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Advances in Geosciences

Hurricane Katrina as a "teachable moment"

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Abstract. By American standards, New Orleans is a very old, very popular city in the southern part of the United States. It is located in Louisiana at the mouth of the Mississippi River, a river which drains about 40% of the Continental United States, making New Orleans a major port city. It is also located in an area of major oil reserves onshore, as well as offshore, in the Gulf of Mexico. Most people know New Orleans as a tourist hotspot; especially well-known is the Mardi Gras season at the beginning of Lent. People refer to the city as the "Big Easy". A recent biography of the city refers to it as the place where the emergence of modern tourism began. A multicultural city with a heavy French influence, it was part of the Louisiana Purchase from France in early 1803, when the United States bought it, doubling the size of the United States at that time.

Today, in the year 2007, New Orleans is now known for the devastating impacts it withstood during the onslaught of Hurricane Katrina in late August 2005. Eighty percent of the city was submerged under flood waters. Almost two years have passed, and many individuals and government agencies are still coping with the hurricane's consequences. And insurance companies have been withdrawing their coverage for the region.

The 2005 hurricane season set a record, in the sense that there were 28 named storms that calendar year. For the first time in hurricane forecast history, hurricane forecasters had to resort to the use of Greek letters to name tropical storms in the Atlantic and Gulf (Fig. 1).

Hurricane Katrina was a Category 5 hurricane when it was in the middle of the Gulf of Mexico, after having passed across southern Florida. At landfall, Katrina's winds decreased in speed and it was relabeled as a Category 4. It devolved into a Category 3 hurricane as it passed inland when it did most of its damage. Large expanses of the city were inundated, many parts under water on the order of 20 feet or so. The Ninth Ward, heavily populated by African Americans, was the site of major destruction, along with several locations along the Gulf coasts of the states of Mississippi and Alabama, as well as other parts of Louisiana coastal areas (Brinkley, 2006).

The number of deaths officially attributed to Hurricane Katrina was on the order of 1800 to 2000 people. The cost of the hurricane in terms of physical damage has been estimated at about US$250 billion, the costliest natural disaster in American history. It far surpassed the cost of Hurricane Andrew in 1992, the impacts of which were estimated to be about $20 billion. It also surpassed the drought in the US Midwest in 1988, which was estimated to have cost the country $40 billion, but no lives were lost.

Some people have referred to Katrina as a "superstorm". It was truly a superstorm in terms of the damage it caused and the havoc it caused long after the hurricane's winds and rains had subsided. The effects of Katrina are sure to be remembered for generations to come, as were the societal and environmental impacts of the severe droughts and Dust Bowl days of the 1930s in the US Great Plains.

It is highly likely that the metropolitan area of New Orleans which people had come to know in the last half of the 20th century will no longer exist, and a new city will likely replace it (one with a different culture). Given the likelihood of sea level rise on the order of tens of centimeters associated with the human-induced global warming of the atmosphere, many people wonder whether New Orleans will be able to survive throughout the 21st century without being plagued by several more tropical storms (Gill, 2005). Some (e.g., Speaker of the US House of Representatives Hastert) have even questioned whether the city should be restored in light of the potential impacts of global warming and the city's geographic vulnerability to tropical storms.

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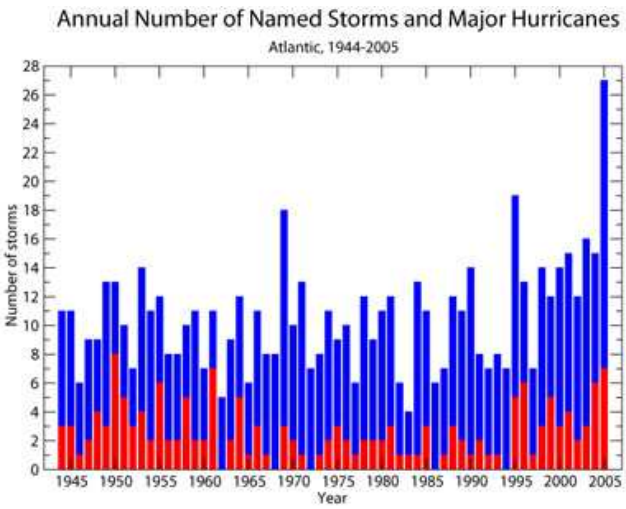

Fig. 1. Annual number of named storms and major hurricanes. Source: NOAA.

1 Teachable moments about science

Hurricane Katrina can serve as an instructive case study of the multifaceted impacts of a natural hazard on a mega-urban setting. As such, it provides students of disasters a "teachable moment", meaning that there are many lessons to be identified by reviewing Hurricane Katrina: the forecast of it, the social responses to the forecast and to Katrina's physical impacts and to differentiated impacts on poor and rich, white and black, and of course the politics of a so-called natural disaster. I have chosen to highlight six teachable moments that are briefly discussed in the paper. The list is as follows:

1. There are limitations on the value to society of a hurricane (or any meteorological) forecast.

   In theory, a perfect forecast several days in advance of a hurricane can be of infinite value to the at-risk society. However, in reality such a perfect forecast is of little value if it is not used to move people out of harm's way. Such movement will depend on a society's decision-making capabilities (timeliness, effectiveness) in the face of an impending threat from a natural hazard.

2. A disaster's direct and indirect impacts result from a mix of natural and societal factors.

   It was only a few decades ago that natural hazards such as droughts, floods, fires and even infectious disease outbreaks were blamed on any one or a combination of climate's various characteristics: precipitation, temperature, relative humidity, cloud cover and variation in the lengths, and therefore expected flow, of the seasons. Research in the mid-1970s and thereafter has shown that a natural hazard's impacts have been worsened by decisions made by policy makers as well as individuals (Glantz, 2001).

3. An early warning by itself does not constitute an early warning system.

   An early warning alone in the form of a forecast is not sufficient to ward off a potential disaster. It is only an early stage in the warning system process, which then involves translating the forecast into usable language for the public, widespread and timely dissemination of the forecast to those at risk as well as those responsible for those at-risk communities, disaster preparedness and even post-disaster reconstruction activities (Glantz, 2007).

4. Superstorms come in all sizes.

   Since the early 1990s, there has been an increase in the use of the adjective "super" with regard to meteorological and hydrological anomalies. A storm could be super because of its record-setting physical parameters, because of the level of damage it causes, because of the number of deaths and injuries, or because someone thoughtlessly labeled the anomaly as having been a superstorm. A definition of superstorm is needed (Glantz, 2004).

5. Katrina has educational value for use by decision makers as an analogue for risks faced by low-lying coastal urban areas worldwide.

   Most likely, all low-lying coastal urban areas have taken notice of the plight of New Orleans and the rest of the US Gulf coast via the electronic and print media. They had to do so, because they may face similar fates in the future given a global warming of the atmosphere: sea level rise, storm surges, changing storm tracks, and changes in storm intensity and frequency. A Katrina case study can be used to "forecast by analogy" the possible impacts that other low-lying coastal cities might have to face with global warming.

6. There are limitations on the use, and therefore value, of scenarios.

   As will be seen below, having a perfect scenario in hand (e.g., the scenario for Hurricane Pam) in no way ensures that proper and timely responses will be undertaken when a similar (but real) hurricane has been forecast.

2 Teachable moments about society

There are also teachable moments about the societal aspects of Hurricane Katrina or, for that matter, any extreme climate, water or weather event. Several of the following statements have actually been made in one context or another related to Katrina. I consider these statements to be either misconceptions or myths. Each of these statements, which some people might accept as valid or as partial truths, demand close

scrutiny, evaluation and discussion and, where appropriate, rejection. They are as follows:

1. Poor people choose to live in dangerous places.

   It is quite clear that poor people do not choose to live in at-risk locations. If they had the financial means to avoid it, they would do so. They are often the victims of circumstances beyond their control.

2. Technology is the answer.

   Technology may be an answer to climate, water or weather related problems, but one must ask, "What was the question for which technology is the answer?" Even with an excellent forecast sixty hours in advance of landfall, the magnitude of death and destruction for Hurricane Katrina was of major proportions.

3. People "learn" from their mistakes.

   This is really an expression of wishful thinking. Sometimes people learn from their mistakes as well as from their successes, but sometimes they don't. That societies, groups, or individuals learn from their mistakes must not be accepted as a universal truth. Whether societies do learn will depend, to a large extent, on the context surrounding (in this case) the forecast of the natural hazard, the ensuing disaster, and societal and governmental responses to it.

4. Global warming has nothing to do with today's (2007) disasters.

   While scientists are not yet in a position to blame any single event on global warming, there is mounting evidence that increases in sea surface temperatures would fuel the intensity of hurricanes. While a definitive statement cannot yet be made affirming that a warmer atmosphere will increase hurricane intensity (though it seems logical), definitive statements refuting such a correlation can also not be made.

5. The Third World is more vulnerable to hazards than are industrialized countries.

   This statement is repeated in the IPCC reports and is apparently accepted by the research community as if it were beyond question and without exception (Agarwal and Narain, 1998). However, the statement and belief must be reviewed for its correctness. I believe that there are sure to be instances where industrialized countries could suffer global warming impacts as much as developing countries. For example, Hurricane Katrina exposed the failure of the US Government's ability to respond to a climate-related crisis.

6. The impacts associated with Hurricane Katrina were the result of a "natural" disaster.

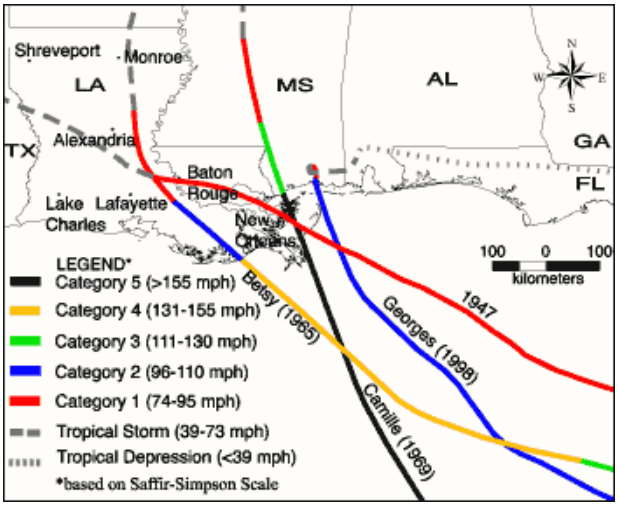

Fig. 2. Was Katrina's path "foreseeable"? From website at http://globalsecurity.org/.

While various government agencies responsible for responding to disaster situations as well as forecasts of them would like to blame Nature for death and destruction, society can usually be shown to have been implicated in the severity of the impacts. Decisions about land use planning, housing developments, land clearing, wetland drainage and levee maintenance can make a society more or less vulnerable by increasing or decreasing its exposure to hazards (e.g., Jackson, 2006).

3 Was Katrina's path or its devastating impacts foreseeable?

The concept of "foreseeability" is borrowed from the law (Gifis, 1991). I view it as a qualitative expression of probability. For example, if I choose to drive a car in a city that I have never visited before and I decide to run through a red light, I would have no idea of the probability for being hit by a car coming from another direction. I do not have the statistics for the traffic at that particular cross-section. However, a person of sound mind would realize that it was highly possible that a car would be coming through the cross-section at the same time. That is why there are red lights at that particular corner to manage traffic. Foreseeability attributes responsibility or culpability. That means that running the red light would be my fault and that I would be responsible for any damages that might occur (Glantz and Cullen, 2003).

This graphic (Fig. 2) shows several hurricane near-misses of New Orleans that have occurred in recent decades. Many articles have appeared during the past two decades in local newspapers (e.g., Times-Picayune) as well as in the national news about the vulnerability of the Gulf Coast to tropical storms. New Orleans has been especially vulnerable, since

Fig. 3. From National Hurricane Center, 26 August 2005.

much of it is below sea level and is protected from flooding by levees. It has been well known for a few decades that the levees were in need of repair. Hurricane Georges in 1998 almost hit New Orleans, but at the last moment it veered to the right of the city.

Hurricane Georges did in fact serve as a wake-up call to those federal, state and local agencies responsible for protecting the city from floods and impacts of tropical storms. All observers accepted the irrefutable fact that the levees had to be repaired. Five years of funding were then authorized by the Congress toward the reparation of levees. Reconstruction began in 2000 and continued until 2003, when funds were diverted away from levee repair to the US war effort in Iraq. Volunteers were left to do their best to continue to work on shoring up the levees. Funds were sorely needed but were unavailable.

One can effectively argue that a Category 3 hurricane would eventually make landfall at or near the New Orleans metropolitan area. Government planners from local to national levels should have foreseen the impacts associated with a hurricane making landfall at or near New Orleans. This observation is not rocket science. It is just common sense to expect landfall, something that seemed to have been missing in the years leading up to August 29, 2005, when Katrina made landfall. Hurricane Pam, discussed below, was a belated recognition of the need to consider a worst-case scenario for impacts of a hurricane striking New Orleans head-on.

Fig. 4. This image was taken by NOAA's Geostationary Operational Environmental Satellite or GOES. Credit: NOAA.

4 Hurricane Katrina

4.1 The forecast on 26 August 2005

This particular graphic (Fig. 3) includes the cone of uncertainty surrounding the projected trajectory of Hurricane Katrina. Note that the trajectory provided on that date depicted a direct hit on New Orleans. The cone of uncertainty shows that the hurricane could have veered to the right or to the left. It did neither.

After this forecast was issued, the director of the US National Hurricane Center suggested on 27 August to the mayor of New Orleans that a mandatory evacuation be undertaken. The mayor, however, chose to call for a voluntary evacuation at that time (Brookings Institution, 2006). On the morning of 28 August, Mayor Nagin ordered a mandatory evacuation.

4.2 After the landfall: post 29 August 2005

This satellite image (Fig. 4) shows that the projected trajectory proved to be the actual path taken by this hurricane. One can also see that the hurricane was several hundred kilometers in diameter. It is important to note that, however attractive this satellite image might be, under those expansive white clouds are death and destruction in coastal Louisiana, Mississippi and Alabama. Under those clouds are homes, streets, neighborhoods, shops, postal zones and communities under water. Under those clouds are uprooted lives, represented by the fact that more than one million people evacuated the region for safer ground. The headline of New Orleans' newspaper, the Times-Picayune, stated "Katrina: the storm we always feared."

The responses to the updated forecasts from a few days in advance until landfall included, but were not limited to, the following: those who had access to cars fled the city, clogging highways for these few days. However, not everyone had access to a car. Many victims chose to stay in their homes, having neither a place to go nor money to get there,

Fig. 5. Breach in 17th St. Canal in New Orleans, LA, 31 August 2005. Credit: NOAA.

if they did find a place to go. Another possible consideration by some who chose not to leave the at-risk coastal areas is that there had been false alarms and calls for evacuations when past hurricanes failed to make landfall. To some Katrina victims, their assumption might have been that this was just another hurricane forecast with a low probability of actually hitting New Orleans.

Once Katrina made landfall, those who remained trapped inside the city eventually had to seek refuge wherever they could. An estimated 25 000 refugees ended up living for several days in the Louisiana Superdome, with no amenities such as toilet paper, soap, diapers, clean clothes, wash facilities and a scarcity of bottled water. Rumors seem to rule media coverage. There were unsubstantiated but broadcasted rumors of people firing guns at rescue helicopters, for example, and allegations of rape occurring in the Superdome. There was considerable finger-pointing by politicians and bureaucrats trying to avoid blame for the ineffective response to the impacts of the hurricane. Frustrated newspersons on TV lost their composure and neutral commentary in favor of blaming the government for its poor response time and inadequate assistance to disaster victims.

Fig. 6. Composite of refugees from Hurricanes Mitch and Katrina (public domain images prepared by CCB).

5 So what happened?

With regard to the physical impacts of Hurricane Katrina, four levees were topped by the waters of Lake Pontchartrain or collapsed (Fig. 5). Eighty percent of New Orleans was flooded, and the poorer African-American parts of the city suffered heavily. As noted earlier, Mississippi and Alabama coastlines, as well as southern Florida, were affected by Katrina, though New Orleans captured most of the media's attention. One million people fled New Orleans by the night of 28 August. Mandatory evacuation was called for on 29 August and, as noted earlier, an estimated 25 000 refugees found their way to the Superdome.

The societal impacts in New Orleans as well as in other affected parts of the Gulf Coast of Mississippi and Alabama and parts of were captured in photos and videos. People were caught on film wading through chest-high water, seeking essentials in flooded shops or transporting family members, neighbors and possessions atop anything that would float (Fig. 6). The pictures showed to the rest of America, as well as to the world, the level of destruction of infrastructure and the depth of despair of those affected by Katrina. Americans everywhere rose to the occasion by sending cash donations as well as food, clothing and other essentials to the victims. They collectively held their breath over the plight of their fellow citizens, regardless of race, creed or religion. A demographic review showed that the victims were in large measure African-American: living in rental housing, disproportionately below the poverty line and, relative to other regions, unemployed (Logan, 2006).

Katrina evacuees fled to the following locations: about 40% to other parts of Louisiana, and about 30% to other parts of Mississippi. Texas, especially Houston, received about 12%; Alabama 8%, and so forth. These numbers are based on applications for federal assistance that had been received by the Federal Emergency Management Agency (FEMA). Houston, Texas, took in the largest number of evacuees who fled Louisiana. The city's government and inhabitants opened their doors to the refugees. Within a year, however, the city wanted Katrina evacuees to return home. A report in

a Newsweek article (Campo-Flores, 2006) stated, "Crime is up. Schools are overcrowded. Hospitals are jammed. Houston welcomed a flood of hurricane evacuees with open arms. But now the city is suffering from a case of 'compassion fatigue'."

The photographs of Katrina's impacts that captured the impacts on affected populations were quite reminiscent of the impacts of Central America's Hurricane Mitch in 1998. Considerable damage was recorded to infrastructure (transportation, electrification and communication), and an estimated 17 000 deaths were associated with Hurricane Mitch. In fact, when Mitch did most of its damage to Honduras, it was no longer a Category 5 hurricane; it had devolved into a very slow-moving tropical depression. There were many photos at the time of victims in Honduras, Nicaragua and El Salvador. To be sure, Americans never expected to see similar photos of American refugees on American soil.

A cursory search on the Internet will find many political headlines about Hurricane Katrina, such as: "Poll: One in three say poor federal response to Katrina hurt race relations"; "Katrina, Miss governance, etc."; "A year later, too little progress"; "Chertoff vows to 're-engineer' preparedness"; "Dying for a home: toxic trailers are making Katrina refugees ill"; "Katrina victims not on Bush's agenda"; "FEMA's 'Pam' simulation foretold Katrina disaster"; "Dry run for Katrina"; and "They knew what to expect."

Scores of cartoons also appeared, focusing on government responses (or lack thereof) to the impacts on Gulf Coast victims as well as to the needs of the refugees. For example, several photos taken during flood stages show people sitting on rooftops throughout the flooded parts of the city, waiting to be rescued by the government, any government. In fact, several offers of assistance in cash and in kind poured in from countries around the globe, most of which were not accepted (Solomon and Hsu, 2007). One particular photo that caught my attention was of a young man in his twenties with his dog sitting on the rooftop of his house, which was submerged, for the most part, under about 20 feet of water. In a cartoon specifically designed to point a finger of blame at President Bush and his administration's abysmal response to the plight of Katrina victims, one sees a caricature of President Bush seated on the roof of the White House holding up a sign for helicopter rescuers to see that read, "Come and git me now."

6 Lessons identified

After every disaster, lessons are identified and recommendations are always made with the hope that similar hazards in the future will not produce the same level of adverse societal, if not physical, impacts. In this regard, Hurricane Katrina was no different than previous disasters. Many lessons have been identified by a wide range of observers as a result of Katrina's occurrence. Yet, a review of retrospective impact assessments undertaken in the past few decades clearly shows that many of the so-called "lessons learned" and recommendations made were in fact not pursued. Most likely what happens is that good intentions are constrained by newly emerging problems and crises that continually arise to confront political leaders and societies. As time passes following a disaster, interest in the disaster and sympathy for the victims tend to wane. This is what American political scientist Anthony Downs referred to as the "issue-attention cycle": in a short period of time, the public becomes tired of focusing on a specific issue and begins to identify with other issues about which to be concerned (Downs, 1972).

Some years ago, I edited a book entitled, *Once Burned, Twice Shy: Lessons from the 1997–98 El Niño* (Glantz, 2001). Since then, however, I have come to believe that what people tend to do following a disaster is to identify lessons but not really learn them. While some of the post-disaster recommendations might be pursued, suggesting that lessons had been learned, most lessons are often not implemented. I now think that the phrase "lessons learned" is part of the problem. By this I mean that the public is led by this phrase to believe that, because lessons have been labeled as learned, they are being used as a guide to the implementing of corrective measures. People are led to believe that an unspecified entity – the government, humanitarian organizations, humanitarian aid agencies of government, citizen groups – is busy applying the lessons that had been identified. However, often this is not the case. It seems that the important chain of events from hazard to disaster to lessons identified to lessons learned is broken in that last link. A web-based search for articles, reports and commentary highlighting "lessons learned" from Katrina yields scores of items.

7 The Hurricane Pam scenario: where real life imitated art

In July 2004, the Federal Emergency Management Agency (FEMA) organized a conference of local and federal government officials to discuss an impacts scenario about a hypothetical Category 3 Hurricane Pam striking New Orleans head on (LSU, 2004). The hypothetical forecast was provided to participants as a perfect forecast to which they and their agencies had to respond. They were asked to respond to expected impacts as well as to the forecast. The scenario for Pam included 20 inches of rainfall, 120-mph winds, and one million evacuees. It was stated as part of the scenario that "as many as 100 000 people lived in households in which no one owned a car." On the order of 250 participants discussed ways to respond to the impacts such an event.

Participants were also asked to develop emergency and recovery plans for New Orleans.

They were told that there would be about 100 000 deaths and many injured, requiring the need for field hospitals to be set up for victims in the flood zone. It was also recognized that there would be considerable debris that would

have to be disposed of and that new landfills would have to be designated. A press conference was held at the end of the exercise, providing the media with a positive view of the preparedness of various government agencies to work together in the event of such a hypothetical disaster (FEMA, 2004). Follow-on Hurricane Pam workshops were conducted in November/December 2004, July 2005, and August 2005.

As it turned out, little in the way of coordination took place in the flood zone for several days after Hurricane Katrina made landfall. Those who had not been evacuated were, for the most part, left on their own, while local to federal agencies tried to get their collective act together. At the time, there was considerable finger-pointing among various local and federal agencies, about who was to have been the first responder, or about who did or did not ask for assistance, and when it was finally requested.

The fact that such a scenario had been played out only one year before New Orleans was tested by an actual hurricane, and the fact that little learning had apparently taken place as a result of the Hurricane Pam scenario, suggest that such worst-case scenarios may have a very short shelf life thereby making them of very limited practical value, even though in theory they may be extremely valuable as heuristic devices.

8 Concluding thoughts

The Hurricane Katrina case study is enough to make any person scratch his or her head in wonderment. How could such a highly industrialized country, the self-proclaimed "leader of the Free World", have responded so poorly to disaster victims on its own soil? The victims were virtually surrounded by the resources they needed.

Two comments made by Congressman Tom Davis at a US Congressional Select Committee Hearing on Hurricane Katrina are very instructive, especially in light of the above:

"[Hurricane exercise] Pam was so very prescient. And yet Katrina highlighted many, many weaknesses that either were not anticipated by Pam, or *were lessons learned but not heeded*." (emphasis mine)

"That's probably the most painful thing about Katrina and the tragic loss of life: the *foreseeability* of it all." (emphasis mine)

Hurricane Katrina is truly a teachable moment. It can help a society to understand its strengths and weaknesses in the face of an emergency situation. If one of the richest countries on earth cannot prepare for or cope with the impacts of a *relatively* weak tropical storm system, one that had been well forecast two-and-a-half days in advance of landfall, what hope might there be for countries whose technological and financial resources are much more limited? Hurricane Katrina also serves to expose not only political and economic differences among social groups in America but also serves to expose racial issues as well. Meanwhile, the scientific community in the United States is divided about the extent to which global warming fueled Hurricane Katrina, the intensity of which had been linked to high sea surface temperatures in the Gulf of Mexico.

A Pew Foundation editorial (2005) entitled "Was Katrina's power a product of global warming?" made the following observation:

"But can science tell us whether Katrina's destructiveness was related to global warming? Not directly: science, as a method, is not good at assigning causation for uncontrolled events, and no single weather event can be linked directly to a long-term driver, such as global warming. This inability to draw a definite conclusion, however, in no sense justifies the conclusion that global warming did not influence Katrina."

As of today, a year and a half after Hurricane Katrina, the issue still remains of who should have been the first responder to the needs of the victims. Finger-pointing continues. While there is enough blame to go around, it is clear (in retrospect) that FEMA's director was incapable of handling a disaster of any magnitude, let alone that of Katrina's. As a political crony (a college friend of President Bush), he came to the office with zero experience in dealing with natural or manmade hazards. After having publicly praised the FEMA director for doing a "heck of a job" a few days after Katrina, an embarrassed President Bush had to release Brown from the agency (CNN, 2005).

As noted throughout, the forecast of Katrina was nearly perfect and was available 60 h – 2 1/2 days – before landfall. There have been several news stories about the success of that forecast. However, no one that I know of has taken credit for coping with the impacts of the disaster that followed in the wake of Katrina. This brings to mind a famous quote attributed to President John F. Kennedy with regard to the failure of the Bay of Pigs in the early 1960s: "Success has many fathers. Failure is an orphan." I have written a variation of Kennedy's quote that applies to the impacts of Katrina: "The forecast of Katrina has many fathers. The impacts of Katrina are orphans." Of one thing we can be sure: there will never be another hurricane named Katrina. Hurricane forecasters retire the names of deadly hurricanes, never to be used again.

As a final comment, all low-lying coastal urban areas should pay attention to the lessons of Katrina, because they too are at risk to coastal storms. As global warming continues throughout the 21st century, sea level will rise and storm surges will move further inland. Tropical storms (typhoons, cyclones, hurricanes) are expected to become more intense and therefore more damaging, if not more frequent. Megacities on the coast must become proactive in the face of the changing global climate.

Lester Brown (2006) made the following observation:

Those of us who track the effects of global warming had assumed that the first large flow of climate refugees would likely be in the South Pacific with the abandonment of Tuvalu or other low-lying islands. We were wrong. The first massive

movement of climate refugees has been that of people away from the Gulf Coast of the United States.

There is a general tendency to move past the last disaster with the optimistic hope of being better prepared to cope with future ones. With regard to the Katrina experience, though, Americans as well as people in other megacities on the coast must take the time to understand and truly learn from this disaster. Megacities beware, in particular all those in low-lying coastal areas around the globe.

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