Reconstruction of New Orleans after Hurricane Katrina: A research perspective

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Four propositions drawn from 60 years of natural hazard and reconstruction research provide a comparative and historical perspective on the reconstruction of New Orleans after Hurricane Katrina. Decisions taken over its 288-year history that have made New Orleans so vulnerable to Katrina reflect a long-term pattern of societal response to hazard events—reducing consequences to relatively frequent events, and increasing vulnerability to very large and rare events. Thus Katrina's consequences for New Orleans were truly catastrophic—accounting for most of the estimated 1,570 deaths of Louisiana residents and $40–50 billion in monetary losses. A comparative sequence and timing of recovery provides a calendar of historical experience against which to gauge progress in reconstruction. Using this calendar, the emergency postdisaster period appears to be longer in duration than that of any other studied disaster. The restoration period, the time taken to restore urban services for the smaller population, is in keeping with or ahead of historical experience. The effort to reconstruct the physical environment and urban infrastructure is likely to take 8–11 years. Conflicting policy goals for reconstruction of rapid recovery, safety, betterment, and equity are already evident. Actions taken demonstrate the rush to rebuild the familiar in contrast to planning efforts that emphasize betterment. Because disasters tend to accelerate existing economic, social, and political trends, the large losses in housing, population, and employment after Katrina are likely to persist and, at best, only partly recover. However, the possibility of breaking free of this gloomy trajectory is feasible and has some historical precedent.

Four propositions drawn from 60 years of research on natural hazards (1–5) and reconstruction after disasters (6) and 288 years of environmental history (7) provide perspective on the vulnerability of the city (parish) of New Orleans to Hurricane Katrina and its prospects for reconstruction. The first addresses the paradox of the human ability to reduce over time the consequences of hazards while increasing their catastrophic potential. The second describes the sequence and timing of reconstruction phases found in a number of long-term studies of reconstruction. The third considers the conflicting goals and behaviors for reconstruction that arise in recovery efforts after disaster. The fourth proposition examines how disasters accelerate preexisting demographic, economic, social, and political trends and lead to very different trajectories of recovery.

Reduction in Consequences, Increase in Catastrophic Potential

Over the long term, societies reduce consequences to relatively frequent hazard events (e.g., return periods of 100 years or less) through improved technology and social organization. However, the reduction in risk to relatively frequent events may increase vulnerability to major hazard events (e.g., return periods of >100 years) resulting in catastrophes characterized by large loss of life or property, major population loss, and out-migration, and even societal collapse. First noted in 1979 in the context of climate fluctuations (8), the reduction of mortality over time, as in death rates and, in some cases, in aggregate deaths, has been found in longitudinal case studies, including drought in the United States and Africa (8), tropical cyclones in Bangladesh (2), and floods and hurricanes in the United States (2, 4). A reduction in property damage is less clear because aggregate property damages have risen along with increases in the population, material wealth, and development in hazardous areas (9). At the same time, the individual losses for hazard victims have been reduced as the larger society absorbs a portion of their losses through disaster relief and insurance (2–4).

Catastrophes from rare events can be attributed to the sheer magnitude of such events. Thus, the linkage between reducing consequences to relatively frequent events and increasing catastrophic potential needs to specify the mechanisms involved. For example, the successful prevention or rapid suppression of forest fires leads to a buildup of combustible material that increases the catastrophic potential of fires that escape rapid suppression (10, 11). Most relevant to New Orleans is the so-called "levee effect," in which construction of levees induces additional development leading to much larger losses when the levee is eventually overtopped (12). A more general statement of this proposition is found in the safe development paradox in which increased safety induces increased development leading to increased losses (13). It is this perspective that helps explain the vulnerability of New Orleans to Katrina.

New Orleans Flood and Hurricane History Before Katrina. For three centuries, New Orleans sought to lessen the impacts of its recurrent floods and hurricanes by providing marginal increases in safety. However, in doing so, they laid the groundwork for the next catastrophic failure. In its 288-year history, New Orleans has had 27 major river or hurricane-induced disasters at a rate of one about every 11 years (14, 15). A pattern of three responses runs through that history. After each event, the city rebuilt and often expanded, small differences in elevation determined the location of the well-to-do and the poor, and levees were rebuilt and often raised. River floods in the years after the city's founding in 1718 did not deter its French founders from pressing forward with building the colony's capital at this strategic location, nor were they deterred in 1722 and 1723 when hurricanes destroyed the incipient city. Inequity in the location of neighborhoods and in the distribution of flooding burdens also appears early.

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When levees failed in 1816 and again in 1849, high water drove many of the city's poor, found in the lowest locations, from their homes for up to a month (16, 17).

The response to riverine and hurricane-induced floods in the Louisiana colony was to build levees. By 1728, it was mandatory for all land owners to do so along their riparian frontage. Later, levee heights were increased to 1 foot higher than the last high-water stage. Even as responsibility for levee construction gradually shifted from land owners, to the state, and ultimately to the federal government, designed protection was based on the last storm. Each increase in storm severity thus led to a succession of catastrophic failures. This has continued to this day with the exception of 1927 when the great Mississippi flood threatened New Orleans. State and federal authorities responded by dynamiting a breach in the levee that flooded St. Bernard Parish down-river to the detriment of its residents (18). Further improvement of the levees, aided by two major floodways that divert high waters, has appeared to make the city safer from river floods but not from hurricanes. In a political culture that often rewarded development and patronage at the expense of safety and efficiency, completion of an effective hurricane protection system suffered from misplaced priorities (19).

Exemplifying the safe development paradox, improved drainage techniques enabled expanded development behind the levees. In the 20th century, the city expanded in two major movements off the natural levee, across the Metairie Ridge toward the vulnerable wetlands near Lake Pontchartrain (Fig. 1). In the first period (1900–1950), early suburbs developed assisted by a municipal drainage system that helped dry out the mucky soils north of the city. These areas felt the impact of a severe hurricane in 1915 that damaged some 25,000 buildings. A local levee district was created in 1930 to enable residential development. The state collaborated in the effort to fill in the lakeside from the natural beach and build a massive 9-foot concrete seawall that in turn further encouraged the city's lakeward expansion. In general, the poor remained in the city and often occupied low areas vacated by those leaving for the newer suburbs. In 1947, hurricane storm surge and waves overtopped lakefront levees and produced severe impacts to these suburban neighborhoods in Orleans and Jefferson Parishes.

The second, post-World War II expansion (1965–2000) accommodated population growth with public housing and new baby-boomer suburbs (Fig. 1). This expansion followed the last round of levee construction and reconstruction after Hurricane Betsy (1965) when >300,000 residents were displaced and 27,000 houses destroyed (14). The improved and much expanded levee system led to a doubling of the protected area. Expected benefits from new development within that protected area were used to justify the project (7, 13). New massive drainage systems accompanied the levees. When a spate of intense rainstorms exposed the inadequacies of the pumps and canals in the late 20th century, the U.S. Army Corps of Engineers participated in a major overhaul of these elements of the system to protect the development that crowded within the levees.

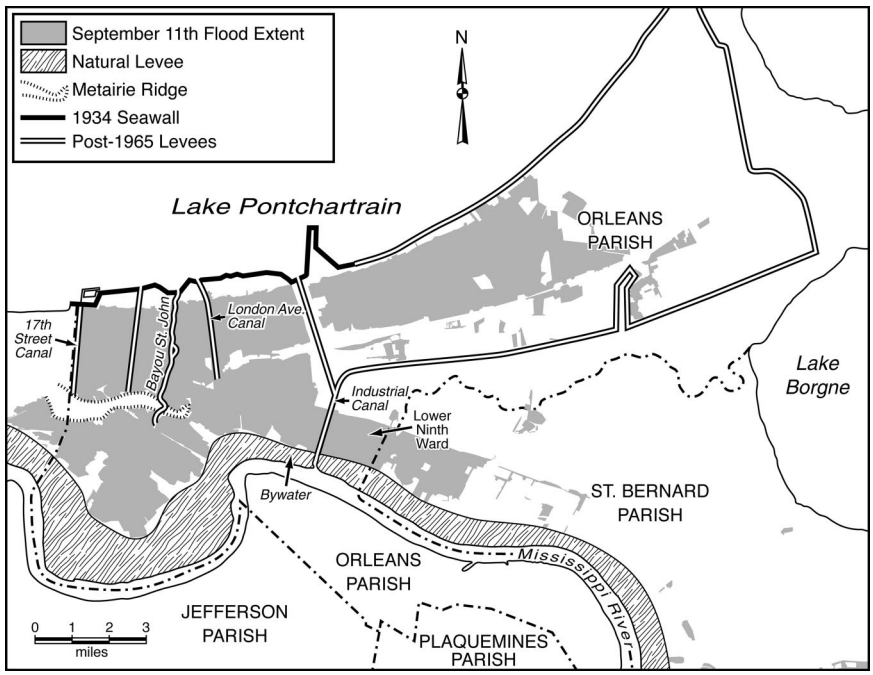

Fig. 1. Levee construction, subsequent development, and Katrina flood area in New Orleans, 1900–2005.

As in previous episodes of urban expansion, those with means moved to new suburbs, and the poor remained within the core city, generally in the low-lying locations (7, 19, 20). Conflicts between local and federal authorities over the final form of the hurricane protection system greatly delayed its completion and exposed everyone to heightened risk. Thus, this most recent round of levee construction and its consequences would lead to America's greatest natural hazard catastrophe.

The Catastrophe of Katrina. In keeping with other disasters, this long history of marginal increases in safety that encouraged new development made New Orleans a catastrophe waiting to happen. Its estimated pre-Katrina population of 437,186 (21) lived in a bowl, half located below sea level, between the natural levees of the Mississippi River and the built levees (pierced by canals) along Lake Pontchartrain. In the 4 years preceding Katrina, there were extensive and repeated warnings from both scientists and the media that the "big one" would eventually hit the city. These included specific concerns for the evacuation of an estimated 130,000 residents without vehicles, homebound, or in hospitals and in-care facilities (22–25).

Beginning on the morning of August 29th, 2005, Katrina brought severe but not catastrophic winds, record rainfalls (up to 14 inches in 24 h), and stormwater damage as the city's pumping system failed to keep up with the rain. Then, within hours of the initial impact, major floodwalls along the 17th Street Canal, London Avenue Canal, and Inner Harbor Navigation Canal (Industrial Canal) failed, allowing water to surge into ≈80% of the city and essentially fill the bowl to depths ranging from 5 cm to 5 m (26). Days later, parts of New Orleans would be reflooded from intensive rains accompanying Hurricane Rita.

As many as a million residents in the metropolitan area may have responded to public calls for evacuation on August 27th and 28th, leaving an estimated one-quarter of New Orleans residents unable or unwilling to leave. These residents took refuge in the Superdome, the Convention Center, in hospitals and nursing homes, in upper stories of their homes,

or on elevated highways, or died during the week before full poststorm evacuations could be completed. The evacuated residents traveled or were moved to other cities, and within a month, refugees from New Orleans could be found in every state. Extensive media coverage shared the failure of complete evacuation, the plight of those remaining in the city, and the subsequent outmigration with a global audience. The burden of these failures fell heaviest on the African-American, poor, aged, and infirm members of the population. Four months after Katrina, the population was estimated at 158,353, only 37% of the pre-Katrina number (21).

The full death toll is still not known, and out-of-state deaths in the month after Katrina are still being reviewed. But the estimated death toll for Louisiana is 1,570, most of which were New Orleans residents (27). As in all other disasters, where the costs of hazards are often hidden and underestimated and a consistent set of methods and databases do not exist, the true costs of Katrina in New Orleans will never be known (4, 5, 28). Limited estimates of damage to the built environment, losses to the economy, and the costs of emergency and reconstruction assistance are available, along with some observations of social and environmental consequences (29–35). Putting together these scattered data, we estimate an aggregate monetary loss of around $40–50 billion in Orleans Parish including direct property losses ($20–22 billion), still ongoing economic losses ($4–8 billion), and emergency assistance ($16–20 billion). The human and social disruption has also been extraordinary given these losses, the out-migration, the trauma of experiences, and the breakup of the community. Only the environmental losses have been somewhat less than expected as high levels of toxic materials found in the environment were primarily products of industrial development before Katrina (33).

The Timing of Reconstruction

A review of the limited set of long-term case studies of reconstruction after disasters tells us that reconstruction takes a long time. Reconstruction is part of a sequence of four identifiable postdisaster periods: emergency, restoration, reconstruction, and commemorative or betterment reconstruction. These four periods were first examined in a retrospective study of San Francisco after the earthquake and fire of 1906 (36). The emergency period is characterized by search and rescue, emergency shelter and feeding, the establishment of order, the clearing of major arteries, and the draining of floodwaters. Before this period ends, the restoration period is started, where the repairable essentials of urban life are restored. And well before this stage is over, replacement reconstruction begins to provide the infrastructure, housing, and jobs for the destroyed city and predisaster population, followed often by a commemorative or betterment reconstruction. Studies of earthquakes in Italy (37), Nicaragua (6), and the United States (6, 38), and floods in the United States (8, 39), have found that the second and third periods last approximately 10 times the interval of the previous period. The use of this sequence and time scale of reconstruction can serve two important purposes: to underscore the length of time required for reconstruction and to provide a calendar of historical experience against which to gauge progress in the four periods.

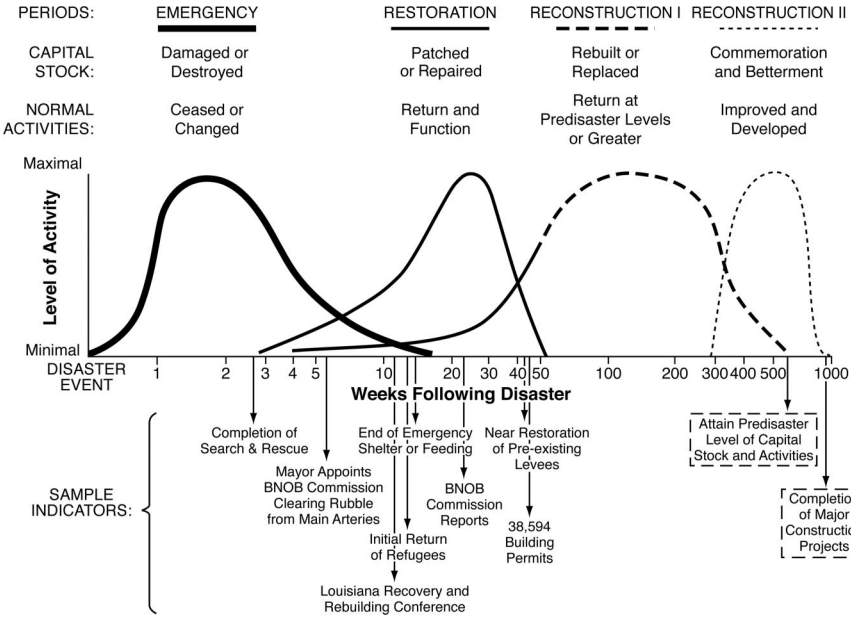

Fig. 2. The sequence and timing of reconstruction after Katrina in New Orleans with actual experience (solid lines) and sample indicators for the first year along a logarithmic time line of weeks after the disaster. The long-term projections (dashed lines) are based on an emergency period of 6 weeks, a restoration period of 45 weeks, and a 10-fold historical experience for reconstruction.

Critics rightly note that the sequence of recovery processes can be uneven, that phases can overlap, and, most importantly, that different social groups, even within the same community, can experience the sequence quite differently (5). Such differences can be partly captured by the initial length of the emergency period, which serves as an overall measure of both the magnitude of damage and the response capacity of different communities subject to the same hazard event (38). These differences can also be evaluated separately for varied groups within a community (40). For example, San Francisco was somewhat analogous to New Orleans with its 1906 population of 400,000 and its catastrophic losses (550 dead, 220,000 homeless, 55% of its housing units destroyed, and 300,000 evacuees). The 1906 emergency period lasted 4 weeks, the restoration period 40 weeks, functional reconstruction 9 years, and the commemorative reconstruction even longer (36). But even in this early study, major differences were observed in the recovery between social, economic, and ethnic groups. For example, a sample of residents selected from city directories showed that 1 year after the earthquake, 74% of unskilled workers had disappeared from the area compared with 40% of white-collar workers (40). Using this sequence and timing, how does the reconstruction of New Orleans compare with other large and rare disasters?

Eleven Months of Restoration, Eight to Eleven Years of Reconstruction

Fig. 2 shows a plot of the reconstruction experience for 1 year after Katrina and projects future reconstruction activity by using the four periods of historical experience. But applying the historical experience to New Orleans is complicated by the magnitude of the damage and failures in response, the massive forced outmigration, and the external aid available for restoration and some reconstruction.

Because of the magnitude of damage and failures in response that characterized Katrina, the emergency period ex-

tended over 6 weeks. This endpoint is determined by the "dewatering" of New Orleans, defined as the point when flood waters were pumped and drained from the city. However, because of the extraordinary damage and dispersal of the population, an alternative length for the emergency period could be as long as 14 weeks, when the end of emergency shelter on December 3, 2005, is used as its conclusion.

Restoration—repairing what is repairable in the infrastructure of urban life—began in the second week. But the forced out-migration and low rate of return complicates the calculation of restoration. The result is that much repairable, but population-dependent, infrastructure has not been restored or used. Most services for which there are data available (electricity, gas, public transportation, schools, hospitals, and food stores) are functioning at less than half of pre-Katrina capacity (34).

The emergency period appears to be longer in duration than any other of the studied disasters and can be readily explained by the evident failures in the initial evacuation and response. Using the 6-week emergency period, the expected restoration period should be 60 weeks in duration based on historical experience; however, the actual restoration period is 40 weeks when the near restoration of the preexisting levee system is used as the key indicator for its conclusion. This shorter restoration period can be explained by the major commitment of funding, resources, and leadership to rebuild the levees and to overcome the clear failures of past construction. An alternative explanation might be that because failures in emergency response extended the emergency period 2 weeks beyond what the logistics of the hazard event might have required, (e.g., 4 weeks in San Francisco), the shorter 40-week restoration period better reflects the historical scale of experience.

Ideas for reconstruction began to circulate even within the emergency period, and serious planning efforts began 10 weeks after Katrina while restoration was underway. Again, the historical experience argues for an extended period of reconstruction, between 8 and 11 years, depending on the restoration period used.

Conflicting Goals and Differential Outcomes of Reconstruction

The long history of urban experience (41) has few examples of cities failing to rebuild in some fashion. For New Orleans, the desire to overcome the failures of the emergency response and to maintain the distinctive role New Orleans plays in African-American politics, culture, and education quickly overcame early commentary that perhaps New Orleans should not be rebuilt. But cities and regions seeking to reconstruct after a disaster seem to simultaneously pursue goals to rapidly recover the familiar and aspire to reconstruct in safer, better, and sometimes more equitable ways. Conflict arises between groups or institutions and even individuals pursuing these different goals because they cannot be given equal attention in time, resources, and values. In addition, in accomplishing one goal, another may be less achievable. For example, compare achieving both rapidity of recovery and safer reconstruction, or betterment for some segments of the population and equity for others.

For three centuries, New Orleans has had the recurrent opportunities found in other disasters to rebuild the familiar in safer, better, and more equitable ways. It essentially rebuilt the familiar, expanded between disasters, and provided marginal increases in safety but laid the groundwork for the next catastrophic failure with major burdens falling on the poor. Now, 1 year after Katrina, the planning effort and the actions taken to reconstruct New Orleans clearly reflect the pattern of conflicting reconstruction goals. Planning for reconstruction is divided between city, state, and federal government, each assisted by outside advisors and contractors, with distinctive but often overlapping responsibilities and intentions. At the federal level, extensive safety-related studies have been undertaken by the U.S. Army Corps of Engineers (26) and a related planning effort by the Federal Emergency Management Agency (FEMA) for the production of new 100-year flood elevation maps taking into account Katrina's flooding, the subsidence of benchmark levels, and protection from rebuilt levees (42).

At both the state and city level, parallel and competing planning processes were launched by the Louisiana Recovery Authority, appointed by the governor, and the Bring New Orleans Back Commission, appointed by the mayor of New Orleans. The initial plan was a brief "starting point" plan developed by the Louisiana Recovery and Rebuilding Conference (43) and included features that were similar to the city plans developed by the Urban Land Institute with proposals for category 5 flood protection; light rail, parks, and playgrounds; and selective neighborhood rebuilding (44). A more detailed set of reconstruction plans came from the Bring New Orleans Back Commission, whose Urban Planning Committee envisioned a smaller city of 250,000 as a "sustainable, environmentally safe, socially equitable community with a vibrant economy. Its neighborhoods would be planned with its citizens and connect to jobs and the region. Each will preserve and celebrate the heritage of culture, landscape, and architecture" (45).

But 1 year after Katrina, the unified neighborhood planning process, envisioned by the city and the state, has barely begun. Some neighborhoods had begun their own planning process; other neighborhoods had professional assistance provided separately by the mayor and the city council. It has taken 10 months for the mayor, city council, and civic leaders to agree on a unified planning process with professional assistance for 73 neighborhoods and on the preparation of a citywide infrastructure plan (46). Underlying the fits and starts in neighborhood planning has been the reconstruction approach of various planning consultants to rebuild the "high ground first—damaged areas maybe" and its conflict with the most important equity issue—the rebuilding of pre-Katrina African-American neighborhoods.

The major planning documents (43–45) reflect the contrasting planning goals. As seen in other reconstructions, betterment emerges as the major planning goal. Perhaps to compensate for the "high ground first—damaged areas maybe," they do give prominence to issues of equity and citizen participation in the planning process. Safety, with one exception, is presented with few details but calls on the federal government to provide protection against category 5 hurricanes. Rapid recovery was not a focus of the plans.

In striking contrast to the reconstruction plans, the actual decisions and rebuilding undertaken 10 months after Katrina—the so-called "facts on the ground"—clearly demonstrate the rush to rebuild the familiar found after all disasters. Proposals for a building moratorium were almost universally rejected by residents. Federal government grants to the state and payments of flood insurance will now provide significant, but not sufficient, funds for rebuilding (47). More than 38,000 building permits have been issued for rebuilding to residents, ostensibly with $<50\%$ damage (34). Many homeowners succeeded in having their damage estimate reduced to below that key benchmark to enable rebuilding without elevation of the structure. New maps, to be used in testing eligibility for flood insurance, have not been completed because rebuilt levees could not be certified as protecting at the level previously protected. In their absence, FEMA requires ground elevation of up

to 3 feet (42). Given the depth of flooding experienced, this appears to be a modest requirement.

A Safer City? Further facilitating a return to the familiar are the completed safety improvements and further work underway. New Orleans will be somewhat safer, but not so safe as it could be. It will surely be flooded again in the future reflecting the threat of even greater or more threatening storms from the multidecadal cyclical period of high hurricane frequency (48). Furthermore, the intensities of these storms are probably being exacerbated by global warming (49–51) and by sea level increase and continued subsidence of the land. Hazard research offers five major types of adaptation that could be used to lessen such risk (1, 2). Adaptive actions taken or planned to make New Orleans safer address three of these: rebuilding of the levees, a limited effort to make buildings flood and wind resistant, and preparation of a new evacuation plan. No actions have been taken to change land use or even to restore wetlands.

The U.S. Army Corps of Engineers nearly fulfilled their promise to rebuild and strengthen the current levee system by June, the beginning of the 2006 hurricane season. This follows in the historical tradition of rebuilding the levee system equal to or slightly higher than the most recent flood. Thus, at a cost of $4.5 billion, the levees that failed have been rebuilt roughly to the nominal 5-m elevation previously authorized but with improved earth materials, better anchored flood walls, and armoring to permit the levees to survive overtopping. Supplementing these improvements are the installation of gates to close off three of the canals and improved pumps and energy supplies for management of interior stormwater or flooding. However, these features may not be sufficient. They will not be fully in place until 2007 and may still leave the city at risk from heavy rains (26).

Protecting individual structures by making them flood- and wind-resistant has been a major feature of modern hazard research. The most common form of flood resistance is elevation above some expected flood level. In New Orleans some individual home and business owners had sought their own protection by elevating structures on piers, often using the space below the structure for open or enclosed garages (e.g., Times-Picayune newspaper), additional storage, or shady workspaces. Nonetheless, there is considerable reluctance to elevate damaged buildings, because of appearance, cost, and the technical limits for elevating concrete slab homes. For most residences, city building permits issued before the FEMA advisory, as well as the FEMA advisory itself, make rebuilding possible with no (or minimal) elevation. As to wind damage, New Orleans had adopted the model international building codes before Katrina. Yet even such highly touted buildings as the Superdome, used as a shelter of last resort, showed considerable wind-induced exfoliation, and expert inspections showed that many buildings failed because the code standards were not sufficient, enforced, or applied to older buildings (52).

In early June, a city plan was announced for the complete evacuation of the city including households without cars, the disabled, and the infirm. It specifically rejects "shelters of last resort" within the city (53). But with hurricane season underway, many aspects of the plan (e.g., assistance for elderly in getting to the pick-up points, evacuations sites, use of trains) have not been defined or tested through preparedness drills. Although much discussed, no new action has been taken to change land use or restore wetlands. All current plans recommend creating parks, open space, or restored wetlands in some of the lowest areas for amenity and beautification, as an appropriate use for land that is not rebuilt, and most importantly, as internal stormwater and flood retention basins. But maps showing such parks and open space in badly flooded neighborhoods were seen by many residents as predecessors to the loss of their property or neighborhoods.

Many environmental scientists also argued that wetlands in the delta below the city serve as a buffer zone that dampens the storm surge (54). Before Katrina, a $14 billion marsh restoration plan, known as Louisiana Coast 2050, had been proposed but not funded (55). In the months after Katrina, strong support emerged for river diversion to the west above the Bird's Foot Delta (at the mouth of the river) permitting a release of sediment to enhance the barrier shoreline and thus protect the marshes that protect the city (56, 57).

A More Equitable City? Extreme events reveal the extreme differences in the way we live and die, cope, and rebuild. Historical reconstruction experiences, as well as New Orleans history, consistently report on inequitable patterns of social vulnerability and outcomes of reconstruction. New Orleans was a predominantly black city (68%), and media coverage would easily suggest that poor African-Americans were the prime victims of the flood, the botched evacuation, and the inadequate shelter. But the distinctions were not as sharp as they appeared, because although 75% of the damaged-area population was African-American and 29% poor, areas with little or no flooding had 46% African-American and 25% poor (58). A little over half of the flood deaths were African-Americans, and deaths occurred primarily among the infirm and aged (27).

There were clearer racial and class differences in the ability to cope with the flood, to return, and to rebuild (59). Those with personal transport were able to seek refuge with family, with friends, or in public shelters of their choosing out of the storm's path. After the storm, many evacuees who had to rely on emergency transport out of the city were scattered to totally unfamiliar locations with some family members taken to separate locations. Half of New Orleans residents lived in rental housing. Most public housing remains boarded up, and four major housing developments will not be rebuilt. Temporary housing has been slowed by "not in my backyard" objections.

The far-flung poor are also less able to participate in postflood deliberations, although many did return temporarily in sufficient numbers to reelect Mayor Ray Nagin. Middle class and especially professional residents, both black and white, are core members of the reconstruction planning committees. The new unified effort may provide new opportunity for more equitable participation in the planning effort (46).

A Better City? As is often the case in disasters, in the immediate aftermath of Katrina, hopeful boosters and politicians proclaimed that reconstructed New Orleans will be "bigger and better." Although bigger is not likely, what constitutes better will be the focus of much debate. Three major but overlapping concepts of betterment have emerged. A new urbanism envisions a smaller but carefully *planned city* with revitalized older neighborhoods and restored portions of badly flooded neighborhoods selected by residents. All are equipped with new schools, parks, walks to stores and services, and sustainable architecture built along a backbone of light rail public transport bringing people to both downtown and suburban jobs. The *improved city* focuses on reversing the past by creating a new and advanced school system, an honest city government that is an efficient provider of services and protection, a more multiracial and integrated city that can reverse population loss, and a city safer from crime as well as disaster. The *investment city* focuses on the new economy, creatively using significant public and private funds to

rebuild and invest in previous areas of strength: tourism, culture, medicine, education, and the ports.

Some modest progress can be found for each of these visions, but none currently makes a compelling case for their realization. The delayed neighborhood planning, seen as the heart of a new urbanism, is finally underway. State supervision of schools has replaced the local system. Charter schools, church schools, and newly restored and reorganized public schools will create a more diverse system, albeit with fewer pupils. A few new services have been provided, such as public, free WiFi internet connections in the central business district. A few decisions have been made to restore or rebuild key hospitals and education facilities.

Trajectories of Recovery

There is historical and comparative evidence that recovery after disaster generally follows the predisaster trajectory with the disaster even accelerating previous trends. For cities with growing population and economies, the disaster may accelerate that growth; whereas for cities in economic and social decline, it may hasten decline (5, 6, 36–39, 60). This is not encouraging for New Orleans, whose population had declined by 31% from a peak 1960 Census estimate of 627,525 to the estimated July 2005 pre-Katrina population of 437,186 (21). Five months later, the Census estimated the population at 158,253, a loss of 64% from the already lower July 2005 number (21). One future projection to 2008 foresees a population of 279,000 or 60% of the pre-Katrina population (61).

Economic projections are similar. One foresees two possible levels of economic growth for the metropolitan area, as measured by employment. The metro New Orleans area recovers 41% of jobs by the year 2008 in the moderate scenario. In the high-growth scenario, 66% of the 190,000 jobs lost from pre-Katrina levels are recovered, but only if an unprecedented capacity for house construction can be created (32). In a different projection for a five-parish region that has lost 40% of its population and 13% of its pre-Katrina employment, the optimistic economic recovery scenario projects only 73% of its population and 93% of its employment 5 years after Katrina (33).

There will also be less space to support reconstruction because historical experience indicates that reconstruction always requires more land, sometimes two to four times the previous area (6). To replace previous housing and infrastructure, rebuilding must conform to new standards of activity, construction, or comfort. In addition, some previous land uses are diverted to commemorative or betterment reconstruction. Proposed denser development could house a larger population, but proposed parks, open space, and flood detention basins would remove significant acreage. Future improvements of existing levees and new internal levees would also require additional area. Moreover, some of the city may end up as brownfields requiring long-term cleanup before development.

However, the past is not necessarily a prologue to the future. There are interesting examples of reconstructions that have broken the trends of their predisaster trajectories. In these cases, the city's reconstruction is assisted by some larger contextual changes that overcome the local situation. Three types of such contextual changes have been found after other disasters: external aid that is sufficiently large to actually spur development, spillover effects from larger regions on a different trajectory, or spillover effects of the disaster itself. The first two changes are illustrated in the successful reconstruction of the decaying industrial city Tangshen, China, after the 1976 earthquake that killed over half a million people. The Chinese government refused external assistance from outside China but mobilized exceptional amounts of internal assistance to not only rebuild but to spur development. In addition, the city also benefited from the major economic changes and growth in the Chinese economy that coincided with the completion of its functional reconstruction (62). A more recent example is the growth of Homestead, FL, after it was destroyed by Hurricane Andrew in 1992 and suffered a decade as a depressed local economy. The rising economic tide of downtown Miami and soaring real estate values have made the open farm lands of Homestead into the new suburbia (63).

Disasters themselves have strong spillover effects. Thus, the Great Plains droughts of the 1890s (8), the Mississippi floods of 1927 (18), and the dust bowl droughts of the 1930s (8) all led to massive out-migrations and reshaping of the social and political landscape of the nation. And in Latin America, the failures of the governments in power to rescue, shelter, and rebuild the areas affected by the Managua earthquake of 1972 and the Mexico City earthquake of 1985 led to profound political changes (64).

These examples suggest contextual changes that might reverse the current limited prospects for New Orleans. The first, after the Tangshen experience, would be an extraordinary national effort inspired by the desire to reverse the failures of response to Katrina by all levels of government. Another possibility to reverse decline is the potential impact of upgrading the hurricane protective system to a category 4 or 5, which could encourage a new round of major development while ironically increasing the future catastrophic potential. It is also possible to envision a fortuitous and rapid growth in some of the four economic and employment areas identified by most planners: culture, health, education, and port economy. All four of these are growing rapidly in many other cities fueled by larger national and global trends. Culture economies are replacing retail and office functions in many central cities. The aging of the boomer generation will only add to the rapid expansion of health education and provision of health care services. Globalization will spur educational opportunities to maintain economic and technological competitiveness and draw more international students. It also creates a demand for an expanded and specialized port economy.

Finally, a possible but remote change is the type of political change seen after other great disasters, particularly in Latin America (64). In such a change in trajectory, New Orleans would benefit from a new national initiative to address issues of race and poverty deeply embedded in the society and for which Katrina served as a metaphor and call to action. But an entrenched local and national political culture does not bode well for such a major trajectory change.

Sustaining New Orleans

From the extensive research on natural hazards and the smaller body of research on reconstruction after disasters, we selected four key propositions to explain the catastrophic vulnerability of New Orleans to Katrina; to observe the pace, process, and progress of reconstruction; and to consider its trajectory for recovery. From this perspective, we argue that the broad sequence of decisions, made during New Orleans' history and resulting in an increased vulnerability to Katrina, reflect a long-term pattern of societal response to hazard events: reducing consequences to relatively frequent events while increasing vulnerability to very large and rare events.

The sequence and timing of recovery is somewhat controversial, but it provides a calendar of comparative historical experience against which to gauge progress in the necessary phases of reconstruction. Using this calendar, the emergency period appears to be somewhat longer in duration than any

other of the studied disasters, but the restoration period is in keeping with or ahead of historical experience. The effort to reconstruct the physical environment and urban infrastructure is likely to take a decade, and no commemorative reconstruction is in sight.

The conflicting policy goals of rapid recovery, safety, betterment, and equity and their relative strengths and weaknesses largely reflect experience with large disasters in other places and times. The actual decisions and rebuilding undertaken to date, the so-called ''facts on the ground,'' clearly demonstrate the rush by the residents themselves to rebuild the familiar. This trend is found after all disasters, whereas those involved in the planning process do not share the same urgency. The effort to reconstruct the failed levees to their existing height is also in keeping with historical action. Planning, as in all other studied reconstructions, strongly emphasizes betterment. The considerable emphasis on equity in planning conferences and documents differs from previous experience and may reflect a greater formal sensitivity to minority concerns. The obvious inequities in risks from flooding and in the failures of evacuation result in an inherent conflict with a reconstruction process that although rational, seems to threaten the recovery of some poor and African-American neighborhoods.

Because disasters tend to accelerate existing economic, social, and political trends, the trajectory for full recovery (preexisting population, economy, and infrastructure) is not promising. The large losses in population and employment after Katrina are an accelerated continuation of its 45-year-long decline in population and economic growth, now compounded by the major losses in housing stock. But the bleak prospect offered by the accelerated trends proposition can be yet altered by larger contextual changes found in other reconstruction experiences.

However, drawing upon the extensive research perspective, even the smaller New Orleans of the future can achieve a better balance in its reconstruction efforts. Missing from rapid recovery has been adequate attention to the needs of evacuees who lived in rental housing, especially public housing. The range of safety actions needs to be more redundant than simply restoring or improving the surrounding levee system. Critical areas within the city can be hardened by using secondary protection both by elevation and by a set of inner levees. Financial incentives are needed to enable all homeowners to rebuild to forthcoming FEMA elevations. Experience from developing countries would argue for a redundant system of neighborhood sanctuaries in the form of public buildings—schools or community centers—with upper floors that are able to withstand flooding, maintain power and water, and be converted easily from everyday use to shelters. Betterment reconstruction could use the opportunity of reconstruction to make New Orleans a sustainable city, and some locally produced plans are already available (65). Some equity would be achieved if all evacuees who want to return have the help needed to return by voucher-supported housing, reconstructed public housing, new developments, or reconstituted neighborhoods. All Americans have a stake in the rapid, safe, better, and just reconstruction of New Orleans.

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