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U.S. Floods: The Necessity of Mitigation

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Abstract

Floods are the costliest natural hazard events in the United States in terms of lives and property losses. The financial costs of flood disasters are unsustainable, especially for the national government, which assumes the most costs while state and local governments have the greatest ability to avoid great losses due to their influence over land use, economic policy, and other areas that can help mitigate floods and reduce the high costs of relief and recovery. This article summarizes the types, causes, and occurrence of floods in the United States and their unsustainable economic and social costs. It explains that the growing burden to taxpayers from disaster response and recovery has resulted in increased interest by national decision makers in shifting more disaster responsibilities and costs to state and local governments. The article reviews the broad tool kit of mitigation strategies available to local governments and their residents in taking greater responsibility for the impacts of flood events.

Keywords

floods, natural hazards, mitigation, disaster costs, structural mitigation, nonstructural mitigation, the intergovernmental paradox of emergency management, NFIP, moral hazard, green infrastructure

A major responsibility of government is the protection of life and property. Among U.S. disasters stemming from natural occurrences, floods are the most costly in terms of lives and property lost and people affected (Stromberg 2007). Between 1900 and 2015, 40 percent of the 35,000 U.S. disaster events were major floods and related storms. Over the past fifty years, 85 percent of Presidential Disaster Declarations were for floods (United Nations International Strategy for Disaster Reduction Secretariat 2013). In the past five years, all U.S. states had a flood and twenty-one states had frequent flooding, although occurrences and severity vary by state. Floods are increasing in frequency and severity, especially in the Northeast and South Central United States. "Billion Dollar Disasters" occurred once every two years in the 1980s, but there have been about 10 per year since 2010.

U.S. national government spending on extreme weather is significant—about US$400 per household in an average year. Events in bad weather years are more costly, for example, US$1,100 per household in 2011. The costs are overwhelmingly for response and recovery. Just 4 percent of federal disaster spending is for preparation. Just one in

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US$10 is for mitigation to prevent a disaster in the first place or reduce its impact; nine in US$10 is for response.

Lost economic activity is not included in the numbers, but one Federal Emergency Management Agency (FEMA n.d.) study found that 40 percent of small businesses never reopen after a disaster. Disasters were the second highest nondefense spending for the national government in 2012—more than either education or health. Since 1983, national government disaster spending has topped US$1 trillion. Homeowner insurance typically does not cover flood costs and insurance typically pays only one-half of damages. All told, disasters are a financial burden for taxpayers who pay for disaster relief and subsidized government insurance, and individuals and businesses directly affected since they must pay for what insurance does not cover or pay.

Emergency management historically has focused on the immediate and urgent aspects of a disaster—(1) the *response* function of police, fire, emergency medical services, and civil defense personnel; (2) *preparedness* that involves advance planning and training necessary for emergency operations when a flood event occurs; and (3) the postdisaster *recovery* period in which damage is repaired. But emergency management has a fourth phase, *mitigation*, which has attracted more attention by practitioners and academics in recent decades. Government's protection of life and property involves not just crisis-reactive responses to emergencies but also finding ways to avoid flood problems and to reduce losses from events that undoubtedly occurs. Flood m*itigation is defined as actions taken to reduce or eliminate risk to human life and property before a flood occur and to foster resilience after a flood.* The U.S. emergency management system uses an "all hazards" and "whole community" approach throughout the four disaster phases of mitigation, preparedness, response, and recovery.

Mitigation can be structural, bricks-and-mortar projects, or nonstructural, primarily land use actions involving planning and zoning, education for risk awareness, and insurance. (Cigler 1988a). Ultimately, the goal is for communities and their businesses and residents to be resilient in withstanding floods or any other extreme events without suffering great losses.

Mitigation Works

The strongest incentive for promoting mitigation may lie in the fact that mitigation works. The National Institute of Building Sciences/Multihazard Mitigation Council (2005) found that for every dollar spent on mitigation, nearly US$4 is saved on reconstruction and recovery. Those figures are being updated in Fall 2017. A recent Congressional Budget Office (2013) report found a 1–3 cost–benefit ratio from the mitigation grants studied. Lloyd's of London and Risk Management Solutions (2008) predict that flood losses along tropical Atlantic coastlines will increase 80 percent by 2030 with about one foot of sea-level rise, a figure in line with conservative estimates of the Intergovernmental Panel on Climate Change (2007).

Flood risks and their associated economic impacts can be dramatically reduced. Leading commercial insurer FM Global's 500 clients had about 85 percent less damage from Hurricane Katrina as similarly situated properties that didn't undertake loss prevention strategies and preparedness measures taken by the firm's policyholders. That is an incredible return on investment: US$500 million in avoided losses via a US$2.5 million investment in loss prevention (Mills and Lecomte 2006).

Researchers at the Wharton School's Risk Management and Decision Processes Center, University of Pennsylvania, found that Florida homeowners can reduce severe hurricane losses by 61 percent and save US$51B just by building to strong construction codes (2007). Higher design standards for buildings, for example, have more than a 4:1 ratio for payback on money spent. The U.S. Environmental Protection Agency (EPA) found that stormwater runoff volume, a significant cause of flooding, is reduced by 99 percent through the use of green infrastructure (2017), which is a way to absorb heavy downpours and reduce stormwater runoff by using parks, constructed wetland, and a

host of other measures explained later in this article.

This article elaborates on the need for mitigation and provides details on mitigation tools and strategies for local governments who want to more effectively mitigate their flood hazards. Background on floods, including the major types and causes of flooding, and the escalation of its costs, is reviewed. The goal is to help readers—taxpayers who bear the costs of disaster relief; individuals, businesses, and communities vulnerable to flood hazards; those with responsibilities before, during, and after disaster events; and researchers—become more aware of the flood problem in the United States and the important role of mitigation.

Background on Floods

This section outlines the major types and causes of flooding, its rising costs and likely future severity and costs, and the changes being debated by governments to shift more responsibilities for flood problems to individuals and businesses, along with state and local governments and communities.

Types and Causes of Flooding

Major flooding that accounts for the heavy economic tolls discussed earlier is primarily caused by hurricanes and severe storms. It's not the wind that causes most damage; it's the water. Sea-level rise due to climate change—whether a natural occurrence or human induced—exacerbates the damage of hurricanes and has devastating cumulative effects on communities. Six of the ten urban centers in the United States most vulnerable to storm surge are in Florida. California, Washington, and Pennsylvania which already require disclosure of past flooding or susceptibility to future flooding for homes and businesses. Virginia, where Norfolk has among the highest rates of annual sea level rise on the East coast, requires real estate agents to divulge if a property has defective drywall.

Another type of flood event is "nuisance flooding," which is the inundation becoming commonplace caused more by tides than weather. Low-lying roads, high tides, erosion, and flooded waterfront areas are increasingly common, and property damage is often significant. Water damage to basements, automobiles, and public infrastructure, as well as contaminated groundwater, results from these "slow disasters" that are sometimes called "blue-sky floods." Washington, DC, Miami, New York City, Seattle, and San Francisco already keep data on flooding by the hour as public infrastructure erodes, with increasing financial costs and inconvenience to residents.

"Flash flooding" occurs in rivers and streams due to heavy rains and disrupts many systems, with risks to life and property. Summer 2017, for example, saw record flooding in Missouri, with torrential rains and flash floods throughout the Ozarks and mid-Mississippi. Heavy precipitation is increasing—since 1950 by 71 percent in the Northeastern United States. These types of floods can result in major disasters, but heavy rains that occur anywhere can lead to periodic stormwater overflows. Runoff from rain or snowmelt flows over land surfaces and causes flooding. Roads, driveways, parking lots, rooftops, and other impervious surfaces prevent water from soaking into the ground, which greatly increases the volume of runoff during a storm, especially in overdeveloped areas. Water fills basements and damages landscaping and infrastructure. The damage is exacerbated not only by heavy rain but by human-induced changes to the earth's surface. In addition to urbanization, farming and deforestation increase runoff that inundates areas that otherwise wouldn't experience flooding. Careless building in hazard-prone areas, poor watershed management, and other human actions further increase flood damages.

The Rising Financial Costs of Flooding

Population and related changes directly increase flooding and, thus, its costs. More people result in more affected by floods. Increased urbanization and coastal living affects more than 123 million coastal residents—roughly

40 percent of the U.S. population—and is much greater when considering adjacent counties. Nearly 50 percent of the U.S. population is within fifty miles of a coastline. The United States has 3.5 million miles of shoreline on its oceans, lakes, and rivers, and heavy rain causes flooding. A July 2017 publication of national research by The Union of Concerned Scientists identified when U.S. coastal communities will face flooding that is disruptive to people's homes, daily routines, and livelihoods. The research documents that 170 communities in thirteen states face tough choices by 2035 regarding chronic inundation, defined as high tides flooding 10 percent of usable nonwetlands at least twenty-six times per year (or every other week). That's roughly twice as many affected communities as today and the severity of flooding—and number of communities affected—rises significantly by 2060 and then 2100, other time points in the study. For example, about 60 percent of all oceanfront communities on the East and Gulf coasts fall under a high inundation scenario by 2100.

Another reason for the rising costs of flooding is that there is *more building in disaster-prone areas* than in the past. *More exposure results in greater economic loss because of more wealth*. Insurable assets on U.S. coastal areas, estimated to be US$10 trillion in 2012, have increased by about 15 percent since 2007. Six states hold most of that value, especially Florida and New York. We "build to the past" and not for the future. Sea-level rise and stronger hurricane winds cause greater storm surge and coastal inundation than previously (Brandes and LeBlanc 2013). Real estate sales are slowing near the water's edge. Half of the nation's gross domestic product, US$4.5 trillion, is generated in the coastal counties and adjacent ocean waters (U.S. Commission on Ocean Policy 2004; Heinz Center and Ceres 2009).

Wide variations exist across the states: 75 percent of California's population lives in coastal counties; half of Louisiana's population lives on the coast, where disappearing coastline at the equivalent of one football field of land per hour led the governor to declare a "state of emergency" in April 2017. Arizona, Wyoming, and Nevada—landlocked states—are affected by flooding as inward population migration occurs. Lives are lost, and the economic toll on livelihoods, property, and communities can be high.

Physical vulnerability endangers communities, but *social vulnerability* results in disproportionate effects on people and groups in terms of their ability to anticipate, cope with, and recover from disaster events. The most socially vulnerable to flood events have fewer resources for preparing for a flood, such as a car for evacuation or temporary funds to cover living expenses after evacuation or a job loss. Living in unprotected wooden structures or being physically disabled increases vulnerability. The poor, elderly, disabled, and other special needs residents experience disproportionate impacts from a flood. Hurricane Matthew, which struck low-income areas in North Carolina, caused US$10.2 billion in losses, but just 23.8 percent of property was insured. Louisiana floods in August 2016 resulted in thirteen deaths and US$10 billion in losses, only one-fourth of which were insurable losses. Social vulnerability affects the costs of disaster response and relief, with costs borne by the entire nation.

Challenges to Enhanced Mitigation to Reduce Flooding

Dealing with disasters is a significant problem for all levels of government and intergovernmental relationships are very much a part of efforts to mitigate. This section examines what I call the "Intergovernmental Paradox of Emergency Management" and then turns to the increasing use of Presidential Disaster Declarations to aid local governments, the related unsustainability of the national government's financial burdens regarding disaster relief, recent and ongoing changes in governmental policies toward disasters, and some of the other problems in achieving greater attempts at mitigation.

The Intergovernmental Paradox of Emergency Management

The "*intergovernmental paradox of emergency management*" is that the governments least likely to perceive the threat of disaster as a very high priority (local governments) are at center stage in terms of responsibility, whereas the national government is concerned with the aggregate threat of disaster nationwide and has the most resources (Cigler 1988a, 1988b, 2006). A lack of financial, managerial, technical, and political capacity limits most local governments in dealing with less than routine emergencies. The magnitude of events often overwhelms response and the lack of capacity works against aggressive predisaster mitigation.

The states' role as capacity builder of local governments is also problematic, especially in providing a strong regulatory role in promoting-wise land use policy by educating people about risk; mapping flood-prone areas; setting and enforcing strong building codes, zoning, and subdivision regulations; reinforcing structures to withstand natural forces; and actually relocating homes and communities away from harm, which is a much used option.

The challenges of the intergovernmental paradox have never been more evident. It is highly likely that states and their local governments will have to bear more responsibility and more costs for disasters. Both the national and state governments recognize that the whole community is responsible for dealing with all types of hazard risk. The obvious policy choice is to avoid a disaster in the first place—or reduce its impact. Mitigation strategies are gaining attention.

Increased Presidential Disaster Declarations

Since 2007, there have been more than 22,700 floods recorded in the United States by the National Oceanic and Atmospheric Administration (NOAA). There were 174 disasters declaration by President George H. W. Bush or 43.5 per year. Under Presidents Clinton and George H. W. Bush, declarations rose to 716 and 1,037, respectively—averaging 89.5 and 120.6 per year. There were 854 declarations under President Obama or 106.8 per year. Current laws and regulations have made it easier for local- and small-scale disasters to qualify for national funds, leaving fewer resources for larger events. Supplemental funding requests to deal with disasters have been used in 17 of the last 22 budget years.

Current national government spending on floods is viewed as no longer sustainable (Weiss and Weldman 2013). The national government pays 75 percent of disaster costs among government entities, arguably promoting "*moral hazard*." State and local governments and their residents appear to be willing to take more risks because they believe they will be protected. The amount that state and local governments spend on disaster relief and mitigation is not fully known, but there are not research findings that show a significant effect on state finances by disasters.

Changing Governmental Policies Regarding Hazards

Proposals in mid-2017 by the Trump Administration call for reducing the FEMA budget, specifically funds for floodplain mapping, which is a shared responsibility among levels of government and the foundation of insurance rates, mitigation, and rebuilding. FEMA's pre- and postdisaster mitigation grants, as well as Community Development Block Grants (CDBG) administered by the Department of Housing and Urban Development (HUD), the key to rebuilding housing after a disaster, are candidates for budget reductions. Funds for weather forecasting are uncertain as the national government's commitment to climate change initiatives changes.

In mid-August 2017, President Trump signed two executive orders (EOs) on flood hazards. One rescinded President Obama's EO that required government agencies to take into account the best available science on sea-level rise when designing new buildings and public works and to elevate infrastructure in

flood risk areas. The other revoked a 2015 EO by Obama that amended a 1977 EO on floodplain management establishing a federal flood risk management standard and a stakeholder input process to improve the resilience of communities and federal assets against the impacts of flooding through an interagency process.

The Union of Concerned Scientists study (2017) offers an example of the adverse impacts of these actions: Three feet of sea-level rise threatens to submerge 128 military bases by 2100. Virginia's Norfolk Naval Base already shuts off electricity supplies to docks during high water events. Since 1927 Norfolk has recorded 15 inches of sea-level rise—the most on the east coast.

Also in August 2017, the Trump administration disbanded a government advisory committee of business and local government representatives that advised NOAA on the required National Climate Assessment by translating its findings into concrete guidance for public- and private-sector officials. That is the information used in building roads and other infrastructure and shaping building codes. Other flood pertinent advisory boards in the departments of interior and the EPA were disbanded earlier in the administration.

The Most Significant Government Mitigation Program

The most significant and comprehensive flood mitigation program used in the United States is the *National Flood Insurance Program (NFIP)*, created in 1968, now managed by FEMA, and up for reauthorization by September 30. The NFIP is a subsidized insurance program that requires local governments that participate to use an array of specific mitigation tools. The NFIP affects 56 states and territories and 22,000 U.S. communities. Participating communities must meet some minimum standards before their residents become eligible for disaster assistance.

The NFIP was US$24.8 billion in debt as of January 2017, largely because recovery and rebuilding costs rose dramatically after Hurricanes Katrina and Sandy. Low, subsidized, premiums can't keep pace with disaster payments. There still is a large flood insurance gap that leaves many people and businesses exposed to flood risk but not covered by flood insurance (Kousky 2017).

NFIP insurance rates have increased about 6 percent per year in recent years, and increases will continue as the program moves toward risk-based insurance premiums. Proposals being considered may increase deductibles to the states for participation in the program resulting in fewer Presidential Disaster Declarations for smaller events and more cost shifts to the state and local levels. Proposals under review are attentive to the provision of incentives to states to reduce the deductibles burden by giving credits for the use of mitigation tools. Since long-term financial solvency is a concern for NFIP reauthorization, premiums could rise and private insurance companies will be encouraged to enter the market. If Congress provides adequate funding for timely mapping, individual costs for insurance would likely rise since more land area is flood prone than shown on outdated maps.

These changes in government policies toward hazards highlight the need for state and local officials and vulnerable property owners to become more familiar with and engage in effective mitigation activities. Some national government mitigation grants are available, but it is increasingly the case that state and local governments and their residents will have to bear more costs and be more creative and proactive in using an array of mitigation options.

Problems in Moving Toward Mitigation

The current mismatch between government powers and responsibilities and fiscal realities is likely to change dramatically as floods increase in frequency and severity. *The national government does not possess the key powers needed* to control land use, local transportation, and economic development policies. It is in those policy areas that the policy tools best equipped to reduce flood hazards are found. Land use and economic development

policies especially can affect where residential, commercial, and industrial entities are located, thus reducing risk to life and property in vulnerable flood hazard areas.

There are problems in attaining interest and action in mitigation by state and local officials and community residents. It's difficult and extremely costly to update hazard maps and a challenge for residents to learn about and accept their risks. Faulty risk perception can lead to a false sense of security. Residents living behind a levee or dam may not realize that human-made structures can fail, may not understand the magnitude of an event, or don't grasp the language of engineers (e.g., the "100-year flood") compared to regular public discourse. "Political will" is often lacking in devising or enforcing strong land use regulations—zoning, subdivision regulations, or building codes. "Takings" issues related to the use of land prove to be costly and intimidating. Financial costs of mitigation, such as building retrofits, preservation of open space, or relocating buildings and people, are perceived as overwhelming. The complexity of the intergovernmental milieu can also be overwhelming. Problems are encountered by developers and engineers when faced with municipal and state regulations regarding, for example, installing types of green infrastructure.

Structural and Nonstructural Mitigation Tools and Strategies

This article has discussed the types, causes, and occurrences of floods and their enormous costs. Likely changes in roles and responsibilities related to the intergovernmental paradox should serve as incentives to interest and action by state and local officials who must work with individuals and businesses to identify specific flood hazard risks in communities and on individual property. Next, examples of the tools used are reviewed.

Multiple Tools and Strategies

A useful concept for understanding that multiple tools used together can be effective in dealing with flood risks is what's called a "multiple lines of defense" strategy, primarily used to sustain coastal areas (Lopez 2009; Cigler 2009). A good example is the current work in the New Orleans region by the Lake Pontchartrain Basin Foundation (2017). The concept utilizes the foundational idea of military defense strategy. Simply put, there is no one "silver bullet" for dealing with flood reduction. Goals are to reduce storm risk by reducing the probability of adverse consequence for a hurricane, for example, or to reduce exposure to the event itself. On coasts, barrier islands, marshes, ridges, and so on, engineered structures such as levees, elevated homes, floodgates, highways, and evacuation routes are historically most common. However, natural features can be used to complement engineered structures. Coastal restoration involves hundreds of options such as marsh creation, restoration of barrier islands and shorelines, stabilization of banks and shorelines, freshwater redistribution, and land/marsh-building river diversions.

The most typical categorization of mitigation tools is to group them into two broad categories of activities—*structural and nonstructural*. The coastal options presented above are an example of how structural and nonstructural tools can work together. Structural alternatives are engineered floodwalls/seawalls, floodgates, and levees. Nonstructural alternatives are land use measures that reduce the exposure to risk by taking people and property out of harm's way. Elevated structures, property buyouts, and permanent relocation are used, as are sound zoning, subdivision, and building codes that are strongly enforced.

Structural Mitigation

Constructed or engineered structures of concrete and cement are the mainstay of structural mitigation—dams, seawalls, levees, floodwalls, and so on. Usually, large-scale public works or engineering efforts are costly and built by the corps of engineers. They can offer a false sense of safety because human-built structures can fail, as was the case with the levees in New Orleans during Hurricane Katrina and the more

recent Oroville Dam event in California in 2017.

Every four years, the American Society of Civil Engineers (ASCE) releases a report card for U.S. infrastructure that assesses the condition and performance of infrastructure across sixteen categories including drinking and wastewater systems, levees, dams, bridges, ports, rail, and transit. The physical structures are ideally resistant to hazard damages such as flooding—a form of structural mitigation. The latest ASCE report presents grades on infrastructure types for each state, with American infrastructure receiving an overall "D+" (ASCE 2017). Since floods can and do erode infrastructure, the link between infrastructure policy and mitigation strategies deserves attention.

Engineered structural mitigation for dealing with the built and built-up environment is not as popular as in past decades when it was the dominant philosophy—and not just because of costs. Instead, it is related to actual experience with many flood control projects, especially levees built in the 1960s that later failed because they gave people a false sense of security. Structural water control projects built in the entire Mississippi River system in the 1930s after major floods have been criticized since for the problems caused (Cigler 1996), a key lesson from national research in the mid-1980s (Burby et al. 1985). Losses from Hurricane Katrina and the Great Flood of New Orleans in 2005 were greater than what would have occurred if the high risk areas were not developed (Cigler 2007). California's Oroville Dam developed a hole in its primary spillway, along with erosion, and had a nearby levee breach in 2017.

Large engineered structural options in flood prone areas need continuous attention and maintenance. Similarly, the nation's network of roads and bridges will be maintained and updated with new technology that takes hazards into account. For building new infrastructure, in hazard prone areas and in general, however, the structural option is generally considered only after reviewing nonstructural options or the coastal option for those areas. Both structural and nonstructural tools combine to deal with flood hazards in a multiple line of defense strategy.

Nonstructural Mitigation

There are dozens of nonstructural mitigation options. Most involve land use but included are economic tools such as taxes and incentives.

FEMA and the NFIP's Community Rating System (CRS). Both the NFIP and its related program, the *CRS*, are key elements used by the national government to promote nonstructural mitigation at the local level. If a community is in the NFIP, it can be a voluntary participant in CRS, and its residents are then eligible for premium discounts on their NFIP policies. The highest rating for a community means that its property owners are eligible for 45 percent discounts on their insurance premiums.

The CRS links community-level and household-level mitigation. Nineteen flood mitigation activities organized under four general categories are designed to reduce flood damages. The broad categories are (1) public information, (2) mapping and regulations, (3) flood damage reduction, and (4) warning and response.

Only 5 percent of the 22,000 NFIP communities participate in the CRS program, however, among the 5.6 million NFIP policies in force, 68 percent are in the CRS. That is 3.8 million policyholders in 1,390 communities that are expected to implement mitigation tools that exceed minimum NFIP requirements (FEMA 2016). Given the extensive guidance provided to states and communities regarding each of the flood mitigation activities across the four general categories, the CRS program has great potential. The fact that participating policyholders get points to reduce their insurance premiums should be a powerful incentive for mitigation.

NFIP requirements and the voluntary CRS mitigation categories encompass a very wide array of policy tools for mitigation. Public information can help improve risk identification and awareness. Improved mapping lays the

foundation for insurance and regulations. Warning and response systems help prepare and evacuate people (and pets) efficiently from disaster scenes and are steadily improving across the nation.

Flood damage reduction includes design and construction standards—building codes and architectural design—but also soils and landscaping techniques. Land use planning encompasses comprehensive plans, subdivision regulations, easements, stormwater regulations, and green infrastructure. Elevation of structures, filling basements, and waterproofing can be costly but effective tools. The relocation of people and structures and property acquisition are used primarily in areas of repetitive and severe repetitive flooding. Flood resistant building design and stringent building codes are important to new development and to restoration.

Home and business owners can do numerous cost-effective small flood-proofing measures. Examples are landscaping to protect buildings, for example, by maintaining a swale for stormwater runoff; sandbagging during a flood; waterproofing basements; installing check valves to prevent water from backing up into drains; and elevating furnaces, water heaters, and electric panels.

Beyond the financial incentives provided by the NFIP and its CRS program, states can offer tax credits, rebates, cost-sharing arrangements, and grants. Insurance, itself, is a major mitigation tool. Local capital planning, contingency funds, disaster stabilization funds can all be used for mitigation. At the municipal level, environmental impact bonds are getting attention. In repetitive flood neighborhoods, families are being relocated. New developments have strict open space preservation requirements. Ordinances dealing with vegetation cover, the shaping of mounds, and/or siting of buildings are nonstructural measures that are beneficial. Many of the available tools are not yet widely used by states and local governments. Anything that can improve risk awareness and perception—psychological and sociological in nature—can spur interest and action.

Increasing use of natural defenses (mostly nonstructural tools). The significance of natural habitats and ecosystems has been relatively neglected and underestimated in understanding protection from floods. These natural defenses were originally developed, however, by FEMA in a definitive report in 1986, with the 1994 update cited here. In their natural state, floodplains in both coastal and riverine areas provide numerous beneficial functions. This includes water resources benefits such as flood and erosion control through storing water and reducing sedimentation, for examples; water quality maintenance benefits, such as filtering nutrients and impurities from runoff, and recharging groundwater.

There are a number of biological benefits also creating and enhancing waterfowl habitat, protecting rare and endangered species, providing breeding and feeding grounds for fish and wildlife, maintaining biodiversity, maintaining the integrity of ecosystems, and providing rich soils that promote vegetative growth (FEMA 1994).

Wetlands, green infrastructure (explained in more detail later), and floodplain restoration are of growing interest. University of Vermont researchers claim that wetlands offer an estimated US$23.2 billion each year of storm surge and flood protection along U.S. coastlines (Costanza et al. 2008). Large green infrastructure projects are under current development in many locations along the Gulf Coast, South Florida, San Francisco Bay, New York City, and the Carolinas. Conservation groups such as the National Wildlife Federation have been extremely active. Working with academic, nonprofit, and philanthropic organizations, HUD created a rebuild by design competition for coastal resilience projects in June 2013. The Hurricane Sandy Rebuilding Task Force was given more than US$5 billion to promote resilience in the Sandy impacted region.

Green infrastructure. Single purpose gray infrastructure—the engineered conventional pipe drainage and water treatment systems, with pumps, ditches, manholes, and detention ponds—*move stormwater away* from the built

environment. These systems are costly, but flooding caused by stormwater overflow in urban areas continues to increase. There is no single established definition of green infrastructure, but it is a set of techniques for dealing with water runoff that has numerous environmental, societal, and economic benefits along with being cost-effective. Green infrastructure is increasingly used by communities and homeowners for a stormwater management system that protects and restores the natural water cycle, in part, because of federal regulations. Techniques as simple as rain barrels or rain gardens move water away from the built environment *at the source*, thus reducing and treating stormwater and lessening the flooding of roads, basements, and other areas.

Nationwide, communities are creating stormwater authorities and assessing a fee to develop their green infrastructure systems. Runoff from roofs, streets, driveways, and parking lots create water pollution by carrying trash, metals, and other debris into the existing stormwater system. Floods create high flows that damage habitats, property, and infrastructure. Using natural areas, rooftop gardens, rain barrels, green landscaping techniques, and so on, working together create a green infrastructure system as part of the overall stormwater management plan. Some options involve the use of permeable pavements, but most are nonstructural land use techniques of landscaping, such as bioswales or vegetated and mulched channels that offer treatment and retention of stormwater; protected natural areas, use of conservation easements, stream buffers, protected wetlands; or the planting of trees.

Reduction of stormwater runoff through the use of green infrastructure and good land conservation can be cost-effective. Green landscaping is sometimes integrated with blue landscape elements such as pond systems, swales, or artificial buffer basins to form what is called green–blue infrastructure. Green and blue–green infrastructure systems seek to be sustainable in not diminishing the social, economic, and ecological environments. While effective stormwater management is essential in urban areas because of so many impermeable surfaces, it is useful in rural areas, for example, to make good use of precipitation water.

Summary and Concluding Observations

Floods are the costliest disasters related to natural occurrences in terms of lives and property lost as well as people affected. About 1,500 people lost their lives to Hurricane Katrina in 2005; Hurricane Sandy in 2012 took 117 lives. Fortunately, there has been less loss of lives from flooding in recent years due to better warning systems, quicker and more effective response, better evacuation, and highly professional emergency management. Floods will continue to be a natural occurrence, however, and are predicted to increase in both frequency and severity. The vastly increased economic losses to residents, businesses and governments, however, harm local communities' financial well-being.

Floods are natural occurrences that become costly disasters when people and property are placed in harm's way (Cigler 1988a). Tampering with natural systems can be detrimental to wildlife and fish as seasonal inundation of floodplains is essential habitat. Preparedness and response for disaster and crisis management has seen dramatic improvement; short- and long-term recovery is similarly advancing. The growing evidence on the merits of mitigation, a fourth phase of emergency management, and the substantial information available to individuals, business, communities, and states that can be used to avoid or reduce the effects of floods (and other disasters) before they occur is compelling.

Steps are underway to reform and modernize the nation's major mitigation program, the NFIP. There will likely be upgrades to data systems, changes in mapping procedures, rate changes, and ways to deal with debt. The most significant transformation may be a bundle of efforts that address the "intergovernmental paradox," resulting in more responsibility to mitigate being thrust on state and local governments, property owners, and residents of flood prone areas. Congress continues to grapple with

a host of reform issues centering on insurance affordability and fairness to property owners and communities.

The financial costs of flooding are unsustainable. Most spending on floods is for response to disaster events and short- and long-term recovery—not mitigation. It is economically wiser to mitigate flooding predisaster rather than pay the high costs of a disaster event. Structural solutions to flood hazards are important but "technical fixes" are not absolute and are prone to human error. Maintenance costs will always exist, but there is also a trend toward green infrastructure. Homeowners and communities are turning to a broad tool kit of nonstructural or land use–related mitigation strategies to supplement pipe drainage from heavy precipitation for their stormwater management.

There is an uneven realization among insurance companies, consumers, and environmentalists of the significant costs of flooding. Insurance companies are forming partnerships with governments and policyholders to reduce disaster costs. Concerns for fairness dictate that taxpayers in states with minor flooding should not pay the same as taxpayers in Louisiana, Florida, Mississippi, New York, or Texas, as examples, when a flood disaster strikes. Governments and individuals in heavily flood-prone states may soon have little option but to bear greater responsibility for their hazard risks.

There is ample information on "best practices" for mitigation available from FEMA, think tanks, state emergency management agencies, environmental organizations, and university researchers. A good first resource is the Hazard Mitigation Association, which provides links to a wide variety of resources on best practices, funding opportunities, other organizations, and readings (http://nhma.info/) on mitigation for all types of natural hazards. The guidelines and regulations for the NFIP and its CRS option offer advice on proven mitigation techniques.

Hundreds of communities can avoid chronic inundation in this century by taking significant action to deal with rising seas, which is already occurring in such states as Maryland; Louisiana; and Virginia; and in Charleston, SC; Galveston County, TX; Cape May and the Meadowlands, NJ. Communities such as Philadelphia and Hoboken, NJ, are providing a plethora of best practices information to help other communities. The field of emergency management has systematically collected "lessons learned" and best practices to share mitigation successes.

Successful mitigation—after risk is recognized and actions begun—relies on basic good management techniques: planning, partnerships, collaboration, capability- or capacity-building, and so on. Most significant is the realization that *ultimately, building resilience through mitigating flood damages is both a community and a personal responsibility*.

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