons. The New York City Department of Investigation concluded that the city's Build it Back program, which was funded through CDBG-DR, set up an overly complex and onerous application process that created significant delays in disbursing assistance, and state-administered programs also encountered difficulties and delays.[42] "The process isn't working" when it comes to housing recovery assistance, says Comerio. "It's too long, it's too slow. We really have a ways to go to think about how we resolve housing recovery issues."[43] Ongoing evaluation of these programs may reveal best practices for future improvement.

FEMA / Michael Rieger

This Colorado neighborhood's outer road, which doubles as a fire barrier, protected these homes from wildfires in 2009.

Building Resilience Into Disaster Recovery and Predisaster Planning

The Hurricane Sandy Rebuilding Task Force noted that Sandy had revealed that the coastal areas of the Northeast had large concentrations of people and infrastructure at high risk of storm damage and that hazard mitigation was needed to reduce that risk and better protect against future storms.[44] Adding to the urgency of such efforts is the emerging knowledge regarding climate change and its associated threats. Recognizing these threats, the Hurricane Sandy Rebuilding Task Force sought to ensure that as the affected communities began the long and arduous work of recovery, they did not simply rebuild but instead rebuilt "smarter and better," incorporating resilience into recovery. The task force fostered innovative regional approaches to resilient rebuilding by bringing stakeholders together, providing them with reliable data on their risks and vulnerabilities, and setting resilience standards to mitigate those risks.[45] Plyer and Ortiz note that customized, accessible data are in high demand immediately following a disaster because officials must make numerous response and recovery decisions in conditions that are often chaotic. "Having an established data intermediary with a sound technical platform and community-oriented mission in place before a disaster strikes," they argue, "enhances the resilience capacity of a region to meet the myriad and acute data needs that will arise after a disaster."[46] Following Katrina, researchers found that mapping risk factors along with additional data such as social and economic information was highly useful. These tools are becoming increasingly sophisticated and are essential to planning for sustainable and resilient rebuilding.[47] Because lower-income communities are disproportionately affected by disasters, a better understanding of the relationship between the geographies of hazard risks and the geographies of social and economic vulnerabilities is especially vital.[48]

To further encourage collaborative, innovative, and regional approaches to resilient rebuilding in the Sandy-affected region, the task force launched a multistage design competition, Rebuild by Design, in June 2013.[49] Ten interdisciplinary teams were selected from 148 applicants to participate in a research phase that incorporated community outreach and analysis of the critical challenges facing the region. The teams ultimately developed 10 proof of concept plans, from which 6 were chosen to receive CDBG-DR funding (along with additional public and private funding sources) for implementation.[50] The winning proposals, including the "Living Breakwaters" project — a series of sloped walls off Staten Island's south shore that will provide habitats for sea life and dissipate wave energy hazards — embody the goals of sustainable, resilient rebuilding.[51] Although Rebuild

MIT CAU + ZUS + URBANISTEN, courtesy of Rebuild by Design

This rendering depicts New Meadowlands, a winning Rebuild by Design proposal, which aims to provide flood protection and recreational amenities with a system of berms and marshes. The proposal includes transportation elements to improve the connectivity of the wetland and surrounding towns.

Disaster recovery offers an opportunity for people to rebuild for resilience in a place and time in which they are highly sensitive to their vulnerability.

by Design encouraged designs tailored to a specific regional context, the ideas that the competition generated may be replicated elsewhere, inspire other ideas, and promote increased emphasis on disaster resilience in planning and development policy and practice nationwide.[52] Research indicates that when states require localities to "plan and manage development with hazard mitigation in mind, property losses are strikingly lower."[53]

Disaster recovery offers an opportunity for people to rebuild for resilience in a place and time in which they are highly sensitive to their vulnerability. The Hurricane Sandy Rebuilding Task Force, particularly through its Rebuild by Design competition, underscored the importance of integrating resilience into recovery early in the process. Resilience, however, is just as important in disaster preparedness as it is in disaster recovery. As an attribute of a place akin to available amenities or resources, a community's resilience has value for its residents and businesses. To encourage localities to become more resilient, HUD has announced a National Disaster Resilience Competition open to 67 eligible applicants including 48 of 50 states (all but Nevada and South Carolina), the District of Columbia and Puerto Rico, and 17 local jurisdictions that are recovering from presidentially declared disasters that occurred between 2011 and 2013. Applicants will compete for CDBG-DR awards totaling $1 billion.[54]

The competition is intended to have an impact that extends far beyond the benefits of the winning projects; through it, HUD aims to change the way that state and local actors think about spending and planning decisions. "The big money is not the billion dollars, it's the many billions that localities are spending every day on water and sewer, on roads and bridges, on schools and housing, [and] on utility infrastructure," says Harriet Tregoning, director of HUD's Office of Economic Resilience. Most localities spend that money without considering how easily those investments might increase resilience. The hope for the competition is that whether or not applicants ultimately receive a grant, they will use the intentionally long initial phase to examine risks and vulnerabilities (with funding and technical assistance available in some cases) and emerge with a new way of thinking about how resilience can be incorporated into their goals and spending. In addition to the competition, HUD is investigating ways to use technical assistance and core programs (such as CDBG and HOME) as well as its other assets to advance resilience.[55]

Nongovernmental organizations are also promoting resilience through initiatives such as 100 Resilient Cities, pioneered by the Rockefeller Foundation (100RC) and Smart Growth America's State Resilience Program. In December 2013, 100RC selected 32 cities to receive financial, logistical, and expert support, including resources to establish the position of Chief Resilience Officer within municipal governments. This position is designed to foster coordinated efforts across government departments and to incorporate a resilience approach into all of the activities local governments carry out each day. A second group of cities was added in December 2014, building a network of member cities that are then connected to partner organizations to share their knowledge and experience. The initiative emphasizes resilience both to sudden shocks, such as natural disasters, and to constant stresses, such as inadequate public transportation systems or high unemployment, through a city resilience framework.[56] The framework addresses four dimensions of resilience — health and well-being, economy and society, infrastructure and environment, and leadership and strategy — and identifies three areas of activity for cities to pursue to advance each dimension.[57] The city of Norfolk, Virginia, one of the first 100RC member cities, is working to improve resilience through flood mitigation. A coastal city that has long faced flood threats, Norfolk is becoming increasingly vulnerable to flooding because of rising sea levels. Through a collaborative process that encouraged resident input, the city has developed a flood strategy as part of a broader coastal resilience strategy. The approach includes flood preparation efforts, such as encouraging residents to elevate homes, appliances, and utilities and purchase flood insurance; flood mitigation, including reclaiming and reconstructing wetlands and raising roads; and plans for future infrastructure projects. Although not all of the proposed projects have been funded, the resilience strategy has the potential to guide future investment toward such projects.[58]

Smart Growth America's recently launched State Resilience Program provides resources for local leaders who are positioned to incorporate resilience principles and goals into land use and infrastructure decisions among other activities of state governments and over which state governments have influence.[59] Smart Growth America hosts a web-based clearinghouse for relevant resources and in October 2014 convened the State Resilience and Economic Growth Summit, allowing state and federal leaders and policy experts to exchange knowledge and share best practices.[60] State governments are in a position to designate CDBG-DR funds for resilience planning. The state of Colorado, for example, awards grants through a Resilience

History of Federal Disaster Policy

After nearly 150 years (1803–1947) of adhoc disaster responses and limited mitigation activities, the federal government has incrementally expanded relief, recovery, and preparedness policies through permanent funding and institutions, but policy reform has remained largely reactive to large-scale disasters or clusters of disasters.[1]

- 1947: Congress charged the War Assets Administration and the Federal Works Agency with delivering surplus federal supplies to areas in need.[2]
- 1950: The Housing and Home Finance Administration, HUD's predecessor, took charge of disaster assistance until the Federal Civil Defense Administration (FCDA) assumed responsibility in 1952.[3]
- 1950 to 1953: The Disaster Relief Act of 1950 and its amendments established, for the first time, a permanent source of federal disaster relief funds. These funds were initially designated for the repair of local government properties. A 1951 amendment to the act provided support for emergency housing, and a 1953 amendment authorized the donation of federal surplus supplies to individuals.[4]
- 1958: The Office of Civil and Defense Mobilization replaced FCDA and was assigned relief and response activities.[5]
- 1961: The Office of Emergency Planning was charged with coordinating civil defense and disaster-related emergency efforts.[6]
- 1966: The Disaster Relief Act expanded federal relief designated specifically for recovery.[7]
- 1968: Congress created the National Flood Insurance Program to offer flood insurance in communities where private insurers did not provide coverage as long as the communities adopted required floodplain management policies.[8]
- 1970 to 1974: The Disaster Relief Act and its amendments codified and expanded previous incremental policies with an emphasis on assistance to individuals and hazard mitigation. The amendments established procedures for defining emergencies (separate from major disasters) and increased available assistance.[9] They also emphasized government preparation to handle natural or manmade hazards.[10]
- 1979: The Federal Emergency Management Agency (FEMA) was charged with coordinating federal disaster policy including preparation, mitigation, response, and recovery.[11]
- 1988: The Robert T. Stafford Disaster Relief and Emergency Assistance Act established the statutory authority for presidential disaster and emergency declarations as well as the resulting federal assistance.[12]
- 1993: Community Development Block Grant Disaster Recovery program funds were appropriated following Hurricane

Planning and Capacity Building Program.[61] Boulder County, an awardee that sustained flood damage in September 2013, is funding a temporary floodplain permitting specialist to help implement floodplain planning and postflood activities as the county pursues its goal of "building back stronger and more resilient than before."[62]

Promising Practices in Disaster Resilience

As both the 100RC and Smart Growth America State Resilience program recognize, developing and sharing best practices will be helpful as local governments (in some cases working together at a regional level) seek to adopt and implement resilience frameworks and planning. Because the concept of disaster resilience is relatively young and has only recently become an organizing principle of disaster policy and practice, the evidence base regarding best practices for implementing resilience at the local level is still emerging. O'Hare and White argue that despite its ubiquity in academic and policy disaster discourse, resilience has developed neither "certainty regarding its definition nor… agreement regarding its application through policy and practice."[63] Nevertheless, building from experience, research on mitigation and sustainability, and the growing field of disaster resilience, characteristics of resilient communities and factors that facilitate resilience and its adoption can be identified.

Cutter et al. note that "there is consensus within the research community that resilience is a multifaceted concept, which includes social, economic, institutional, infrastructural, ecological, and community elements."[64] Cutter et al., Norris et al., Arup International Development, and other

Andrew, Hurricane Iniki, and Typhoon Omar and thereafter become a major part of federal recovery assistance.[13]

- 2002: The Homeland Security Act placed FEMA under the newly formed Department of Homeland Security along with 22 other federal agencies, effective March 2003.[14]
- 2006: The Post-Katrina Emergency Management Reform Act reorganized FEMA by redefining its mission, consolidating its emergency management functions, and granting it greater autonomy.[15]
- 2011: FEMA developed the National Disaster Recovery Framework to coordinate predisaster planning and facilitate postdisaster response and recovery across all levels of government.[16]
- 2012: The Hurricane Sandy Rebuilding Task Force coordinated local, state, and federal recovery efforts and developed model resilience policies for vulnerable communities.[17]
- 2013: HUD hosted Rebuild by Design, a HUD competition that generated ideas to make the New York-New Jersey region more environmentally and economically resilient.[18]
- 2014: The National Disaster Resilience Competition, an ongoing competition modelled on Rebuild by Design, made $1 billion available to communities to develop innovative resilience projects and plan for the effects of extreme weather and climate change.[19]

[1] Saundra K. Schneider. 1995. *Flirting with Disaster: Public Management in Crisis Situations,* Armonk, NY: M.E. Sharpe, 19.

[2] David A. Moss. 1999. "Courting Disaster? The Transformation of Federal Disaster Policy since 1803," in Kenneth A. Froot, ed. *The Financing of Catastrophe Risk,* Chicago: University of Chicago Press, 315.

[3] Gaines M. Foster. 2000. *The Demands of Humanity: Army Medical Disaster Relief,* Washington, DC: Center of Military History, United States Army, 134.

[4] Moss, 316.

[5] Schneider, 21.

[6] Ibid., 22.

[7] Anna Marie Baca. 2008. "History of Disaster Legislation," *On Call: Disaster Reserve Workforce News* (September), 1.

[8] U.S. Federal Emergency Management Agency. 2011. "National Flood Insurance Program: Answers to Questions About the NFIP," 1.

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[11] U.S. Federal Emergency Management Agency. "About the Agency" **(www.fema.gov/about-agency)**. Accessed 9 December 2014.

[12] Ibid.

[13] Interview with Jan Opper, October 2014.

[14] U.S. Federal Emergency Management Agency.

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[17] U.S. Department of Housing and Urban Development. 2013. "Hurricane Sandy Rebuilding Task Force Releases Rebuilding Strategy," 19 August press release.

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researchers have developed frameworks for measuring resilience that identify consensus characteristics of resilient communities and regions across these categories.[65] Although, as Kulig et al. point out, it is difficult to "differentiate indicators of resilience from the various resources that contribute to it," these indicators point to areas that communities should focus on to assess and improve resilience.[66] Generally, the indicators and resilient practices identified by these frameworks apply broadly, although it should be noted that they were developed based on specific geographic regions, and consideration of local contexts is important for implementation.[67]

- *Communities need to have a realistic understanding of their risks, vulnerabilities, and resilience capacity, and information regarding threats and capacities should be made available to all stakeholders.*[68] For both planners and households, relevant and accurate data such as vulnerability maps are essential for developing resilience.[69] For example, research finds that public information activities are associated with reductions in flood loss.[70]
- *Planning and mitigation reduce disaster losses and increase resilience.*[71] In the short term, the existence of a disaster response plan that gives communities the flexibility to act in the immediate aftermath of an event increases the community's ability to quickly bounce back.[72] Over the long term, Burby et al. conclude, "[c]ommunities with a coherent land-use plan and hazard-mitigation strategy are able to build settlements that will be resistant to natural disasters, able to recover quickly from a natural event, and able to last for many years with little cost in dollars or lives to their inhabitants."[73]

Studies on the effectiveness of specific mitigation measures can point to practices that can make communities more resilient by addressing corresponding risks and vulnerabilities.[74]

- *Resilience frameworks should take a holistic or comprehensive approach.*[75] Communities can enhance their resilience when they consider the ways that various social, economic, and physical systems interact. For example, physical infrastructure and attributes such as walkability and connectivity that have resilience implications of their own also affect resilience through their effects on social networks. McIlwain et al. conclude that "social connectivity and the ability of residents to assist each other are critical for survival and rebounding during and after natural disasters."[76]

- *Meaningful and democratic community involvement in resilience and mitigation processes increases community support and builds the social capital that is characteristic of resilient communities.*[77] Shared long-term networks and community identity, trust, and other factors that foster social cohesion strengthen community disaster resilience.[78] Research finds that similar social capital characteristics are important for forming and sustaining the public-private partnerships that develop disaster resilient communities.[79]

- *Addressing social and economic vulnerabilities strengthens disaster resilience.* Cutter et al. suggest that communities with greater educational equity; better access to vehicles, telephones, and health insurance, among other resources; and greater economic diversity (not dependent on a few sectors or resources) have higher levels of disaster resilience.[80] As Norris et al. put it, "communities must develop economic resources, reduce risk and resource inequities, and attend to their areas of greatest social vulnerability."[81]

Evidence is also emerging on which factors may promote the adoption of best practices. Ashley D. Ross, professor of political science at Sam Houston State University, surveyed county emergency managers throughout the Gulf Coast about how they understood and practiced resilience.[82] Ross finds that institutional aspects of resilience such as planning and zoning are stronger in counties with past disaster experience and with higher levels of resources available to emergency management offices, such as additional staff members. Ross says, "Those communities that exhibited more resilience had a grassroots effort to collectively organize," reinforcing findings on the importance of democratic community involvement and Cutter's contention that "[p]olitical will and strong leadership are essential … to building resilience at any level."[83]

Disaster and Opportunity

Disaster recovery in affected areas and predisaster mitigation planning offer an opportunity to create a more resilient future, building communities that are better able to withstand and rebound from disasters. Furthermore, pursuing resilience can offer multiple benefits. Tregoning notes that "whether it's a stronger economy, more diversified employment, more opportunity for low- and moderate-income residents, or innovation and competitiveness, all of those things can be supported by investments in resilience and vice versa."[84] For example, instead of building a levee, a community could build a waterfront park to offer the same flood protection as a levee but with the added benefits of recreational amenities for residents and a reduction in the urban heat island effect. In the context of scarce public resources, appropriations of disaster recovery funding may in fact offer the best opportunity to pursue such goals. Although the ability to mitigate future threats from disaster has limits, when disaster resilience includes sober assessments and appropriate responses to limits and challenges, communities can become safer and smarter places, even in the face of increasingly frequent and severe disasters.[85] EM

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The Research Basis for Disaster Resilience

Highlights

- Many data sources indicate that natural disasters in the United States are becoming more frequent and costly.
- In the disaster context, resilience research often focuses on the ability of systems and places to mitigate the risk of, withstand, and quickly recover from extreme events.
- The strength of social bonds within communities is a critical component of disaster resilience.

Evidence to support increasing focus and resources on disaster resilience rests on many factors, ranging from detailed analyses of local circumstances and cases to broad datasets examining the causes and consequences of disasters. This article examines both ends of this spectrum, beginning with research on trends in the frequency and costs of natural disasters, followed by an exploration of how resilience is conceptualized and promoted through best practices.

Data on Disaster Frequency and Costs

Detailed data on natural disasters in the United States are more accessible than ever, with many government and private websites devoted to examining the frequency and costs of all kinds of domestic and international disasters. In many cases, however, precise (and therefore comparable) data on the number and scale of U.S. disasters is available only from the 1980s onward, complicating efforts to understand long-term trends. Nevertheless, various sources indicate that natural disasters have become more frequent and severe over the past few decades, and this trend is projected to continue.

Various sources indicate that natural disasters have become more frequent and severe over the past few decades, and this trend is projected to continue.

The number of federal disaster declarations (combining Major Disaster Declarations, Emergency Declarations, and Fire Management Assistance Declarations) has increased precipitously in recent decades. Between the 1950s and the mid-1990s, the annual number of declarations almost never exceeded 60, but the mean from 1995 to 2004 and from 2005 to 2014 was 106 and 133, respectively (fig. 1).[1] This growth does not precisely represent an increasing frequency of natural disasters, both because federal disaster declarations include a small number of non-natural disasters and because changing political and social forces may influence how willing the government may be to declare a disaster. This fact does illustrate, however, that the frequency of disaster situations for which the government has made federal funds available has risen substantially.

Data from the Insurance Information Institute, an industry-supported organization that works to improve public understanding of insurance, confirm that the number of natural disasters is increasing, with almost every year from 2006 to 2013 exceeding the highest number of disasters recorded between 1980 and 2005.[2] Annual financial losses related to natural disasters, both insured and overall, have also risen. Annual insured losses related to thunderstorms (including tornadoes) have increased sevenfold since the early 1980s, and winter storm losses have almost doubled. Annual insured property losses related to hurricanes are dominated by Hurricane Katrina — the $95 billion in insured hurricane losses in 2005 is nearly triple that of any other year since 1980.[3] The year 2005 also marked the highest amount of loss dollars paid through the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program, the primary source for flood insurance in the United States, and between 2005 and 2008, Congress appropriated $19.7 billion in supplemental Community Development Block Grant program funds for disaster recovery for states affected by Hurricanes Katrina, Rita, and Wilson. Since 1978, the five highest years of loss dollars paid through the National Flood Insurance Program have all occurred after 2004.

The number of very severe, high-loss disasters also appears to be growing. The National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center maintains data on disaster events whose costs exceeded $1 billion (adjusted for inflation using the Consumer Price Index). Although NOAA cautions against interpreting trends because of various factors, including the uncertainty of loss estimates and the variability of inflation over time, the data show that only 1 year between 1980 and 2000 saw more than six disaster events exceeding $1 billion in damages, whereas 6 years since 2000 have exceeded that number (fig. 2).[4] In all, severe storms have been

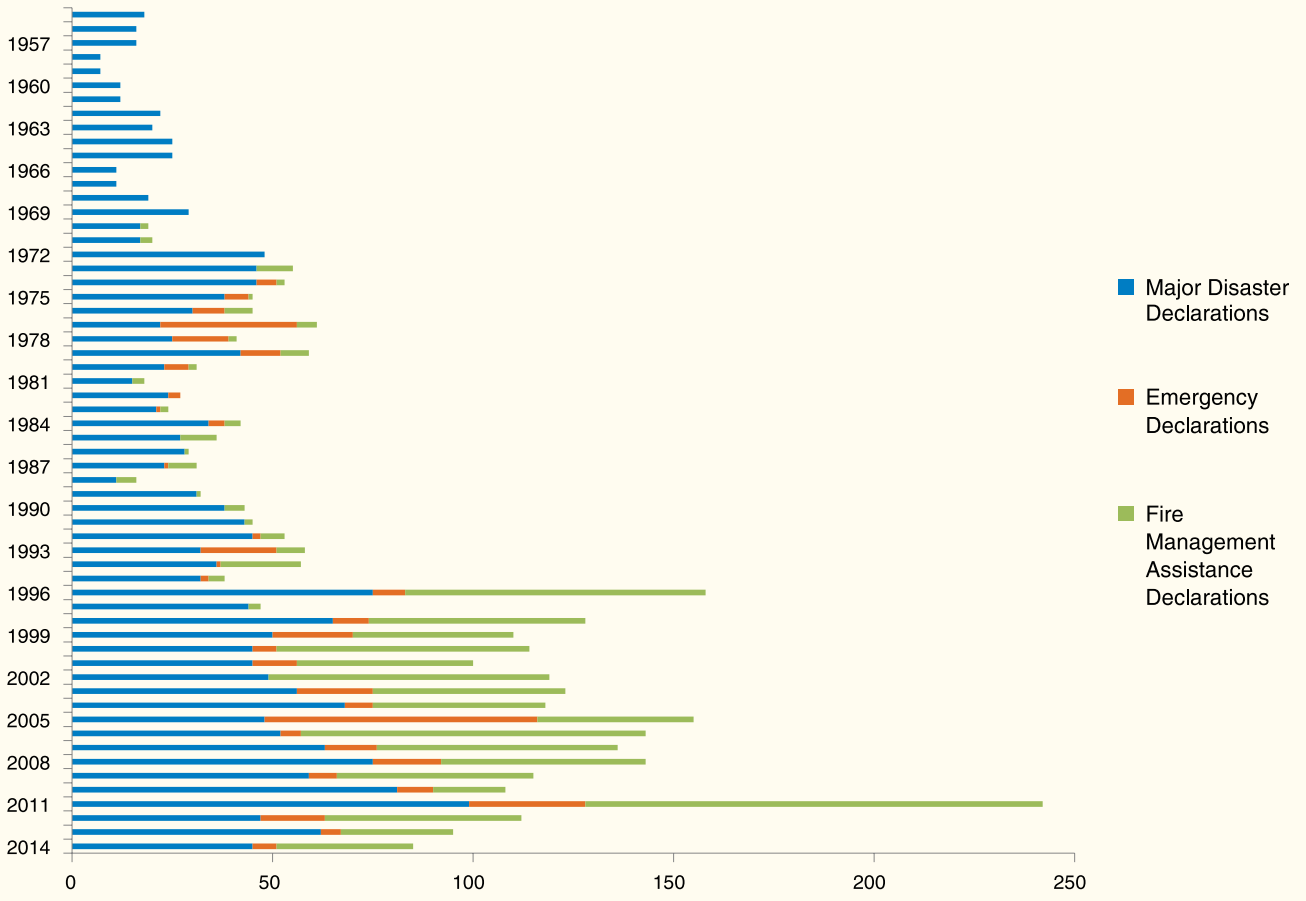
responsible for the highest number of billion-dollar disasters since 1980, followed distantly by hurricanes and tropical depressions, drought, and flooding.[5] Data from the Insurance Information Institute again parallel NOAA's data, finding that 8 of the 10 catastrophes with the highest estimated insured property losses (excluding flood damage insured by NFIP) happened since 2000. Except for the terrorist attacks of September 11, 2001, these are all weather-related events — primarily hurricanes.

National Weather Service data indicate that the number of fatalities attributable to extreme weather reached an average of 640 in the 10 years from 2004 to 2013 compared with 594 fatalities for the 25-year average dating back to 1989, with Hurricane Katrina in 2005 and tornado deaths in 2011 (including Alabama and Joplin, Missouri) accounting for most of the increase. However, it is notable that extreme temperatures caused several of the most deadly natural disasters reported since 1980, and these events were more frequent in the 1980s and 1990s, when assistance systems for heat waves were less well developed.[6] PreventionWeb, a project of the United Nations Office for Disaster Risk Reduction, finds that 6 of the 10 events affecting the most U.S. residents between 1980 and 2010 occurred in the 2000s, led by floods in 2008 (11 million) and storms in 2004 (5 million).[7]

One important contributor to the growing impact of damage caused by disasters is rapid population growth in U.S. coastal regions, which has substantially outpaced that of inland areas; as of 2010, 39 percent of Americans lived in coastal shoreline counties, which had an average population density (excluding Alaskan counties) of 446 persons per square mile, more than 4 times that of the nation as a whole.[8] NOAA projects that this trend will continue, with population densities in coastal shoreline counties growing at triple the rate for the United States as a whole from 2010 to 2020.[9] Even as natural disasters become more frequent, more Americans are living in places that put them at higher risk.

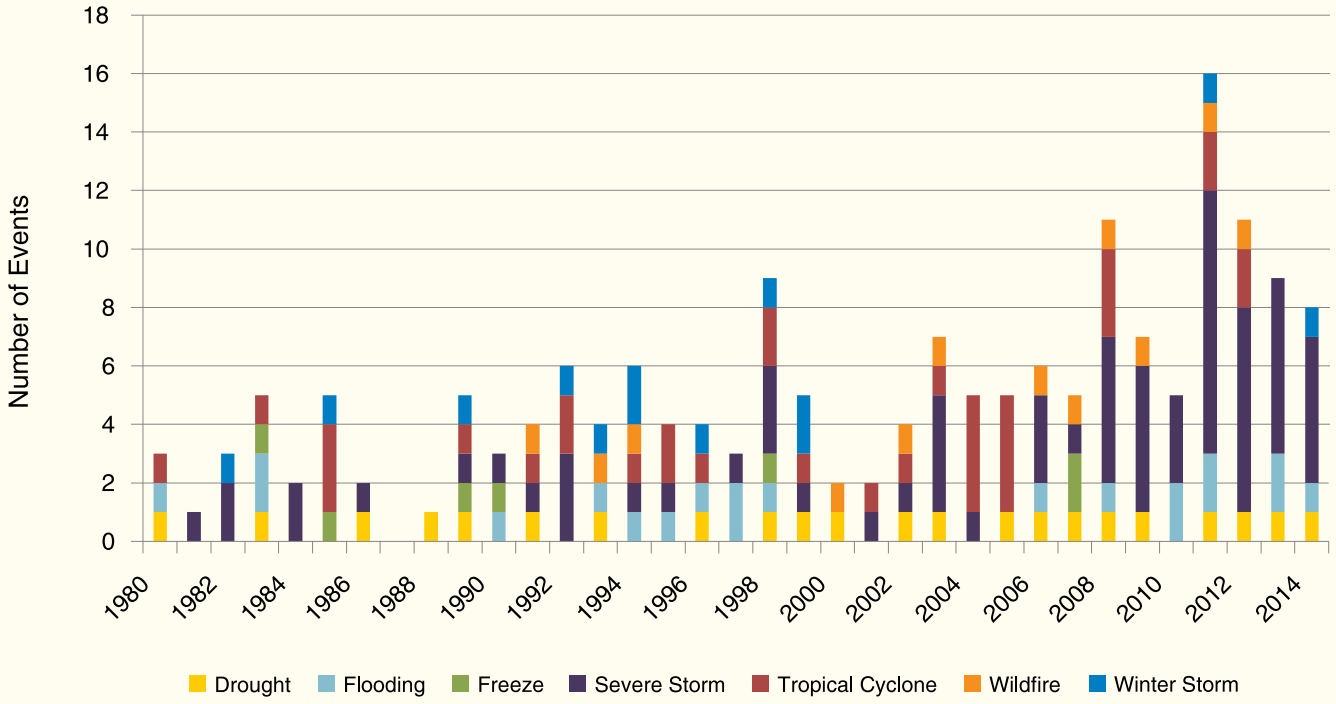
Although this article focuses primarily on natural disasters in the United States, global statistics also show increasing losses from disasters. EM-DAT, a worldwide database on disasters

Figure 1. Federal Disaster Declarations, 1955–2014



Source: U.S. Federal Emergency Management Agency. "Disaster Declarations by Year" **(www.fema.gov/disasters/grid/year)**. Accessed 6 February 2015.

Figure 2. Billion-Dollar Disaster Events by Type, 1980–2014



Recreated with permission from the National Climatic Data Center.
Source: National Climatic Data Center. "Billion-Dollar Weather and Climate Disasters: Time Series" **(www.ncdc.noaa.gov/billions/time-series)**. Accessed 6 February 2015.

funded by the U.S. Agency for International Development and maintained by the Centre for Research on the Epidemiology of Disasters at the Université catholique de Louvain, shows a substantial increase in the number of disasters worldwide reported annually between 1990 and 2013.[10] Researchers from the Centre note that "[o]ver the last decade, China, the United States, Indonesia, The Philippines, and India constitute the top 5 countries that are most frequently hit by natural disasters."[11] And just as low-income individuals in the United States are at greater risk of being affected by disaster and have fewer resources to recover, those in developing countries are especially vulnerable. The World Bank states, "By 2030, there could be 325 million people trapped in poverty and vulnerable to weather-related events in sub-Saharan Africa and South Asia. Large coastal cities, many of them in growing, middle-income nations, could face combined annual losses of US$1 trillion from such events by mid-century."[12]

Disaster Resilience and Mitigation

Even as projections of climate change and disaster frequency continue to evolve, many kinds of practitioners at the local, regional, and state levels — from planners and developers to emergency managers and insurers, among many others — are tasked with adapting to these changing environmental conditions and increasingly extreme weather events in an effort to prevent disasters when possible, mitigate the damage caused when disasters are unavoidable, and help communities and regions bounce back from disasters more quickly. One important concept increasingly used to capture this process is resilience (see "Federal Disaster Policy: Toward a More Resilient Future," p. 1). Resilience has gained prominence as a framework for measuring the capacity of systems, including cities and regions, to bounce back from shocks of many kinds, from long-term economic events such as deindustrialization or the foreclosure crisis to immediate shocks such as natural disasters.

In the context of disasters, the concept of resilience overlaps other concepts such as hazard mitigation and disaster resistance. Tierney and Bruneau, researchers who each direct university centers related to natural hazards, state that disaster resistance "emphasizes the importance of predisaster mitigation measures that enhance the performance of structures, infrastructure elements, and institutions in reducing losses from a disaster," whereas resilience "reflects a concern for improving the capacity of physical and human systems to respond to and recover from extreme events."[13] Although the authors associate mitigation with

disaster resistance in this definition, mitigation also plays a crucial role in resilience. Tierney and Bruneau are members of a national research team affiliated with the Multidisciplinary Center for Earthquake Engineering Research (MCEER) at the University of Buffalo that is tasked with defining and developing metrics for assessing disaster resilience, which they defined as "the ability of social units (e.g., organizations, communities) to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future disasters."[14]

The MCEER team developed the R4 resilience framework, which posits that resilience is determined by four attributes:

- **Robustness**, "the ability…to withstand disaster forces without significant degradation or loss of performance";
- **Redundancy**, "the extent to which systems…are substitutable, that is, capable of satisfying functional requirements, if significant degradation or loss of functionality occurs";
- **Resourcefulness**, "the ability to diagnose and prioritize problems and to initiate solutions by identifying and mobilizing…resources"; and
- **Rapidity**, "the capacity to restore functionality in a timely way, containing losses and avoiding disruptions."[15]

As defined by Tierney and Bruneau, resilience can be exhibited both inherently, in a system's ability to function well under normal circumstances, and adaptively, in how it shows flexibility in and following disaster conditions. The researchers contend that policymakers need to invest in bolstering these four components of resilience, which would require a combination of mitigation strategies and better developed organizational, community, and coping capacities.[16]

The R4 resilience framework and other similar efforts to categorize disaster resilience are the focus of many academics and practitioners, particularly planners, who are developing best practice guidelines for hazard mitigation strategies that improve resilience. For example, David Godschalk, professor emeritus at the University of North Carolina's Department of City and Regional Planning, examines the tools available to local planners and other local officials to create a vision for safe growth that takes hazards into consideration. Godschalk's Safe Growth Audit asks questions pertaining to elements of a community's comprehensive plan, including land use, transportation, environmental management, and public safety. The audit also considers the role of zoning ordinances, subdivision regulations, capital improvement program and infrastructure policies as well as alignment with other local codes and strategies.[17] Many of these questions touch on the robustness, redundancy, resourcefulness, and rapidity of local systems. The ultimate goal of the audit is to give policymakers the information they need to limit the development of areas known to be at high risk of hazards, minimize the degree to which hazards affect already developed areas, and make existing structures more hazard resistant.[18]

Godschalk's work is featured in *Hazard Mitigation: Integrating Best Practices into Planning*, a FEMA-funded guide edited and primarily written by mitigation expert James C. Schwab, manager of the American Planning Association's Hazard Planning Research Center. The guide looks at the central role of planners in visioning and goal setting to ensure safe, resilient development while also noting the need to partner with other local officials such as city managers, planning commissioners, emergency managers, fire and police officials, and transportation planners and engineers throughout the planning process.[19] Schwab and Kenneth Topping, lecturer in the City and Regional Planning Department at California Polytechnic State University and president of Topping Associates International, argue that local mitigation plans, which have been institutionalized by the Disaster Mitigation Act of 2000, need to be better integrated with both local comprehensive plans and state-level mitigation plans; they also state that hazard mitigation elements should be included in area plans, functional plans, and operational plans.[20] Throughout the guide, Schwab and his coauthors advocate that policymakers should engage in consistent, proactive outreach to a range of stakeholders, including community members.

Some research has shown that mitigation activities and other efforts at developing disaster- and climate-resilient infrastructure yield long-term economic savings in addition to benefits such as increased public safety and community well-being, but they do typically require higher upfront costs. For example, according to the World Bank, building structures "back better" during postdisaster reconstruction often costs between 10 and 50 percent more than simply replacing the structures as originally built — and when populations need to be relocated from locations that cannot be made sufficiently resilient, the social and economic costs can be much higher.[21] Nevertheless, the World Bank argues that, given the high worldwide risk posed by increasingly frequent and costly disasters, "it is important to ultimately strengthen all aspects of climate and disaster resilient development, including coordinating institutions, risk identification and reduction, preparedness, financial and social protection, and resilient reconstruction."[22] The World Bank also discusses the financing mechanisms it uses to help fund resilient development programs while also keeping in mind the importance of strong communities: "We know that communities with strong social bonds are more resilient when disaster strikes as neighbors are the first

responders and can help each other in the process of reconstruction."[23]

Cultural Capital and Resilience

The strength of social bonds within communities is a critical component of disaster resilience that is sometimes overlooked in resilience frameworks because it can be difficult to measure. Cultural capital — the social bonds that build and sustain community trust, improve communication, and bolster local responses to shocks — is related to other sociological concepts such as neighborhood effects and collective efficacy. Research has found that "loose" ties that bring community members together outside the more intensive confines of such organizations as churches, clubs, boards, or industry groups promote greater resilience by generating bridging relationships between larger and more diverse segments of the community.[24]

A sad case study that illustrates how communities that lack cultural capital exhibit less resilience in the face of disaster is the July 1995 heat wave that killed more than 700 Chicago residents over the course of a week. As New York University sociologist Eric Klinenberg writes in *Heatwave*, "[P]ublic health scholars have established that the proportional death toll from the heat wave in Chicago has no equal in the record of U.S. heat disasters."[25] Other meteorologists and epidemiologists confirmed through historical research and data models that the extremity of the heat wave could only partly explain the high mortality rate; additional social factors played a key role.[26] After extensive fieldwork, Klinenberg concludes that increased social isolation (especially among older residents), exacerbated by ineffective governmental services and extreme economic inequality that created some neighborhoods where residents were wary of assisting neighbors, was a primary reason why the heat wave was so disastrous.[27] Subsequent Chicago heat waves of similar intensity were far less deadly, likely because city services and nonprofit organizations were better able to actively aid vulnerable residents and community members better understood the necessity of checking up on their neighbors.[28] The continuing development of technical solutions — ranging from building-scale solutions that reduce internal temperatures to neighborhood- or city-scale programs such as smart grid technologies that reduce the risk of blackouts — has also helped reduce fatalities in heat waves nationwide.

Just as limited cultural capital can hinder resiliency to disasters, communities exhibiting stronger community capital often bounce back more quickly and make lasting changes that reduce future risk. A number of communities have empowered their residents to contribute their perspectives to disaster mitigation and recovery plans and bolstered their resilience in the process (see "Preparing for the Next Disaster: Three Models of Building Resilient Communities," p. 19). Cultural capital, like many other components of the research underpinning disaster resilience, is itself a complex topic. But when considered alongside other physical and social elements of resiliency, such as infrastructure and economic indicators, cultural capital provides a more complete picture of the factors that make some communities more resilient than others.

Conclusion

Given the concept's interdisciplinary nature and relative newness, the frameworks and definitions for resilience will continue to evolve. Natural disaster data, however, clearly illustrate the need to emphasize disaster-resilient development, and the ongoing work of planning experts is ensuring that best practices for resilience are shared widely and tailored to local conditions. Only by merging large-scale research into the scale and frequency of natural disasters with local practice that is mindful of community needs and social connections can U.S. communities best prepare themselves for future weather- and climate-related challenges. EM

— Keith Fudge, *HUD Staff*

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Preparing for the Next Disaster: Three Models of Building Resilient Communities

Highlights

- The San Francisco Bay area responded to a major 1989 earthquake by retrofitting the region's lifeline infrastructure and housing stock so it could rebound more quickly and easily from future disasters.
- After a devastating 1997 flood in Grand Forks, North Dakota, the city developed flood mitigation infrastructure like greenways and shifted downtown development away from the river; these adaptations made a 2006 flood much less costly.
- Greensburg, Kansas focused on sustainability as it rebuilt following a 2007 tornado, lowering the long-term operational costs of buildings and creating other economic benefits, such as energy production from wind turbines.

Cities throughout the United States are vulnerable to destructive events — such as wildfires, droughts, tornadoes, hurricanes, earthquakes, and rising sea levels — that risk millions of lives and trillions of dollars in assets.[1] More than 20,000 U.S. communities are in flood-prone areas, containing an estimated 6 to 9 million residential and commercial buildings, and an estimated 16.4 million people live in coastal floodplains.[2] Over the next four decades, $7.4 trillion in assets in the Northeast alone could be affected by rising sea levels.[3] In California, experts estimate a 99 percent probability that the state will experience an earthquake with a magnitude of 6.7 or greater during the next 30 years.[4] To not only recover from immediate disasters but also prepare for potential calamities, many communities are embracing a resilience framework that allows them to develop in a way that can better withstand future stresses.[5]

Having weathered their own catastrophes, three communities — the San Francisco-Oakland region in California; Grand Forks, North Dakota; and Greensburg, Kansas — provide valuable lessons for developing an approach to resilience that is based on consensus and an understanding of the complexities of local conditions. San Francisco-Oakland is enhancing the earthquake resilience of the regional economy by strengthening key physical infrastructure, particularly its transportation systems and housing. Following a flood, Grand Forks revamped its flood mitigation system and redeveloped its declining downtown. Finally, Greensburg, which was destroyed by a tornado, decided to rebuild as a model of sustainable rural development, demonstrating that resilient communities can derive value from disruptive events.[6] During their respective recoveries, these communities worked to mitigate future uncertainties and build better places to live.

Regional Earthquake Resilience: San Francisco Bay Area

The 6.9 magnitude Loma Prieta earthquake struck on the afternoon of October 17, 1989, with an epicenter 60 miles southeast of San Francisco and 9 miles north of Santa Cruz. The earthquake caused 63 deaths, 3,757 injuries, and an estimated $6 to $10 billion in property damage. Perhaps most frightening was the failure of the region's freeways; the Cypress Street Viaduct, a section of the bilevel Nimitz Freeway in Oakland, collapsed, crushing motorists on the lower level. The Embarcadero Freeway, Central Avenue Freeway, and San Francisco-Oakland Bay Bridge also suffered damage.[7] If the next earthquake were centered closer to the Bay Area, it could inflict as much as $17 to $54 billion in damage.[8]

Earthquake resilience, therefore, is crucial to San Francisco's future. The city's approach focuses on two objectives: first, seismic retrofits to individual buildings and structures are designed to limit the number of casualties and damage that immediately result from earthquakes, and second, seismic retrofits target "lifelines" to limit the long-term damage to the regional economy by

H.G. Wilshire/U.S. Geological Survey

The upper deck of the Cypress Street Viaduct sheared off of its support columns and collapsed onto the lower deck. The soft soil around the viaduct's foundation amplified shaking, contributing to its collapse.

J.K. Nakata / U.S. Geological Survey

Soft story buildings are vulnerable to collapse because of their weakened ground floor support, often due to garage doors or large storefront windows.

stemming population loss and facilitating a quick return to normal.[9] Lifelines are important infrastructure systems, such as transportation networks, that other systems and the regional economy depend on to function properly. The failure of one lifeline can cause repercussions in other systems.[10] Patrick Otellini, San Francisco's chief resilience officer, states that San Francisco is "trying to build a city that can withstand the shocks and stresses" of an earthquake. "It's about thriving after a disaster, not just surviving."[11]

Transportation Lessons From Loma Prieta

Loma Prieta exposed many of the physical and operational vulnerabilities of the Bay Area's transportation system. The earthquake damaged freeways, bridges, and other structures. Although the amount of damage a community experiences from an earthquake depends on its distance from the epicenter, the composition of the soil on which the community's structures are built is also a factor. Certain soil compositions can amplify seismic waves and undermine foundations through liquefaction, a process that turns the ground into a water-soil mixture similar to quicksand, or other forms of ground failure.[12] The Cypress Street Viaduct, a section of the Nimitz Freeway, collapsed because the soft mud it stood on amplified the shaking, causing the upper deck of the viaduct to shear off its support columns and fall onto the lower deck. Columns in other parts of the viaduct also broke apart and collapsed.[13]

According to Tom Shantz of the California Department of Transportation (Caltrans), Loma Prieta demonstrated that engineers cannot "overpower earthquakes" with extremely rigid bridges and freeways. Because predicting how the ground will react during an earthquake is so difficult, bridges and elevated freeways are now built to absorb greater stress by keeping their foundations and superstructures elastic.[14] To upgrade the state's freeway and bridge network after Loma Prieta, Caltrans established the Seismic Retrofit Program. Through the program, more than 2,200 bridges in need of retrofits were identified and $12 billion was spent to seismically upgrade them.[15] Over a 25-year period, Caltrans completely "rebuilt the whole freeway system in San Francisco," says Shantz.[16]

Loma Prieta also demonstrated the value of San Francisco-Oakland's multimodal transportation network and the consequences if it were to fail. San Francisco connects with Oakland through two major routes: the Transbay Tube, which carries the regional rail lines for Bay Area Rapid Transit (BART), and the San Francisco-Oakland Bay Bridge. With the Bay Bridge closed due to Loma Prieta, residents were able to shift to alternate modes of transportation such as the regional rail system and ferries, which limited long-term disruption of the economy. Within a week of the disaster, BART's ridership increased by 124,000, reaching a weekday average of 342,000 riders. Most new commuters used BART's Transbay Tube, which saw an increase of 117,000 new daily riders. In total, 40 percent of automobile users switched to transit during the early recovery period, facilitating a speedy return to normal life.[17]

Although the Bay Area's multimodal system was able to cope with service disruptions during Loma Prieta, the system does have limitations. During 2014, BART averaged 399,000 weekday riders, nearly double its weekday ridership in 1989. With the system near capacity, the BART system would be seriously pressed if it were required to accommodate displaced Bay Bridge car commuters as it did in 1989.[18] The ferry service could provide additional capacity, but it is limited by the number of docking sites. If both the Bay Bridge and the Transbay Tube were destroyed or even temporarily out of service, the effects on the Bay Area's economy and quality of life would be both significant and detrimental.[19] To try to prevent this calamity, the Bay Bridge and Transbay Tube were seismically upgraded. The West Span of the bridge was strengthened and retrofitted to allow greater movement during an earthquake.[20] The East Span was completely replaced with a new bridge that is engineered to last 150 years and resist an earthquake that occurs once every 1,500 years.[21] The Transbay Tube received seismic retrofitting through BART's Earthquake Safety Program, which is also upgrading older tracks, stations, power stations, and the Berkeley Hills Tunnel through a $1.2 billion (2004 dollars) effort. Work to secure the interior and exterior of the Transbay Tube, which is still vulnerable to flooding, is ongoing and may take an additional seven to nine years.[22]

Making Homes and Buildings Resilient

Most of Loma Prieta's casualties resulted from the failure of buildings and other structures.[23] According to Laurie Johnson, task force member and contributing author for SPUR's Resilient City initiative, "The damage in the central Bay Area was in pockets with older, vulnerable structures and on soils vulnerable to shaking."[24] Strengthening vulnerable homes and other buildings is a critical component of San Francisco's earthquake resilience strategy because one determinant of a community's short- and long-term recovery following an earthquake is the number of residents that remain. SPUR estimates that about 75 percent of the city's current housing stock will provide adequate shelter following an earthquake. This standard, known as "sheltering in place," allows residents to remain in their buildings while they are being repaired. For San Francisco to be resilient, SPUR estimates that 95 percent of the city's residents need to be able to shelter in place.[25]

San Francisco is retrofitting its housing stock through the Earthquake Safety Implementation Program (ESIP), a 30-year program designed to ensure that buildings remain habitable following an earthquake. It includes a mix of market incentives and mandatory building compliance measures to limit the damage caused by an earthquake. ESIP is the culmination of recommendations proposed in the Community Action Plan for Seismic Safety (CAPSS), a nine-year citywide planning effort that analyzed the impact of four potential earthquake scenarios and elicited citizen input and expert advice on how to respond.[26] "It's the community telling us what they are concerned about," explains Otellini, "and us developing those policy fixes in conjunction with them."[27] The CAPSS recommendations were adopted in 2010 and divided into three phases, with the first phase running through 2015.[28]

In 2013, San Francisco's mayor signed into law the Mandatory Soft Story

The newly reconstructed eastern span of the San Francisco-Oakland Bay Bridge uses hinge pipe beams that absorb seismic energy during an earthquake to protect the rest of the bridge. Damaged beams can be replaced following the earthquake.

As Grand Forks officials charted a path to recovery, they embraced a flood management system that made the city more resilient to flooding and more livable.

Retrofit Ordinance and, to enforce the ordinance, instituted the Mandatory Wood Frame Retrofit program, a key recommendation of CAPSS and a "major accomplishment," according to Johnson.[29] The law requires seismic upgrades for soft story wood-frame buildings with three or more stories and five or more units that were built before building codes changed in 1978. Soft story buildings have large openings on the ground floor such as garage doors that weaken the building's support, making it susceptible to collapse.[30] Based on a recent ESIP analysis, about 4,800 buildings housing more than 100,000 people need soft story upgrades. Retrofits through both the mandatory program and a voluntary program being operated in tandem include adding shear walls and steel bracing to reduce shaking and lessen the probability of collapse to one percent.[31] To help building owners pay for the upgrades, San Francisco worked with 25 different private lenders and created a public financing option available through the city's GreenFinanceSF initiative.[32]

Although retrofits can be expensive, costing an estimated $60,000 to $120,000 per building, the program actually protects the city's affordability because many of these units are in rent-controlled buildings.[33] If these buildings collapsed, residents might be forced to leave the city to find affordable housing. Over the long term, damaged affordable units are returned to the market at a slow rate; for example, it took 7 to 10 years to recover the affordable housing lost during the Loma Prieta earthquake.[34] Rent-controlled units in buildings that collapse may also be permanently lost. In San Francisco, units in a newly constructed building on the same parcel of land are not subject to the rent control requirements of the units in the previous building.[35]

Coordinating Future Actions

Addressing the Bay Area's remaining vulnerabilities "requires an ongoing commitment" and "a culture of preparedness," says Johnson. Following Loma Prieta, she explains, "people and organizations were committed to fixing problems…but that [commitment] can taper off as time goes by."[36] Despite making impressive strides toward improving the resilience of its transportation infrastructure and housing stock, San Francisco has several remaining structural weak spots. One top concern is the Embarcadero seawall, which protects the waterfront from the bay. The seawall was built in many layers over the past 100 years and is seismically vulnerable.[37] Several major infrastructure lifelines, such as power, wastewater, and water services, and the Transbay Tube pass through the seawall. A failure of the seawall could flood the downtown area, inflict significant damage on adjacent streets, and impact fire suppression if water supplies were cut.[38] Responsibility for the seawall and other remaining retrofit projects is shared among a number of stakeholders: state and local government, private and public utilities, local businesses, and residents. For example, BART worked with Caltrans and the California Seismic Safety Commission to design enhancements to the Transbay Tube.[39] San Francisco is completing a vulnerability study of the seawall to determine recommendations for retrofits and future actions that may affect residents and businesses along the waterfront and downtown areas, the San Francisco Municipal Transportation Agency, and BART.[40] According to Otellini, Bay Area governments are coordinating their actions to ensure that local resilience initiatives promote the resilience of the entire region. "The next big step," says Otellini, "is working together as a region and acting regionally to make ourselves more resilient in the face of a disaster."[41]

Recovery and Resilience in a Mid-Sized City: Grand Forks

On April 21, 1997, the Red River of the North crested at just over 54 feet, 5 feet higher than earlier predictions and the height of the levees protecting Grand Forks. An above-average snowfall the previous winter led to excess snowmelt in the spring, flooding 75 percent of Grand Forks. The flood destroyed 9,000 homes and 751 commercial buildings. While the floodwaters inundated homes, a fire raged downtown, burning 11 historic buildings and 60 apartment units beyond repair. No drinking water was available for three weeks, and it took nearly a month for the water level to recede to the point that devastated residents could survey the damage to their homes and community, estimated at $3.5 billion (1997 dollars).[42] As Grand Forks officials charted a path to recovery, they embraced a flood management system that made the city more resilient to flooding and more livable. Adopting an approach similar to the Netherlands' Living with Water paradigm (see "A Dutch Approach to Flood Resilience," p. 24), Grand Forks has built a flexible flood mitigation system that can accommodate and withstand floodwaters while limiting potential damage.

Flood Mitigation Efforts and the Greenway

In the 17 years since the flood, Grand Forks has implemented a range of flood mitigation strategies. Eight miles of levees were built to protect the city's downtown from the river. The

levees are 10 feet wide to withstand the pressure of hundreds of thousands of gallons of water and have a 60-foot river gage that measures 6 feet beyond the 1997 flood crest. To reduce the water load on the levees, Grand Forks installed a 9.5-mile English Coulee diversion channel that redirects floodwater around the city and away from the downtown area. The city also built 12 new pumping stations, the largest of which can move 112,000 gallons of floodwater per minute. These flood protection measures, in conjunction with mitigation efforts in East Grand Forks, will protect the cities from a flood that occurs once every 250 years.[43]

The centerpiece of Grand Forks' flood mitigation system is the Greenway, 2,200 acres of parkland between the dike system and the river. With higher dikes, Grand Forks can resist more water than before. The Greenway increases the protection of the dikes by creating additional floodwater capacity. Instead of the river inundating vulnerable low-lying neighborhoods, it harmlessly floods parkland that retains its primary function when the water recedes. When the water level is low, Grand Forks residents have access to 20 miles of recreational land for camping, fishing, picnicking, golfing, and the annual Grand Cities Art Fest.[44]

The Greenway was built on land that flooded in 1997 with funding from the Community Development Block Grant program and Federal Emergency Management Agency's (FEMA's) Hazard Mitigation Grant Program. The city bought 850 homes in neighborhoods in the floodplain through a voluntary program. In total, the city acquired and demolished nearly 1,000 homes and 500 other structures.[45] To increase citizen support for the buyout program, Grand Forks officials took steps to improve the transparency and efficiency of the program. The city met regularly with affected residents, used local home assessors, and determined the value of the homes based on prices from before the flood. Also, officials from the city and federal agencies (HUD, FEMA, the U.S. Small Business Administration, and the U.S. Environmental Protection Agency) collaborated to more efficiently coordinate their agencies' activities, further expediting the process.[46]

According to Tom Dennis, opinion editor at the *Grand Forks Herald*, the Greenway helped "unite different factions during the early planning and recovery phase" because residents saw that the Greenway would be "such an obvious benefit to the community." Resident enthusiasm for the Greenway, in a positive self-reinforcing cycle, encouraged

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FEMA/Brenda Riskey/UND

The centerpiece of Grand Forks' new flood protection system is the Greenway, parkland between the river and the new dike system that can be safely flooded during periods of high water and used as recreation space at other times.

A Dutch Approach to Flood Resilience

Municipality of Nijmegen/Room fort the river Waal

Although a dramatic change in the urban fabric of Nijmegen, the new flood resilience measures shown in this rendering will protect the city against a flood that occurs once every 1,250 years.

At a narrow bend in the Waal River in the Netherlands, the city of Nijmegen is reducing its flood risk by widening the floodplain of the river and adding a diversion channel. These flood mitigation measures are part of the Room for the River program, a nearly $3 billion effort that seeks to restore natural floodplains on Dutch rivers away from the places where people live and work.[1] With nearly 60 percent of the country susceptible to coastal and river flooding, including the major cities of Amsterdam, Rotterdam, Utrecht, and The Hague, flood protection is always at the forefront of Dutch thinking.[2] A worst-case scenario flood could inundate half of the Netherlands, affecting 10 million people and inflicting more than $200 billion in damage.[3] Room for the River, which started in 2007 and is expected to be completed by 2016, restores natural "water sponges," such as marshes and wetlands, to increase floodwater storage capacity. These restoration projects also improve the biodiversity of rivers and enhance their aesthetic and recreational value. Other mitigation efforts include lowering floodplains, relocating dykes further inland, removing river obstacles, and deepening riverbeds.[4]

At $460 million, the project at Nijmegen is largest and most expensive of the 39 Room for the River projects completed or ongoing in the Netherlands.[5] The dike on the north side of the Waal River will be moved inland 350 meters, reducing the high-water level of the river by 13 inches. The new diversion channel, once completed, will be 3 kilometers long and 200 meters wide and create an island in the Waal River. Placed at a bottleneck in the river, the diversion channel will prevent flooding by allowing water to flow more freely when the water volume of the river increases. Local officials seized on the potential of the newly created island to build a new riverfront park and add new bicycle and pedestrian paths along the dike and on bridges connecting the island to the mainland. Along the shore, Nijmegen is rejuvenating the waterfront by adding new housing and a quay, which is a paved walkway that runs along the edge of the shore and gradually slopes down toward the water.[6]

In addition to improving Nijmegen's quality of life, these flood protection measures offer greater long-term benefits than cheaper measures such as simply deepening the riverbed, which Room for the River officials estimated would have sufficed for only 10 to 20 years and still would have required relocating the dike. Including a diversion channel, on the other hand, should protect the city for the next 100 years.[7] When first introduced, the plan encountered stiff opposition because it called for the elimination of 50 homes in the established village of Lent, which is part of the municipality of Nijmegen. The city offered displaced residents compensation and land in other parts of the city, which helped soothe opposition, and involved residents in designing improvements to the waterfront. Through negotiations and collaboration with stakeholders, including 19 local, regional, and national organizations involved with developing or implementing parts of the overall project, the officials were able to address many residential concerns and build strong support for the final plan.[8]

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[2] Netherlands Environmental Assessment Agency. "Correction wording flood risks for the Netherlands in IPCC report" **(www.pbl.nl/en/dossiers/Climatechange/content/correction-wording-flood-risks)**. Accessed 28 January 2015.

[3] Ruimte Voor De Rivier Programme. 2012. "Room for the River Brochure: From higher dykes to river widening," 5 **(www.ruimtevoorderivier.nl/english/publications/)**. Accessed 28 January 2015.

[4] Ruimte Voor De Rivier Programme, "Room for the River Factsheet."

[5] P. Nijssen and M. Schouten. 2012. "Dutch national Room for the River project: Integrated approach for river safety and urban development," Integrative Sciences and Sustainable Development of Rivers conference.

[6] Flood ResilienCity. "The Room for the River Project at Nijmegen" **(www.floodresiliencity.eu/frc-output/133/1-the-room-for-the-river-project-at-nijmegen)**. Accessed 2 December 2014; Ruimte voor de Waal Nijmegen. "Room for the Waal" **(www.ruimtevoordewaal.nl/en/room-for-the-river-waal/)**. Accessed 2 December 2014; Ruimte voor de Waal Nijmegen. "Room for the Waal English Brochure" **(www.ruimtevoordewaal.nl/getFile.ashx?fileID=90&type=original)**. Accessed 28 January 2015; Pim Nijssen. 2012. "Integrated approach for river safety and urban development," presentation at Dutch National Room for the River Programme conference.

[7] European Climate Adaptation Platform. "Room for the River Waal – protecting the city of Nijmegen (2016)" **(climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=3332)**. Accessed 28 January 2015.

[8] Nijssen 2012; ClimateWire. 2012. "How the Dutch Make 'Room for the River' by Redesigning Cities," *Scientific American digital,* 20 January. Accessed 28 January 2015.

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leaders to add more amenities, which increased residential support. Although residents might have been interested in pursuing a project such as the Greenway before the flood, "it was only after the flood that people saw it as obtainable," says Dennis.[47] All of these actions — working with residents, quickly administering funds, and adding amenities — increased public support for the buyout program and the Greenway.

The success of Grand Forks' flood management system has influenced other riverfront communities. In 2008, the Cedar River flooded and destroyed much of downtown Cedar Rapids, Iowa. In response, the town learned from and adapted Grand Forks' flood mitigation system, including building a floodable greenway.[48] Then, in 2012, the city, county, and state agreed to create an innovative financing mechanism, the Growth Reinvestment Initiative (GRI), to fund Cedar Rapids' Flood Mitigation Program (FMP). GRI returns a portion of the increase in revenues from Linn County's $0.06 sales tax to the city. GRI is expected to raise $264 million over 20 years to cover 46 percent of FMP's cost for 6.24 miles of permanent and removable levees and floodwalls, 11 pump stations, and improvements to a flood-prone bridge, among other actions.[49]

Rebuilding Downtown

Grand Forks used the recovery as an opportunity to rebuild its downtown. Before the flood, new development was occurring outside of the downtown and on the suburban fringe, following a pattern similar to that of other cities across the United States.[50] In the 1970s, the city tried to attract new investment to its downtown with a suburban-style mall, but the mall's eventual failure ended up contributing to downtown blight. The mall was partially damaged during the 1997 flood, and in response, Grand Forks officials tore it down and restored the original street grid.[51] Using $28 million in Community Development Block Grant Disaster Recovery program funds, the city rebuilt the central business district, which was declared a historic district in 2005, and created an open-air plaza.[52] Downtown businesses also received grants for up to $230,000 to repair damaged buildings, and the city built a $16 million, 100,000-square-foot office complex.[53] In total, $280 million of federal disaster recovery money was invested in Grand Forks, including $49 million to help businesses recover.[54] After a slow start, private investment in the city's downtown increased in 2004 and continues today.[55]

The Greenway and other flood protection measures facilitated Grand Forks' recovery in two crucial ways. First, with the risk of future flooding high, Grand Forks had to rebuild in such a way that stakeholders would feel their investments, particularly in the downtown area, were protected.[56] Second, the Greenway, as one of Grand Forks' main amenities for recreation and tourism, helped anchor new development in the city's downtown.[57] According to Dennis, "It's on everyone's short list of attractions. Residents show it off to friends and relatives," and the city uses it to attract new businesses.[58] The city used its flood mitigation infrastructure to both protect and enhance the downtown. In recent years, Grand Forks' downtown has undergone a structural shift in its land use; its focus has shifted from predominantly retail uses to mixed uses such as offices for professional services, high-end and niche retail, restaurants, and housing.[59] From 1997 to 2007, Grand Forks added 2,907 housing units, including 1,922 townhomes and multifamily units. Grand Forks is now a growing community that has surpassed preflood population levels.[60]

Residents saw the flood as "the best thing and the worst thing" that happened to the city, says Dennis.[61] The destruction wrought by the Red River was heartrending for the victims, but through strong leadership; a bold vision for the future; and a comprehensive, consensus-based approach, Grand Forks is now stronger than before. Although some points of the recovery triggered heated debate,

FEMA/Michael Rieger

Floodgates help protect Grand Forks from rising water levels of the Red River.

FEMA/Greg Henshall (left); FEMA/Steve Zumwalt (right)

The town of Greensburg, Kansas was almost completely destroyed by an E5 tornado on May 4, 2007 (left). The rebuild that ensued transformed the town into a model of rural sustainability (right).

particularly the issue of where the levees would be placed, local, state (both North Dakota and Minnesota), and federal officials and residents supported the process. The 1997 flood, in addition to forcing residents to reevaluate their priorities, united disparate elements of the community; everyone understood the pressing need to protect the community and was willing to work together to increase the city's flood resilience.[62] Grand Forks has already seen the benefits of its flood mitigation strategies. The levees, pumping stations, and diversion channel spared the city from a flood in 2006 that was the third highest on record and crested only a few feet lower than the 1997 flood.[63]

A Model for Sustainable Rural Development: Greensburg, Kansas

On May 4, 2007, a tornado obliterated the small rural town of Greensburg, Kansas. The tornado tore a swath of destruction a mile and a half wide that demolished 90 to 95 percent of the buildings in the town; more than 500 homes, the hospital, local schools, grocery store, water tower, and municipal buildings were gone.[64] As the residents emerged from the rubble, they faced the crucial question of how the community should rebuild. Although some wished a return to pretornado normalcy, many remaining residents and leaders from the government, nonprofit, and the business communities gravitated toward the idea of transforming Greensburg into a model for rural sustainability. Local residents saw becoming a "green" town as an opportunity to both recover from the tornado and build a future that might otherwise have been beyond their reach.[65]

Greensburg, like many similar farming communities, was in decline. The town "had [experienced] a disaster before the tornado," explains Mayor Bob Dixson.[66] Agricultural employment was shrinking due to automation, and people left as job prospects declined. The town's population peaked in the 1960s with 1,988 residents and then dropped every year until it hit 1,378 in 2006.[67] The population was also growing older. The city's median age rose from 40.9 years to 45.6 years between 1990 and 2000, and the percentage of residents between the ages of 18 and 44 decreased from 30.4 percent in 1990 to 27 percent in 2000.[68]

Although the tornado eventually presented opportunities, simply recovering was a struggle. The cost of rebuilding exceeded the amount of insurance money that many residents received. Greensburg's housing stock was mostly older, built immediately after World War II. This made the town affordable — the median value of a home in 2000 was $46,500 — but meant that the value of a new, comparable home exceeded the old one.[69] These problems were exacerbated by Greensburg's remote location in the western plains of Kansas, more than 100 miles from Wichita, the closest city with a population greater than 100,000 people. Workers and supplies had to be brought in from neighboring towns, raising the cost of construction.[70]

Building Community Consensus

The tornado and cost of recovery caused nearly half of the town's population to leave. Although dramatic population loss is a setback for most communities, in Greensburg it had at least one positive outcome: most of the people who stayed were committed to sustainably rebuilding the community.[71] Sustainability, argues Daniel Wallach, founder of local nonprofit Greensburg GreenTown, is "building for the long term" in a way that does not "leave environmental debt."[72] Greensburg's small size made promoting sustainability easier because it fostered person-to-person interaction. "With the town gone, all we had were each other," explains Dixson. "You'd have a meeting and 500 residents would show up."

Residents and leaders were therefore able to talk directly to the each other about the benefits of sustainability and "discuss the long-term vision of the community," says Dixson.[73]

Local leaders partnered with outside experts to inform and educate residents on the financial benefits of sustainability. Residents participated in planning sessions to identify important community assets and a "distinct way of life in Greensburg."[74] This form of partnership and consensus building ensured that the information presented was not only high quality but also relevant and credible, which encouraged residents and leaders to buy into the plan. According to Daniel Wallach, "It's about making people aware that rebuilding in an optimally sustainable and resilient way is in their best interest. And that relates to the cost of ownership being much less in a well-built home, even if the front-end costs are more….We've found that between a 2- and 10-percent increase in upfront costs can affect 40 to 70 percent [of the cost of] heating and cooling."[75] The sustainable features added to residential structures allowed the town to reduce its overall energy consumption by about 42 percent. Wallach reports that many of those who rebuilt their homes without energy-efficient features regretted their decision after they saw the savings accruing to those with more efficient homes.[76]

The city eventually decided that all municipal buildings should be Leadership in Energy and Environmental Design (LEED) Platinum certified but allowed individuals to decide what made sense for them.[77] In a small town like Greensburg, Wallach states, it was possible to "empower people through education and information" about the benefits of sustainability.[78] Many in the business community were won over by the economics of efficiency. For example, Kelly and Michael Estes, owners of the local BTI-Greensburg John Deere dealership, constructed a new LEED Platinum certified dealership. According to Michael Estes, "As one of the major employers, we wanted to show leadership….LEED Platinum was the best and so that's what we wanted." The upfront costs for the upgrades, which included a wind turbine, a system for recycling waste oil, and high-efficiency lighting, will be paid back in approximately 7 to 10 years through utility savings.[79]

Making Greensburg Sustainable

Between 2007 and 2014, Greensburg added 28 sustainable buildings, including 5 LEED Platinum buildings, and rebuilt a walkable downtown core.[80] Branding the community as a model for sustainable construction helped Greensburg attract outside experts such as the National Renewable Energy Laboratory (NREL), which collaborated heavily with Greensburg GreenTown.[81] With NREL assistance, Greensburg GreenTown built a silo-shaped "green" house, the first of 12 eco-homes, as a demonstration project. The house, built from reclaimed materials, has a green roof, a rainwater catchment system, low-flow and dual-flush toilets, a solar water heater, and solar panels. The entire house acts as a safe room, able to withstand winds of up to 200 miles per hour because of its durable concrete construction, the absence of interior load-bearing walls, and circular shape, which reduces the buildup of air pressure during a tornado. The shape of the building also improves energy efficiency by reducing heat transfer to the outside.[82]

Outside groups also assisted Greensburg residents in developing a Sustainable Comprehensive Master Plan and a Long-Term Community Recovery Plan.[83] Two key elements of both documents are an understanding of the region's ecological assets and an emphasis on prudent stewardship of precious resources, principles that many residents saw as connecting the town to a pioneer past that demanded conservation for survival. With the town's average annual rainfall measuring only 22 inches, the success or failure of Greensburg's farming community often depends on the availability of water. Recognizing water's importance, the Sustainable Comprehensive Master Plan declares that one of the community's goals is to "treat each drop of water as a precious resource."[84] Water conservation efforts include rain gardens and rainwater collection systems, low-flow water fixtures, and native drought-resistant landscaping.[85]

The town also sought to turn wind from a destructive force into a tool for energy production, declaring in the Sustainable Comprehensive Master Plan that "Greensburg's vast wind resources are part of an emerging economy and should be harvested."[86] Many buildings, such as the 5.4.7 Arts Center and the local K–12 school, incorporate wind turbines on their property. The city funded a 12.5-megawatt wind farm outside of town built by John Deere Renewables that allows all of the city's energy to be generated by renewable sources.[87] "Many of these ideas were floating around the community," says Dixson, but the tornado provided the space and motivation to connect different sustainable ideas into a continuous and comprehensive approach.[88]

Between 2007 and 2014, Greensburg added 28 sustainable buildings, including 5 LEED Platinum buildings, and rebuilt a walkable downtown core.

Greensburg's long-term sustainability and resilience, however, will be determined

FEMA/Greg Henshall

Discussions of Greensburg's future included a literal big tent, where residents of the devastated town gathered to listen to plans and offer feedback.

by its population and economic growth. The town's population, at 888 in 2012, is still half of pretornado levels, but elementary school enrollment has risen slightly and the town's median age has decreased slightly. Employment and other financial indicators are similarly mixed. Although the town has a low unemployment rate (3.2% in 2012), as of 2014, an outside employer in the green industry has not located in Greensburg despite two manufacturers showing a strong interest.[89] According to Dixson, however, Greensburg has "seen local businesses diversify into sustainable fields. A great example is the local John Deere dealership, BTI-Greensburg," which began selling and servicing wind turbines and added solar panels to its portfolio of products.[90]

Conclusion

Developing and implementing a resilience framework that allows a community to withstand future stresses involves making numerous decisions that affect the community's physical, social, and economic environment. The process of becoming resilient, says Henk Ovink, senior advisor to the former Hurricane Sandy Rebuilding Task Force, requires "connecting all of the dots in regards to future uncertainty." Ovink advocates embracing the complexity of future uncertainties; by understanding the interconnected nature of policy decisions, policymakers can avoid "divert[ing] them into different subject matters or sectors with divided views."[91] For example, because transportation and housing are essential infrastructure components that drive the regional economy, the San Francisco-Oakland community's investments in housing and transportation resilience not only made those systems safer for residents but also increased the area's economic resilience.[92] In Grand Forks, officials and residents understood that water affects residents, downtown businesses, and farmers, among others. By developing a strategy that accounted for these interactions, these officials facilitated the recovery of Grand Fork's downtown and improved quality of life in the community. In Greensburg, residents' prudent stewardship of resources both lowered costs for homeowners and enhanced the community's ability to withstand climate change and face future uncertainties.

These communities have learned that building resilient homes and infrastructure reduces the cost of future disasters and uncertainties by limiting the amount of damage that disasters inflict. Grand Forks faced a costly flood in 1997 but a relatively cheap one in 2006, which was attributable in large part to the flood mitigation infrastructure the community built after 1997. In San Francisco-Oakland, retrofitting the region's lifeline infrastructure and housing stock will allow the region to recover significantly faster and with fewer lives lost than without these improvements. In Greensburg, linking resilience and sustainability has lowered the long-term operational costs of buildings and allowed the community to save money by conserving water and generating its own power.

In each community, resilience strategies were strengthened through a process that promoted consensus among residents and stakeholders, coordination of individual and institutional actions, and

an understanding of local assets and challenges. Deriving effective solutions involves "investing in all stakeholders… [who then] inform the plan through a consensus-building process," says Ovink. He argues that rather than simply agreeing to a particular strategy, residents should be active participants in crafting it, and design can drive such a comprehensive and inclusive approach.[93] Consensus among stakeholders and coordination among actors foster an understanding of the needs of the community and make implementation more practical. For example, San Francisco's major housing retrofit law grew out of recommendations from CAPSS, the city's 10-year citizen engagement effort. Grand Forks increased public support for the Greenway, as well as its scope and effectiveness, by actively soliciting resident input. In addition, Greensburg managed to get the entire town to discuss their ideas for the community's future, which made enacting the town's extensive sustainability measures possible. As Dixson says, "Don't do exactly what we've done, but have a process in place to do what you want and what works for you."[94]

These communities show that developing a resilience approach is a long-term, evolutionary process. San Francisco-Oakland is still working to seismically upgrade its infrastructure 25 years after Loma Prieta. "We've just learned a lot," explains Johnson. "It's taken lessons from other events."[95] Although major infrastructure elements such as the West Span of the Bay Bridge and Transbay Tube are stronger than ever, Johnson points out that they still could suffer damage during an earthquake. As a result, efforts to make the Bay Area's infrastructure systems more resilient are ongoing. Similarly, Grand Forks waited years to see the benefits of its postdisaster response and is still developing new strategies to make the Red River Valley region more resilient to floods.[96] And seven years after the tornado, Greensburg continues to work to become a sustainable, resilient community. A focus on long-term change is important and beneficial, argues Ovink, because "it gives the opportunity for a lot of stakeholders to actually start to own the new way of doing and to own the solutions."[97]

As innovation, research, and experience accumulate, San Francisco-Oakland, Grand Forks, and Greensburg demonstrate the importance of having the capacity to develop policies that integrate relevant ideas with local resources and energies in a way that controls the costs of future disasters. Having a framework that strives for long-term resilience helps these communities continually adopt solutions that effectively and efficiently adapt to future changes, challenges, and opportunities. EM

FEMA/Steve Zumwalt

Declaring its wind resources valuable, Greensburg built a wind farm to supply energy to homes and businesses, becoming a 100 percent renewable energy community.

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Additional Resources

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- "Resilient Communities: Empowering Older Adults in Disasters and Daily Life" (2014), by Lindsay Goldman et al., examines the experiences of older adults and their communities during Hurricane Sandy and applies a community resilience framework to make recommendations for ensuring that older adults are connected to and participating in support systems before a disaster occurs. **www.nyam.org/news/docs/pdf/Resilient_Communities_Report_Final.pdf**.
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- *U.S. Geological Survey Natural Hazards Science Strategy — Promoting the Safety, Security, and Economic Well-Being of the Nation* (2013), by Robert R. Holmes, et al., outlines a science-based strategy for improving national resilience to natural hazards. **pubs.usgs.gov/circ/1383f/**. Additionally, the U.S. Geological Survey website provides a wealth of information regarding natural hazards and vulnerabilities including those related to climate and land use change. **www.usgs.gov/natural_hazards/**.
- The Natural Hazards Center of the University of Colorado at Boulder's website contains a range of disaster-related resources, including the center's own research and publications as well as topically organized and annotated bibliographies. **www.colorado.edu/hazards/**.
- The Office of Policy Development and Research's Disaster Recovery Tool Kit hosts an array of relevant print and video disaster recovery resources. **www.huduser.org/portal/sandy.html**.
- Rotterdam Climate Initiative is a climate change adaptation effort by Rotterdam, a delta city below sea level whose economy depends on water transportation, to become the most sustainable port city in the world. **www.rotterdamclimateinitiative.nl/en**.
- The European Union's FloodResilienCity project is funding and developing flood mitigation and resilience infrastructure in six European countries in cooperation with local government. **www.floodresiliencity.eu/**.

For additional resources archive, go to **www.huduser.org/portal/periodicals/em/additional_resources_2014.html**.

Evidence Matters

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