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# “Mieux Vaut Prévenir que Guérir”: The Effect of Natural Disasters on Water- and Sanitation-Related Infectious Diseases and the Increasing Need for Disaster Preparedness

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*SIT Study Abroad*

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**“Mieux vaut prévenir que guérir”:  
The Effect of Natural Disasters on Water- and  
Sanitation-related Infectious Diseases and the  
Increasing Need for Disaster Preparedness**

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Fall 2010

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## **Abstract**

The world is suffering from an extreme global water crisis. 1.1 billion people in the world lack access to adequate clean water, and 2.6 billion people lack access to water and sanitation. Approximately 10 million deaths per year can be attributed to this water crisis; water-borne infectious diseases play a significant role in this death toll. Diarrhoeal disease accounts for 2.6 million deaths per year and is one of the leading causes of death in many developing countries.

We are entering a period of undeniable climate change which is bringing about more natural disasters and extreme weather events than ever before, and unfortunately these catastrophes significantly exacerbate the already dire global water crisis. It is now more than ever important to understand the complexities of the relationship between water and health. Lack of access to water and sanitation, and infectious diseases severely detract from the quality of life and impede the progress of the developing world. Further, as Hurricane Katrina reminded us in 2005, natural disasters know no national borders or socioeconomic status. We cannot ignore the effect that natural disasters across the world have on water and sanitation systems, especially those across the world that are already sorely lacking, and the resulting burden of disease, and what comprises the response and rebuilding process.

The results of this research highlight the dire need for improved methods of disaster prevention, preparedness, and response. There are many disaster-prone areas of the world that are very ill-prepared to handle these natural disasters when they occur. They lack the physical infrastructure to withstand the disasters, the human and financial resources to mitigate the effects after the disasters, or both. A comparison of the recent natural disasters in both New Orleans and Haiti demonstrates the successes and failures of disaster preparedness and response in both the developed and the developing world. It is absolutely vital to learn to adapt our world to understand to be better prepared for such disasters to mitigate the effects on water systems, and the health of the public overall.

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Finally, I would like to thank my interviewees who helped my research immensely. Mr John Coe from Green Cross Canada made me aware of many of the issues facing Haiti and explained to me in detail one of the many possible solutions for the water crisis in Haiti, both after disasters and in the long term. I am also very grateful for the help of Professor Robert Bea from the Civil and Environmental Engineering department of the University of California at Berkeley. I contacted him after hearing an interview with him from 2006 and he very kindly let me interview him and sent me several documents to assist me with my research.

Once again, this project would not have been possible without the help of these individuals. Thank you very much.

## Introduction

In a time when population is increasing faster than ever (“World Population Growth”, 2004) and climate change is causing natural disasters more often and more extreme than ever before (Greer et al, 2004), it is now more than ever important to understand the complexities of the relationship between water and health. Lack of access to water and sanitation, and the prevalence of infectious disease severely detract from the quality of life and impede the progress of the developing world. Even the industrialized world, as we know it today, struggled with principles of sanitation and water systems for centuries, keeping them from reaching the modern definitions of development. With the natural disasters of the all-to-recent past, such as Hurricane Katrina and the earthquake in Haiti these fragile water and sanitation systems are even further compromised. Additionally, as Katrina reminded us in 2005, natural disasters know no national borders or socioeconomic status. We cannot ignore the effect that natural disasters across the world have on water and sanitation systems and the resulting burden of disease. Though efforts are underway worldwide to impede the progress of climate change, we cannot afford to be unprepared for the change and disasters it is already bringing. With an examination of the world-wide water situation and the resulting burden of water-related diseases and specific exploration of this burden of disease and methods of response in both New Orleans and Haiti before and after their respective natural disasters, the implications for prevention and response practices for the future are apparent: It is vital to learn to adapt our world to understand to be better prepared for such disasters

Across the developing world, independent of the catastrophic interruptions of natural disasters, the water and sanitation situation is severely impeding development (Human Development Report, 2006). Even now, in the 21st century, the lack of clean water and a toilet is one of the leading causes of death for children all over the world (Human Development Report, 2006). Approximately 1.1 billion people, or one fifth of the developing world lack access to clean water, and 2.6 billion, or almost half of the developing world, lack access to sanitation. Further, for another 1.8 million people in the developing world that fall under this umbrella of “having access to clean water”, this term still only signifies that they live within one kilometer of the closest safe water

source (Human Development Report, 2006). For such individuals, the World Health Organization (WHO) places the water poverty threshold at 50 liters per person per day, with the absolute minimum water intake for drinking and basic personal hygiene at 20 liters per day. The averages for most developing countries rest below this water poverty threshold, with several even falling below the absolute minimum (Human Development Report, 2006). Most countries in the developing world provide clean water for less than 70% of their citizens, with coverage rates averaging between 50-60% and dropping as low as 22% in Ethiopia (Human Development Report, 2006). The sanitation situation is, if possible, even more disturbing, with the majority of developing countries providing safe sanitation for fewer than half of their citizens (Human Development Report, 2006). Finally, 10 million deaths per year can be attributed to unsafe water consumption, poor sanitation, and insufficient hygiene (Viladent, 2010). Clearly, the water and sanitation situation of the developing world is already fragile enough without any outside interference.

In contrast, the day-to-day water and sanitation problems of the developed world were largely solved by the beginning of the 20th century. Countries such as the United States can boast 100% coverage for both access to an improved water source and sanitation (WHO "Coverage Estimates", 2006). Further, developed nations use upwards of 300 liters of water per person per day, with the United States coming in on top with an average of more than 600 liters per person per day (Human Development Report, 2006). This contrast is staggering, and throws into even sharper focus the severity of this world-wide situation.

Clearly, with 10 million water related deaths per year, there is a plethora of effects that water has on both the health of an individual and the community; most compromised by natural disasters is the burden of water-related diseases. There are several classifications of such diseases. Waterborne diseases are infections spread through a contaminated water supply; water-washed diseases are infections spread through lack of water for personal hygiene; water-vectored diseases are infections spread by insects who rely on water for some part of their life cycle; and water-based diseases, infections spread by an aquatic invertebrate host (Viladent, 2010). According to the WHO, many water-related diseases must be regarded as a top priority post-

disaster in order to reduce the impact following natural disasters and improve the health status of populations that are continuously disaster-affected (Watson et al, 2006).

Diarrhoeal diseases, responsible for 2.6 million deaths world wide each year, are the most deadly (Human Development Report, 2006). Maladies such as norovirus, rotavirus, salmonella, shigella, campylobacter, giardia, cholera, E. coli, Hepatitis A and E, and leptospirosis are considered to be at the highest risk after natural disasters. Such diseases have been confirmed in both developing and developed nations after disasters (Watson et al, 2006). Although “the overall risk of communicable disease outbreaks is lower than often perceived”, the risk of transmission does increase following natural disasters and it is vital to be prepared to handle such risks to prevent an even deadlier disaster (Watson et al, 2006).

In reality, the actual level of risk post-disaster is very dependent on the individual population; the size of the population, the degree of displacement, and the range of diseases already epidemic or endemic in a certain community all affect the level of risk. It is not the disaster alone that triggers such epidemics and outbreaks (Watson et al, 2007). Developing nations are inordinately affected due to these reasons and the general lack of resources, infrastructure, and disaster preparedness (Watson et al, 2006). However, natural disasters are not confined within the borders of developing nations. There are many disaster-prone regions found in the developed world, and despite a stronger infrastructure and more abundant resources, disaster preparedness can still be sorely lacking. Even today, natural disasters in both the developed and the developing world have absolutely devastating and catastrophic results, though the developed world is often disproportionately affected.

The major cause behind these catastrophic results is not the disaster itself - it is the lack of preparedness to prevent or respond. The lesson throughout history, when it comes to investment in prevention, has continuously been the same: either pay now, or pay a lot more later. However, though some areas of the world have taken this lesson to heart, there are many disaster prone regions that still remain vulnerable to utter devastation. Professor Robert Bea, discussing his theory on Prudent Investment in Prevention (PIP), said “Investments in prevention require a long-term view of the future. The American public generally seems to be focused on the short-term view.” He cites

the major reasons for this being the political process, which encourages this view due to the short re-election cycles, and the commercial-industrial process, which encourages this view due to stockholder requirements for immediate growth and return on investments (Bea, 2010). This mentality needs to change to provide better protection to disaster prone regions all over America and the world. According to his mathematical formula for PIP to justify in which methods one should invest, only the areas that have the possibility to be adequately protected should be protected (See Appendices I and V). However, throughout history, the public tries to do too much, too inefficiently, and too impractically (Bea, 2010).

This short-term view is not restricted to the American public; with few exceptions, this is the view held by most disaster-prone areas across the world. A juxtaposition of two of the most devastating natural disasters in the recent past clearly demonstrates the this short-term blindness and the ignorance of national borders and socioeconomic status of natural disasters, and a comparison of the resulting burdens of disease sheds light on the pros, cons and disparities of disaster preparedness and response methods. Though often natural disasters can be impossible to predict, we are fully aware of many disaster prone areas of the world, and the concept of disaster epidemiology, introduced in 1976, states: "Death rates, according to type of disaster, and attack rates for various types of disorder in survivors could be computed and these indices used in planning appropriate supplies for rescue and relief" (Michel, 1976). Hurricane Katrina in 2005 and the earthquake in Haiti in 2010 both absolutely devastated their respective communities. However, both are located in very disaster-prone areas of the world; this knowledge and the concept of disaster epidemiology should have given them the opportunity to be somewhat prepared to handle the natural disasters Mother Nature brings upon them. Now, these areas must revise their methods of disaster response and preparedness to mitigate future consequences, and the rest of the disaster prone regions of the world must use these experiences to better prepare themselves. As Professor Robert Bea put it so eloquently: "There are no such things as Natural Disasters. There are natural hazards. There is human hubris. When we combine natural hazards with human hubris, we have disasters. When we combine disasters with more human hubris, we have catastrophes" (Bea, 2006).

## Methodology

To conduct this research, I used a variety of sources in order to gather the most complete and comprehensive data possible. I began with a broad overview of the importance of water to public health. I then examined the water infrastructure and burden of disease before the natural disasters in New Orleans and Haiti, the destruction of infrastructure and the resulting change in the trends of the burden of disease. I additionally examined the responses to each disaster and how each response focuses on the water catastrophe. For my study on Hurricane Katrina, I primarily made use of journal articles based on studies done in the months and years after the Hurricane. I also used Morbidity and Mortality Weekly Reports (MMWR) published weekly by the Centers for Disease Control and Prevention (CDC) from the weeks following the hurricane to evaluate the change in the burden of disease. I also used many resources from the United States Environmental Protection Agency (US EPA), and the United States Army Corps of Engineers (US ACE), and the CDC to evaluate the response to the hurricane. For my study on the earthquake in Haiti, as it is a much more recent event in a much less developed country, there were very few journal articles on which to call. However, using news articles in the weeks and months after the earthquake from internationally respected sources, such as CNN, BBC, and Reuters, I was able to gain an equivalent understanding. Additionally, the World Health Organization (WHO), specifically the Pan American branch (PAHO), and other international relief organizations have published briefings on their work and the results in the Haiti earthquake relief effort. Finally, to gain a deeper understanding of the complexities of disaster response, preparedness, and prevention, I conducted two interviews, despite many unanswered efforts to make contacts with other professionals. The first interview was with Mr John Coe, the head of Green Cross Canada, who is trying to set in motion a disaster preparedness effort by Green Cross International. Specifically, he is working on a bio-sand water filter initiative as both a response in Haiti to the water crisis and as a semi-permanent solution as well. The second interview was with Professor Robert Bea of the University of California at Berkeley, who was the head of the definitive report post-Katrina on the levee system failure of New Orleans, and who has many expert opinions on how New Orleans can improve their disaster preparedness and response.

## Discussion and Results

### New Orleans: Hurricane Katrina, 2005

Hurricane Katrina was the costliest and one of the top five deadliest hurricanes in the history of the United States and, according to the National Hurricane Center in 2006, the most devastating natural disaster in United States history (Knabb et al, 2006). It was the deadliest hurricane since 1928, with the final death toll unknown due to the hundreds of persons who remain missing after the storm. A minimum of 1,836 lives were lost in the actual hurricane and subsequent floods, with 450,000 displaced, for anywhere from a few days to a few weeks, and over 200,000 who never returned to their city (Seed, et al, 2006). According to one doctor who responded to the crisis, "New Orleans became a developing country after Katrina hit... there was water everywhere, but you could not possibly dip your hand in it and drink it because it was mixed with sewage" (Khan, 2009). The truth of this statement becomes apparent when compared with the status of the United States in general before Katrina. Infectious diseases, including waterborne infectious diseases, do not appear in the top fifteen causes of death over the last several decades (Xu, 2010). From 1991 to 2002, there has been an annual average of approximately 17 clusters of waterborne disease outbreaks (WBDOs), comprising about 10,000 cases of disease, with a median of 6 deaths per year, representing a negligible percentage of the annual deaths in the United States. The most common diseases from this time period include unidentified acute gastroenteritis (AGI), giardiasis, norovirus, E. coli, and shigellosis (CDC "Surveillance", 2006). In other words, waterborne infectious diseases are no longer an issue that significantly contributes to the burden of disease in the United States. The population is not immune to the possibility of such an outbreak, but the sanitation and water coverage is widespread enough that they no longer pose a significant threat to the public health. By and large, waterborne infectious diseases are no longer a major public health concern in the United States.

## Disaster

Nevertheless, in the immediate aftermath of Hurricane Katrina, waterborne infectious diseases became just that. Countless news articles in the immediate aftermath of the August 29, 2005 hurricane cite the concerns of significant, deadly WBDOs. Further, the official recommendations of the Centers for Disease Control and Prevention (CDC) warned of the much higher likelihood for contraction and outbreak of infectious disease, and describe the various methods of prevention and protection in such a disaster setting (EPA "Flood Water Health Precautions", 2005). Due to the destruction of both the physical water and sanitation infrastructure and the massive inundations of floodwater, this was a very justified concern.

Much of the water system of the Greater New Orleans Area was completely wiped out after the storm. In the entire area affected by the hurricane, over 1,200 water systems and 200 wastewater systems had been affected. Two weeks after the storm, about 40% of these systems were up and running again; even a full month after the storm only 85% of the water systems in this area were fully operational. Further, many of these systems, though they were again functional, were still operating on boil water notices pending tests as to the quality of the water (Copeland, 2005). In Louisiana alone, 23% of the drinking water facilities and 29% of the waste-water facilities were inoperable after the storm, all of which were located within 100 kilometers of the coastline (Muthuramalingam, 2005). Considering that not the entire area of Louisiana was affected by the hurricane, these percentages represent an extremely large portion of the affected area. The impact was severe enough to incur \$2.25 billion of damage (Muthuramalingam, 2005). Direct physical damage and extended power outages affected both the ability to treat and distribute water throughout the area (Ram et al, 2007). New Orleans specifically took the worst hit on their water and wastewater systems in the entire storm-affected region. The cities two largest drinking water plants were completely underwater for at least two weeks after the storm, and even after they were repaired to allow for flow for fire-fighting, toilet flushing, and showers, they did not provide potable water for over a month after the storm. The two largest wastewater treatment plants were also out of commission in the weeks following the storm. In any city, wastewater plants are put at the lowest point so as not to cause run off into the rest

of the city; in a city that is already below sea level, these areas are of course the hardest hit during flooding. Together these two plants serve over 1.8 million customers. In a congressional report published one month after the storm, officials believed that these two systems would need extensive repairs (Copeland, 2005). Estimates by Louisiana public officials declared that 50% of existing treatment plants and 20% of sewage collection systems needed rebuilding (Copeland, 2005). For a population who is used to the comfort of a faucet in their own home, this sudden termination of water treatment can be very dangerous to their health. With little concept of the dangers of this unsanitary water or knowledge of alternative methods sanitation, these infrastructure deficits will inevitably lead to more negative health effects, and possibly an outbreak of waterborne infectious disease.

Waterborne infectious diseases were not only a concern due to the physical destruction of the water and sanitation system infrastructure, but also due to the massive amounts of floodwater in the city that was directly caused by the failure of the hurricane protection system and the levees. Though of course hurricanes bring with them intense rain fall, the drainage system of New Orleans was strong enough to contain any major flooding simply from the rain fall. The levee system, designed and constructed by the US Army Corps of Engineers (US ACE), was the ultimate failure which led to much of the destruction of the city (Seed et al, 2006). The system is a 350-mile protective ring of levees, flood walls, gates, and pumps (Schwartz, 2010). During the hurricane and subsequent storm surges, the levees were breached in 50 different places. Forty-six of these breaches were due to storm surges that were simply too tall and overtopped the levees. Four of these breaches were due to actual structural flaws in the foundations of the levees (NPR, 2006). In 2006, two reports were published that revealed the flaws in the levee system; one was published by the US ACE themselves, and another was published by University of California at Berkeley and funded by the National Science Foundation. Both reports declared that the system was “a system in name only”, with unfinished sections, outdated structures, and lack of coordination both in design and maintenance (NPR, 2006). According to these reports, the levee system had a long history of disorganization and inefficiency. The project was begun over 40 years before and was not projected to be completely finished until 2015; as a

consequence of this, there were several parts left unfinished or not built high enough to withstand the storm surges. Additionally, throughout the history of the levee system, the US ACE had many opportunities to update the technology, especially in 1979 when the entire system was up for review. Despite the fact that the definitions and parameters of storms were outdated at the time of this review, the US ACE did not make any upgrades to the system (NPR, 2006). Many of these failures were simply due to a lack in funding: as other governmental organizations, the budget for the US ACE is constantly under review, and budget choices must be made. Further, the local government is expected to foot 30% of the bill for each US ACE project, and these budget decisions come to vote annually in these local governments as well (NPR, 2006). It was negligence and ignorance that created a problem that cost thousands of lives. Another major problem with the levee system was the method of governance. Some of the levees were controlled and maintained solely by the US ACE, but the rest of them were maintained by several different levee boards that lacked any common governance. Additionally, there is an entirely separate system that manages the water pumps for the drainage of the city, the Water and Sewage Board. With each entity having its own agenda, this lack of governance made it very difficult to effectively govern and maintain the levee and drainage system of the city (NPR, 2006). For a major metropolitan area, this is unacceptable. Frankly, it was negligence and laziness of both the federal and local governments that cost almost two thousand lives. The waterborne infectious disease dangers that come with the flood waters are huge as well: flood waters are inevitably contaminated with raw sewage, which can be a threat to health if individuals drink it or if it comes into contact with untreated wounds (Muthuramalingam, 2005). The catastrophic consequences of Hurricane Katrina left New Orleans with water everywhere, but not a drop to drink.

## Response

The response to Hurricane Katrina was a multi-faceted collaboration of both local, state, and federal governments. The remediation of the water crisis made up only one portion of the overall response, with three major steps in the process: the dewatering of the city, the provision of clean water to victims confined to the disaster area, and the physical reparation of infrastructure to allow continued function of the water and wastewater systems. The primary responders to the water crisis were the Environmental Protection Agency (EPA) and the US ACE, and the Sewerage and Water Board of New Orleans (SWBNO).

The first order of business, before any more advancements could be made, was to remove the actual floodwaters from the city streets. Their actions immediately post-storm included a de-watering of the city, or a removal of floodwater to protect public health. As previously mentioned, floodwaters are inevitably contaminated and pose a threat to the health of the public; additionally, the presence of these floodwaters was making it nearly impossible many other parts of the relief effort to take action. Skimming booms were employed to remove oil and debris from the floodwaters before pumping the clean water into Lake Ponchartrain, the large lake that borders the north shore of New Orleans (EPA "Hurricane Katrina Response", 2010).

The second task is to provide clean drinking water options to those still confined to the affected areas. The EPA responded to this immediate need for clean drinking water with mobile response systems (Muthuramalingam, 2005), and as early as August 30, the day after the storm, Water Division Assistance Teams had been deployed to restore the systems and to deliver safe drinking water to the affected areas (EPA "Hurricane Katrina Response", 2010). Boil water notices were also issued by the EPA all across the affected areas (EPA "Hurricane Katrina Response", 2010). To distribute this information, the EPA used informational handouts and Public Service Announcements (PSAs); however, in the immediate aftermath of the storm, lack of electricity and internet access made distribution of this information very difficult. Further, power lines and natural gas disruption often made such orders impossible to carry out (Pavani et al, 2005). Overall, the effectiveness of such awareness campaign methods is questionable.

The physical reparation of the water and sanitation infrastructure is the final step in the water crisis response process. These repairs took place in the days and weeks after the storm. With the repair of electricity, power lines, and natural gas distribution systems, much of the infrastructure was back up and running. The SWBNO was in charge of many of the immediate repairs of the water and wastewater system. In the days following the storm, SWBNO worked with FEMA to repair the damages to the physical infrastructure. This fall, SWBNO published a report outlining their work in the five years since Katrina, including their emergency response. On August 30, only one day after the storm, SWBNO sent staff to Baton Rouge to obtain diesel fuel to run the water treatment plant in Algiers and to secure cement to prevent flooding of the crucial electric generator that runs many of their plants. On August 31, SWBNO contacted General Electric (GE) to assist in emergency repair of drainage pumps and power plant turbines, with work beginning as early as September 3. Also by September 3, over 350 employees and their families had returned to the city to provide services at pump stations, sewer plants, and water treatment plants all of the city. The SWBNO used Harrell Park, an area near the Carrollton Water Plant, to house many of their employees and their families so that they could return to the New Orleans to work despite the fact that their houses had been destroyed in the storm. By October 16, they had restored primary treatment at the East Bank Waste Water Treatment Plant, one of the major plants destroyed in the storm; one month later, they had fully restored the plant (SWBNO, 2010). Despite the fact that SWBNO sprung into action very quickly, yet it still took almost 2 months for them to restore some of their major water and wastewater treatment plants. It is important both to understand what they did that was effective, and how they could better design their system to evade such widespread destruction in the first place.

## Outcomes

The response, which focused on those three specific steps of the relief process, was lacking in many ways, despite the fact that it was overall a relative success. Though the waterborne infectious diseases never became the greatly feared and talked about epidemics, New Orleans still has a long way to come on their water crisis disaster response. According to one study conducted approximately one month after the hurricane which interviewed respondents from eight communities which had boil water orders instituted, only 31% were aware of the orders. Only 42% of that group and 5% overall reported boiling their water. Further, only 27% were aware of alternate forms of water disinfection, such as chlorination, despite the fact that 87% had a container of chlorine bleach at home (Pavani et al, 2005). These figures are appalling: in a region of one of the richest countries in the world that is an annual victim of the hurricane season, the importance of boil water orders and alternative methods of water disinfection should be common knowledge. Though most of these residents do spend the majority of their lives living in relative comfort, the danger of their surroundings is a very real threat, and it should not go ignored.

Though there was a demonstrated increase in waterborne diseases in the area immediately post-Katrina, these infectious diseases never exploded into the epidemics that the public health community feared. In one study from the Mortality and Morbidity Weekly Report (MMWR), the CDC received reports of diarrhoeal disease from evacuation centers in four affected states: Louisiana, Mississippi, Tennessee, and Texas. Among survivors in these evacuation centers, 20 clusters of outbreak were reported and investigated, surpassing the previously mentioned annual national average in a very confined area in a matter of a few short weeks. The 1,000 cases of diarrhoeal diseases that comprised these 20 outbreaks included norovirus, Salmonella, and nontoxigenic *Vibrio cholerae*, and several other types of gastrointestinal illnesses. Within three weeks of the hurricane, the diarrhoeal disease ceased (MMWR "Infectious Disease and Dermatologic Conditions", 2005). Another report from MMWR described a total of 18 cases of *Vibrio* illness, an infection contracted from contaminated flood and drinking waters; five of those infected with *Vibrio* died (MMWR "Vibrio Illness After Hurricane Katrina", 2005) (See Appendix II).

However, despite the fact that these figures did represent an increase from the annual average rates from previous years, there were no significant outbreaks or major increase in mortality or morbidity solely related to an outbreak of infectious disease. Their response was inadequate, as evidenced by how little the communities knew about the boil water orders and methods of water sanitation; relative the resources available to this city, these results are appalling. New Orleans has the fortune of being a part of one of the world's most industrialized nations; the United States had many resources, both human and monetary, to respond to such a disaster. Though the federal and national response left much of the population of New Orleans wanting much more, it was still effective enough to curb any major outbreaks of infectious disease.

## Preparedness

In a disaster prone region such as New Orleans, lack of preparedness and inadequacy of disaster response has no excuse. In its 288 years of existence, New Orleans has experienced 27 major hurricanes, an average of once every eleven years; climate change has exacerbated both the frequency and intensity of these storms in recent years (Kates et al, 2006). In the past half a century, the city has been destroyed twice by hurricanes: Hurricane Betsy in 1965 and Hurricane Katrina in 2005 (Schwartz, 2010). Additionally, over the past century, a major, debilitating flood has occurred once every 30 to 50 years (Bea, 2006). Further, hurricanes present themselves with several days warning; Katrina formed as a tropical depression on August 23, almost a week before it hit the gulf coast (Knabb et al, 2006). Many residents had the opportunity to prepare for the disaster by evacuating; even those who did not evacuate had time to buy bottled water in anticipation of impaired drinking water facilities. The governments had ample time to distribute and disseminate important information for the health of the public. Yet, overall, prevention, preparedness, and response all failed.

In 1965, New Orleans was similarly destroyed by Hurricane Betsy. Professor Robert Bea, who was living and working in New Orleans at the time, has lamented that he and his family lost their home and all their possessions, including their wedding photos. Further, there were many plans for improvement after this storm as well, and he says that "if everything that was authorized following Hurricane Betsy had been in place and worked, we would have had a few missing shingles, broken glass, and tree limbs - not a devastated city" (Bea, 2010). Fifty years later, Hurricane Katrina did devastate the city, now giving it another chance to provide adequate flood protection to its inhabitants.

Improvements have been made since this disaster to better prepare New Orleans for future disasters; however, some still say that it is not enough. In an article published in August 2010, 5 years after the storm, the New York Times reports on the status of the improved levee system, due to be complete by the beginning of the 2011 hurricane season, beginning in June. Many of the fundamental designs of the levees have changed: where before many were built on mud and shell that was eroded by the storm, the foundations are now reinforced with clay, a substance that is much more difficult to erode. Further, the shape of the levees have changed; they are now shaped

like inverted T's, braced with pilings driven deep into the ground, and built on cement mixed with soil. The system is now designed to withstand the type of storm that is predicted to form once every 500 years, whereas before it was designed for a storm that is predicted to form once a century (Schwartz, 2010). Clearly, the system is strengthening for the better. Additional improvements have been made with the governance of the levee system. There is now a somewhat consolidated levee board, created to remediate the mistakes of these previously un-unified entities (Schwartz, 2010). However, many experts still believe that though the governance system has improved, it still may not be unified enough to allow for the necessary maintenance of the system (Bea, 2010). Finally, the pump systems have been strengthened as well to withstand more flooding. Previously, they were designed only to drain rainfall from the city streets; now they are larger, stronger, and designed to drain the massive amounts of water that would come with a levee breaching (Schwartz, 2010).

However, in an interview with a representative from the US ACE, Edward Link admitted that the strongest parts of the levee system now are those that have been repaired and that "the system is only as strong as its weakest point" (NPR, 2006). In other words, despite these improvements the levee system may still not be able to withstand the next major storm. In fact, many experts believe that even after the improvements are completed in 2011, the system will still not be strong enough to protect New Orleans from the massive flooding that comes with a major storm (Schwartz, 2010). In the same interview, Professor Bea agreed, asserting that an entire upgrade of the system may still very well be necessary (NPR, 2006). Now, four years later, Professor Bea still has a similar opinion. Though he does feel at this point that the system is significantly stronger, "the levels of protection do not match the consequences of failure". Yes, the protection is now adequate enough to protect against another "near miss" like Katrina, where the eye of the storm passed just east to the center of the city. The storm veered off that path at the very last minute. If there was a direct hit, or a storm stronger than Category 3, even with the new and improved levee system, the city would still be devastated (Bea, 2010). Even with all of these opportunities, the New Orleans government and public are still sitting back and allowing their city, their water system, and their well being to be destroyed every few decades.

Additionally, the SWBNO has made many major improvements to the pumping system, the water and wastewater sanitation system. Millions of dollars have been spent on repairs to the infrastructure damaged during such a disaster, such as the Old Carrollton Water Pumping Station, the Central Yard Annex Station, repairs on the Fluidized Bed Incinerator for treating sewage, rehabilitation of the East Bank Sewage Treatment Plant, the replacement the Michoud and Lamb Sewage Pumping Stations, and miscellaneous water leak and electrical repairs (SWBNO, 2010). In addition to the basic repairs that were made on the damaged infrastructure, other actions have been taken to better prepare the system to withstand such a disaster. A system of emergency bypass pumps have been installed, allowing the pumping of water and sewage around damaged stations in the case of disasters such as Katrina. The US ACE has re-started a \$60 million project to build a concrete box culvert canal along Dwyer Road. This project would greatly improve drainage in New Orleans East, a particularly low-lying area of the city where much of the worst flooding occurred. SWBNO has also begun construction on a \$3.5 million, 15 mega watt generator at the Old Carrollton Water Purification Plant. This generator will improve the capability of operation of the pumping systems in all types of emergencies, especially in emergencies where the water system is damaged (SWBNO, 2010). Both the new levee system and the improvements to the SWBNO system, including the generator, are planned to be completed in 2011 (SWBNO, 2010). This response to “storm-proof” New Orleans is the most aggressive in the history of the city, and but still may not be enough to withstand the next major storm.

## Conclusion

The ill-preparedness of New Orleans is not an isolated case in the world; it is not even an isolated case in the United States. In the interview with the experts on levee design and maintenance, they cite many dam and levee projects across the country that remain unfinished. They even declare that the Napa Valley region of California, with its unfinished dam project, is in much greater danger to flood in the next week than New Orleans (NPR, 2006). In one of the most resource-rich nations in the world, the protection of our people in these major metropolitan areas goes largely neglected.

Many disaster-prone nations cannot afford the luxuries of the United States, and most disasters do not offer such advance notice. As mentioned before, disasters such as hurricanes can offer up to a week of notice, giving the government ample time to issue evacuation orders, stockpile supplies, and issue other warnings. The public, in their turn, have the resources to choose whether or not to evacuate, to stockpile fresh water and food, and to prepare themselves for the disaster. Other disasters, such as earthquakes, for example, strike with no warning, and it is equally as important to be prepared to handle such disasters as well. Though today scientists can use seismometers to study earthquakes after the fact, or even to predict a 4 to 10 year window that an earthquake might occur in a particular location, these tools do not provide any concise method of earthquake prediction (Ludwin, 2004). Further, scientists in some countries assert that animal behavior can be carefully analyzed to predict an earthquake, but statistical studies have found no correlation (Schaal, 1988). Though of course it creates a huge advantage to know the exact day or time that a disaster is going to occur, these regions cannot use this relatively little warning to excuse their lack of preparedness.

Further, other disaster prone regions of the world have proved that adequate flood protection is in fact possible. The Netherlands was completely devastated by the North Sea storm of 1953. Almost the entire nation was flooded, and thousands of lives were lost. However, since then, they have provided adequate flood defenses for their people. Today, they have what Professor Bea calls “a flood defense and management system that is a miracle of social and facilities engineering” (Bea, 2005). This system is meant to provide protection for storms that occur once every millennium or once every

10,000 years, as opposed to the system in New Orleans which, when remodeled, should protect against a storm that are projected occur once every 500 years. Now, their unique history and culture are preserved and no longer at danger to imminent destruction during the annual hurricane season, as New Orleans still is. Professor Bea states that such protection for New Orleans would cost in excess of \$100 billion and would have to be completed over the course of 50 years or more, but it will be worth it if executed correctly (Bea, 2007).

The disaster-prone areas of the world know well that they are just that, and it is absolutely vital to enhance awareness of these regions of the consequences of large-scale disasters on the water supply, and water disinfection strategies such as boiling and chlorination, to protect the health of the public in the aftermath of such disasters (Pavani et al, 2006). The flood protection system cannot be inadequate. Professor Bea defines adequate flood protection as “the degree of protection matches the potential consequences of failure of that protection.” He understands that this means that not all parts of the city can be protected; this must be acknowledged by the governments and the public, and policies and plans must be adjusted accordingly. The major failures of the water system and infrastructure in New Orleans were organizational and technical. Though it was a natural storm, the disaster itself was man made (Bea, 2010).

Hurricane Katrina was a horrible catastrophe from which the city of New Orleans and the Gulf Coast is still recovering; yet, as horrible as it was, they were lucky in some ways. They had the opportunity to evacuate. They had the opportunity to prepare. Most importantly, they had the richest country in the world to call upon for its recovery. Most disaster prone areas of the world do not have such luxuries, and in these less developed regions the consequences are significantly worse.

## Haiti: Earthquake, 2010

In contrast, the victims of the earthquake in Haiti were not so lucky. In an article published only days after the earthquake, a doctor from Temple University who led relief efforts in both New Orleans and Haiti compared the two disasters. Dr. Paul Lyons explained, “The two disasters share some similarities, in that both took out most of the infrastructure of an entire city... but Port-au-Prince is at least eight times larger and incomparably poorer than New Orleans... Regardless of what you think about our response in New Orleans, it’s very clear that our ability to respond was infinitely larger than Haiti’s government’s ability to respond (Smith, 2010)”. Places like Haiti are a prime example for the need of such prevention measures: a disaster-prone area that does not have the financial, physical, or human infrastructure to respond to such devastation.

To further contrast the two disasters, it is important to understand the health and water status of Haiti before this disaster as well. Haiti provides water coverage for approximately 55% of the population and sanitation coverage for approximately 30%, as opposed to the 100% in both categories of the United States. Additionally, the average Haitian uses approximately 12 liters of water per day, far below the water poverty threshold, and appalling when compared to the over 600 liters per day of the United States (Human Development Report, 2006). The infrastructure for the system is virtually nonexistent. There is no single water ministry; the responsibility for providing water is spread among the ministries of agriculture, public health, and public works (Guy, 2004). It is very difficult to manage a system like this with no one who is officially in charge of the system or fully invested in it. For a system as vitally important as the national water system, the management must be remodeled. There are two government-owned water services: Centrale Autonome Metropolitaine d’Eau Potable (CAMEP), responsible for providing water in the Port-au-Prince metropolitan area, and the Service National d’Eau Potable (SNEP), responsible for providing water on the national level. However, only between 20-30% of the Port-au-Prince population is covered by CAMEP, and only between 16-24% of the national population is covered by SNEP. Additionally, a lack of regulations does not ensure that this water is of high quality or even potable. Since 1997, there has been a proposal circulating through the Haitian government to create a Ministry of Water and Environment. This would be a

huge step in the progress of Haiti's water system; however, even once that was passed, it would still be millions of dollars that Haiti does not have before any effective infrastructure could be implemented (Guy, 2004).

Further, the status of infectious disease as a public health concern was drastically different. From studies conducted by the Pan American Health Organization (PAHO), a regional office of the WHO, diarrhea is the second leading cause of death in Haiti (PAHO "Health Situation Analysis and Trends Study", 2010). According to the CDC, studies have shown that diarrhoeal diseases account for up to 16% of deaths in Haiti, with an average of 4-6 episodes per child per year across the country (CDC "Haiti Pre-decision Brief", 2010). *Shigella* is highly endemic in Haiti and is the most common cause of bloody diarrhea; according to a study by the CDC, 5% of children under 5 years of age experienced bloody diarrhea in the preceding two weeks (CDC "Haiti Pre-decision Brief", 2010). Leptospirosis and typhoid fever are also considered endemic in Haiti (CDC "Haiti Pre-decision Brief", 2010). Compared the United States, where these waterborne infectious diseases are no longer considered to be a public health concern, Haiti was in a much more dire situation long before the earthquake hit the island.

## Disaster

The 7.0 magnitude earthquake struck Haiti on January 12, 2010 and lasted about 30 seconds, with several smaller aftershocks ranging from 4.2 to 5.9 magnitude in strength. The epicenter was about 10 miles from Haiti's overcrowded capital, Port-au-Prince, with a population of approximately two million. Approximately 250,000 homes and upwards of 30,000 commercial buildings collapsed. The official death toll was set at around 230,000, but many officials believe it to be much higher. An additional 300,000 were injured and 1.5 million were displaced (Fox News, 2010). Consider the difference in the two disasters: Katrina is considered the most devastating natural disaster in United States history, yet its death toll represents less than 1% of Haiti's.

Further, though there was much less infrastructure to be destroyed, the earthquake still had a catastrophic effect on the drinking water status of Haiti. After the earthquake, there was no plumbing left underneath Port-Au-Prince, and many of the water tanks and toilets were also destroyed (Valcárcel, 2010). According to a map published by the United States Agency for International Development (USAID), of the 27 major water tanks in Port-au-Prince, 17 were inoperable, and the remaining 10 were either operable or unassessed. In other words, a minimum of 63% of the water and wastewater infrastructure was inoperable immediately after the earthquake (Mattison et al, 2010). In a country where, on the best of days, sanitary drinking water is hard to come by, this could have catastrophic effects.

Similar to the media post-Katrina, countless news articles published in the days, weeks, and months after the earthquake once again cite the concern of waterborne infectious diseases. In one report from the National Institute of Health, experts discussed the role of waterborne infectious diseases after the earthquake. Of course, with a disaster such as an earthquake, the most significant issues are physical trauma and crush injuries; however, after the first few days, the most significant problem becomes the infectious diseases associated with the lack of clean water. Especially in a situation like Haiti, where the earthquake led to such massive population displacement and overcrowding in make-shift camps, the risk for outbreaks becomes a serious concern (NIH "Special Report", 2010). Another article expressed the struggles of Haiti in comparison to a developed country: "In developed nations, there are plenty of water

stores and portable bathroom units that can be easily brought in to help during a natural disaster. In a place like Haiti, where the airport is small, the roads have been severely damaged, and the port is semi-operational, bringing in water and hygiene supplies is going to be difficult” (Najera, 2010). Further, there was even more concern as the rainy season approached. In an article published in the *Lancet* two months after the earthquake, the public health community’s concerns are very clearly expressed. “The rainy season poses a big risk for the camps, and we’re particularly concerned about outbreaks of diarrhea due to fecal contamination of the water supply,” said Stefan Wiktor, the head of the CDC relief effort in Haiti (Adams, 2010).

At the beginning of November, this fear of the rainy season became a reality. With the imminent threat of Hurricane Tomas, predicted to fatally slam the island, the public and officials in Haiti began to prepare for the worst. Similar to Katrina, Tomas’ path changed at the very last minute, clipping Western Haiti but avoiding the capital. That is not to say its effects were not deadly and catastrophic; in fact, there were at least seven deaths attributed directly to the storm, and as it exacerbated the cholera crisis to be discussed later, many more attributed indirectly (BBC, 2010). Further, the disaster made the world painfully aware of the fact that still, eleven months after the earthquake, over 1.3 million Haitians were still living in displacement camps in dismal conditions. The entire city of Leogane was covered with over 3 meters of water, and in many of the displacement camps people were left standing ankle deep in water (BBC, 2010). In a matter of a few short weeks, this disaster became two simultaneous disasters, with catastrophic effects.

## Response

Over 400 non-governmental organizations (NGOs) have responded to the crisis (Fisher, 2010). Sanitation is a number one priority; especially now, as the rainy season is in full force. The WHO, with their Water, Sanitation, and Hygiene (WASH) cluster, has been a major actor in the water response. According to their estimates, their efforts have reached 1.72 million Haitians affected by the earthquake. At least 5 liters of safe drinking water per person per day is being delivered to 1.2 million people; though this still falls far below the UN estimate for minimum daily water intake, it is a major improvement for some. The Direction Nationale d'Eau Potable et Assainissement (DINEPA), the water and sanitation authority, requested several tons of granulated chlorine immediately after the earthquake, to disinfect drinking water for survivors. The fact that the major airport and port city had been completely destroyed made it very difficult to supply this granulated chlorine, created some serious obstacles for a supply that is usually very easy to obtain. Collaboration with the International Development Bank (IDB) and the water and sanitation utility that serves the Dominican Republic, however, allowed them to find a reasonably priced supplier in the Dominican Republic and provided trucks to bring the chlorine across the border. The IDB has, among other equipment, also helped provide large, collapsible water tanks to store water at emergency distribution points, and conducted a thorough assessment of the damages to the water and sanitation system (IDB, 2010). The WASH cluster has also been responsible for running several training programs for Hygiene Promoters, training a total of 2,200 Hygiene Promoters; significant progress against their initial goal of 2,600 (Fisher, 2010). They have achieved their initial goal in constructing over 11,000 toilets, with 33,000 total toilets projected. They have, however, encountered many obstacles, such as ensuring consistent water quality, a lack of space for construction of sanitation services; landowners that do not allow construction; land that is concreted in that does not allow construction, and constantly migrating populations so the number of permanent residents are unclear (Fisher, 2010).

The construction of the latrines, though it went relatively quickly, is posing other issues as well. A sludge truck arrives daily to pick up the waste from the camps. However, there is really only one dumpsite in Port-au-Prince for disposal of the waste

called Trutier. The dump has four separate areas, for trash, rubble, excreta, and biomedical waste, but since the earthquake the area for excreta is not nearly big enough because all the sludge trucks are forced to empty here. Especially now, with displacement camps springing up in all the outskirts of the city, there is even less space for new landfills. Due to lack of space, some trucks have begun dumping illegally into rivers and canals (Valcárcel, 2010). These actions, if not corrected, will have catastrophic effects on waterborne infectious diseases.

Additionally, in anticipation of the rainy season and increased vulnerability for waterborne infectious diseases, the WHO, in collaboration with UNICEF and the Haitian Ministry of Health, lead a massive vaccination campaign in the affected areas. The campaign, which began in mid-February, had reached 900,000 Haitians by May, and is one of the major successes of the disaster response (PAHO “Nine Months After”, 2010). The campaign vaccinated against many diarrhoeal diseases, among others such as measles (UNIFEM, 2010). They did not, however, vaccinate against cholera. According to the WHO, cholera vaccines are only effective in very specific circumstances. The vaccine is an orally administered, two dose vaccine with the second dose between 1 and 6 weeks after the first. If there is known to be cholera in the area, periodic preemptive vaccination campaigns for at risk populations can be very effective. They are not proven to be effective mid-outbreak, and can often provide a false sense of security and actually contribute to higher rates of transmission. As cholera had not been present in Haiti since the 1950s, it was not seen as a threat and therefore not a part of the massive vaccination campaign after the earthquake. Additionally, as it is not proven to be effective mid-outbreak, there was no campaign after the outbreak had begun either (PAHO “Position on Cholera Vaccination in Haiti”, 2010). These efforts have been effective in containing most major outbreaks of disease; however, one of the most deadly did of course break through.

## Outcomes

Though there was again a demonstrated increase in the burden of disease, for many months, most waterborne infectious diseases did not explode into epidemics as promised. Two new surveillance systems put into action after the earthquake showed no major outbreaks of disease (Fox, 2010), though this is hard to support as there was no surveillance systems in place before the earthquake. Without concrete statistics to compare, it is impossible to confidently assert that there have been no outbreaks. There has been significant mortality and morbidity due to waterborne infectious diseases; however, how it compares to the conditions before the earthquake is hard to say. According to the WHO, diarrhoeal illnesses are the third leading cause of illness and death in the toll of 230,000, falling behind physical trauma and respiratory infections from dust and mold in the air post-earthquake (Bayard, 2010). For many months, even though waterborne infectious diseases remained a significant contribution to the overall burden of disease, all major epidemics were contained.

However, in late October of this year, the post-disaster infectious disease nightmare became a reality with a vicious outbreak of cholera in disaster-struck Haiti. Immediately after the earthquake, though infectious diseases were ranked as a high concern, cholera was not given the highest priority because the disease had not been present in Haiti since 1950 (CDC "Haiti Pre-decision Brief", 2010). Though this is not something that could have been anticipated and fixed by the initial response, it is a lack in preparedness that allowed the water system and infrastructure of Haiti to be destroyed to the extent to let cholera back into the nation. Yet in late October, health officials in both Haiti and the United States confirmed that there had indeed been an outbreak of cholera in Haiti (Gay, 2010). The epidemic began in Artibonite, a suburb of Port-au-Prince. As of November 22, the most current statistics cite a death toll of 1,523 with 27,933 other hospitalized cases, with hundreds more that remain unhospitalized. The mortality rate for the disease is 7.5% (PAHO "Haiti Emergency", 2010). The disease is also present in seven of the ten provinces (PAHO "Health Cluster Bulletin", 2010). For a few weeks, officials believed that they were on their way to containing the epidemic, yet the number has continued to increase.

The national response strategy of the Haitian Ministry of Health in association with WHO/PAHO for the cholera epidemic involved protection of the families in the community, reinforcement of the 80 primary health care centers in the Metropolitan Area, and management of severe cases in hospitals. The plan projected about 100,000 cases in need of services in the Port-au-Prince metropolitan area, and about 200,000 total in the country (“National Epidemic Response Strategy”, 2010). Once again, vaccination was not seen as an effective option for prevention, and was therefore not included in the strategy. PAHO is also using a widespread education campaign to help prevent the spread of cholera. PAHO has sent over 2 million SMS messages to residents in the Artibonite/Port-au-Prince area providing people with basic but life-saving information. They plan to send an additional 2 million over the course of the coming weeks (PAHO “Health Cluster Bulletin”, 2010). They have also distributed posters and pamphlets and hosted educational sessions throughout Port-au-Prince with specific attention to the displacement camps (PAHO “Haiti Emergency”, 2010). There are fears that if the disease does in fact reach the displacement camps, it would become impossible to contain (PAHO “Haiti Emergency”, 2010). PAHO has also begun an educational campaign promoting breast feeding for babies. Organizations such as PAHO/WHO and the UN promote exclusive breast feeding for the first 6 months of life anyway, with complementary breast feeding until the age of 2 for nutrition and immune purposes. During an outbreak such as cholera, breast feeding gives infants and young children two major advantages. Not only does it boost nutrition and their immune systems, it also eliminates the need for baby formula which, if made with contaminated water, will increase the spread of cholera (PAHO “Haiti Emergency”, 2010).

Further, the rainy season did in fact become a major concern with the threat of Hurricane Tomas, which hit Haiti on the morning of November 5. The hurricane was of significant concern to public health officials, and for good reason. This could have very well been the one last hit that would entirely take out the water and sanitation infrastructure, leaving the displacement camps and the populations living there totally vulnerable to the threat of cholera (Partners in Health, 2010). Though in some ways, the Haiti population was lucky in that it was not a direct hit as anticipated, the hurricane has still had catastrophic effects on the cholera epidemic. In the immediate aftermath of the

hurricane, officials said the epidemic had increased by 40% (BBC, 2010), and since then it has increased by more than 200% (Reuters, 2010). Hospitalizations and deaths have both increased drastically since Hurricane Tomas (PAHO “Health Cluster Bulletin”, 2010) (See Appendix II). After dealing with the initial damages from the Hurricane, which were in fact minimal compared to what had been anticipated, it was absolutely vital to continue cholera treatment and prevention without hesitation.

Cholera treatment is very simple, if caught early. The disease can be treated by oral rehydration salts and, in extreme cases, intravenous fluids. In fact, cases of cholera show up every year in countries all over the world, but the disease does not spread in the appropriate public health conditions when treatment is available. This disease would have spread in the conditions in Haiti pre-earthquake as well; in the aftermath of this disaster, the effects were only exacerbated (PAHO “Haiti Emergency”, 2010). The strain has been confirmed to resemble that most commonly found in South Asia, putting a UN base on the Artibonite river that houses Nepalese troops under serious scrutiny, and causing many Haitians to lose faith in the UN effort overall (New York Times, 2010). This lack of faith has increased frustration with the earthquake response and has led to violence and protests that lead to obstruction of care in many areas (PAHO “Haiti Emergency”, 2010). Dr Mirta Roses, the director of PAHO, said “Every hour that the efforts of medical and relief workers are obstructed means more deaths of Haitians from cholera.” With a fatality rate already above 7%, it is anticipated that with continued obstruction of care this fatality rate could increase to five times that. Shipments of medical supplies have arrived, but the airport and many major roads have been closed due to violence, disrupting distribution of the supplies. Since violence erupted on November 15, many PAHO staff members have been confined to their living quarters for almost a week, unable to assist with distribution of supplies, and training and coordination of health workers in the region (PAHO “Haiti Emergency”, 2010). However, no organizations have any intention at the time of evacuating their staff to safer territory. They know that treatment must continue, as consistent and uninterrupted as possible in order to contain the epidemic. Person to person transmission of the disease is very rare; for this reason, educational campaigns and drinking water treatment are the most effective methods prevention and control (PAHO “Haiti Emergency”, 2010).

## Preparedness

Compared to New Orleans and the United States, Haiti does not have the same luxuries to be prepared for or to respond to these disasters. However, some significant achievements have been made, both policy- and infrastructure-based. The major policy-based achievements made represent huge steps in progress for Haiti. Two surveillance systems have been put in place to identify and monitor outbreaks of such diseases in order to better contain them. Two weeks after the earthquake, the CDC implemented the National Sentinel Site Surveillance System in order to better target relief efforts through identification and tracking of disease outbreaks. In collaboration with the Haitian Health Cluster, the CDC also implemented the Internally Displaced Person Surveillance System, tracking trends in the make-shift camps throughout the country (Infectious Disease News, 2010). These surveillance systems were helpful in targeting the areas where relief effort was most necessary; however, they did not give us as much insight because they were newly implemented after the earthquake. The public health system of Haiti previously had no method of surveillance. This is clearly a major gap in the prevention efforts of this disaster-prone area; instead of wasting time and lives while the data is gathered after the disaster, it is absolutely vital whenever possible to have such information before. According to the committees that implemented these systems, “Improving future humanitarian response requires advance development and distribution of easily adaptable standard surveillance tools, development of an interdisciplinary strategy for an early and reliable population census, and development of communication strategies using locally available internet and cellular networks” (Infectious Disease News, 2010).

Additionally, in response to the earthquake, the government has modified the National Contingency Plan in case of future emergencies. Primarily, the plan had to be revised to account for the coming hurricane season and 1.5 million displaced citizens. A new Emergency Operations Centre has been constructed to replace the one destroyed by the earthquake; a 24-hour emergency hotline has been established; and emergency stocks of food, medical supplies, and water have been pre-positioned throughout the country (Fisher, 2010). These adjustments are major improvements for

the overall public health system of Haiti; however, had they been in place before the earthquake, the impact of the earthquake could have been significantly mitigated.

An interview with Mr John Coo, the head of Green Cross International's Canada branch, revealed one of the many ways international NGOs are attempting to build back the water infrastructure in Haiti in a sustainable, disaster-resistant fashion. His organization has appealed for funding and has begun to implement a program of "biosand" filters in Haiti, as both a short-term and long-term response (See Appendix III). The biosand filters are a very efficient and low-cost technology that could be a very good medium- to long-term solution for a country like Haiti (Coo "Interview", 2010). A 93% decrease in waterborne diseases and a 40% decrease in diarrhoeal diseases have been associated with use of this technology. These filters removed 95-99% of organic contaminants such as bacteria, viruses, protozoa, worms, and particles, and inorganic contaminants such as arsenic and mercury. They cost about \$100 each to construct, deliver, and install (Coo "Green Cross Appeal for Haiti", 2010).

Mr Coo sees this disaster as a potential chance to build back a more efficient and effective water system in Haiti, but before this can happen the disaster responses must be better adapted to be more sustainable in a nation like Haiti. The normal water response in disasters such as this is reverse-osmosis, which is not a sustainable method of water purification. For a nation that had severely lacking water services before the disaster, these methods are especially unsustainable. It is a complex method that involves bagging and trucking the water. This is not a sustainable method of water provision for a developing country like Haiti. For an industrialized country, this is a more sustainable disaster response because the infrastructure for permanent water provision already exists and can usually be rebuilt in a reasonable amount of time (Coo "Interview", 2010).

According to Mr Coo, one solution to make the Haitian water system more resilient in future disasters is to have independent, local water provision and purification. "If a storm washes out local roads, or knocks down power lines or destroys 50% of the buildings, the other 50% will still be able to treat their water" (Coo "Interview", 2010). This is true of any disaster- or conflict-prone region, Coo says. In these types of situations, interdependence makes them very vulnerable; local; independent systems

makes them resilient. The biosand filters are a very effective technology that should be part of the permanent solution, but not the only part of the permanent solution. They can be locally made with 95% local materials, with very minimal training and manufacturing facilities; in this way, this method can help jump start and sustain the local economy. According to Coo, a proper well is a better permanent solution, but these are very easily contaminated after a disaster. These biosand filters, if installed in the majority of households, can provide clean, drinkable water for any one that has the ability to draw water or even collect rainwater, which can sometimes need treatment. "Yes, this is an opportunity to build back a more effective water system, and maybe more efficient... however we must try to avoid being drawn into defining efficiency solely in terms of low-cost. Resilience has to be factored into the equation" (Coo "Interview", 2010). There are many choices for disaster response and reconstruction of the water infrastructure in Haiti, and the biosand filters may be the most sustainable and resilient for the purposes of Haiti.

Haiti is a very different case than New Orleans because, though they have long been aware that they are a disaster-prone region of the world, they have never had the resources to address these problems. Of course they were aware of their lacking water and sanitation infrastructure, but "if they are living hand-to-mouth even in good times, they are not going to be investing in preventative measures" (Coo "Interview", 2010). It is difficult to begin development projects in areas such as this, when the government can provide little to no funding, and sporadic funding from the general public and other governments. Though this funding is always appreciated, it is very hard to convince reactionary populations like this to fund preventative measures. Other funders, like international development institutions and foundations, will fund research and preventative measures. However, both types of funding will be necessary to totally revamp the water and wastewater infrastructure of Haiti to make it more resilient and sustainable in future disasters, something that is proving absolutely necessary with the evidence of the recent cholera outbreak (Coo "Interview", 2010). The world cannot stand by when such changes in disaster preparedness and prevention can be made so easily and at so little cost to the general public.

## Conclusion

Haiti has a long history of being vulnerable in almost every way. They are prone to disasters such as earthquakes and hurricanes, they have a history of unstable governments that do not look out for the best interests of their people, and are plagued with infectious diseases, high infant, under five, and maternal mortality rates. They are one of the poorest nations in the world; most residents of the United States or other developed countries could not even begin to fathom the dimensions of the poverty in this country. Much more so than New Orleans, Haiti has somewhat of an excuse for their lack of disaster-preparedness; most people in this country can barely muster together the resources for day-to-day life, much less expensive preventative measures which they may never truly see the results from.

However, as with the comparison of New Orleans and the Netherlands, we know that comprehensive earthquake protection is in fact possible, with the example of Japan. A mere month and a half after the earthquake in Haiti, an earthquake with a magnitude between 6.9 and 7.3 struck Japan which caused no major damage (Weiss, 2010). The earthquake in Haiti, of the same magnitude, killed hundreds of thousands of people and the country is still feeling the effects from it, and will be for a long time. Japan, like Haiti, is an earthquake-prone country, with 20% of the world's earthquakes with a magnitude of 6 or greater occurring near or in Japan (Weiss, 2010). However, their buildings are constructed in accordance with a strict earthquake code, with expensive materials such as the rubber-based elastomeric isolators, a material that was, ironically, discovered on Hispaniola, the island that Haiti shares with the Dominican Republic (Häne, 2010).

Experts acknowledge that there is no way that Haiti, on its own, would be able to afford such expensive technological changes. However, as Haiti is building back their cities, there are some very simple principles they can follow that will increase the structural integrity of the houses. However, experts also acknowledge that the Haiti government is so troubled with corruption and instability that even if these building codes were to exist, there would be no effective way of enforcing them. If this is seen as a specific aim in the reconstruction of these cities, the new city will be more prepared to handle a disaster such as this in the future (Häne, 2010). Unfortunately, however, it is

unlikely that Haiti will ever be as earthquake-resistant as Japan. Foreign and outside donations can only do so much; without internal resources and internal motivation, these policies will have little to no effect.

John Coo encapsulated the need to focus on disaster preparedness in Haiti as a method to pull it out of poverty once and for all.:

*“It will be a huge job, but yes, proper preparedness, response and rebuilding can help pull Haiti out of poverty. When people live on the margins, as so many in Haiti do, they are vulnerable in every way. Their daily life is precarious - flimsy shelters and food and water systems that are easily destroyed by natural disasters - even minor ones. This, coupled with their marginal economic existence means that any set-back can be devastating and undo years of trying to pull themselves up out of poverty. And then they have to go back to subsistence living. If that happens a couple of times to someone they may just give up on the idea of trying to elevate themselves, saving and building a business, because it will just be swept away again by the elements, fate or government. They have to believe that working hard to improve their lot will have a long-term benefit” (Coo “Interview, 2010).*

The vicious cycle linking environment, poverty, and health has Haiti in its clutches. International collaboration is absolutely necessary to focus on the disaster preparedness of this region of the world, as they lack their own resources to help themselves. To improve the public health and prosperity of this nation, it is absolutely vital to help Haiti break free from this vicious cycle of periodic destruction by natural disasters. The technology is available; currently, the resources are not. However, in our increasingly global community, it is nothing short of irresponsible to let an area of our world be periodically destroyed and ravaged by disease when the technology is available to stop it.

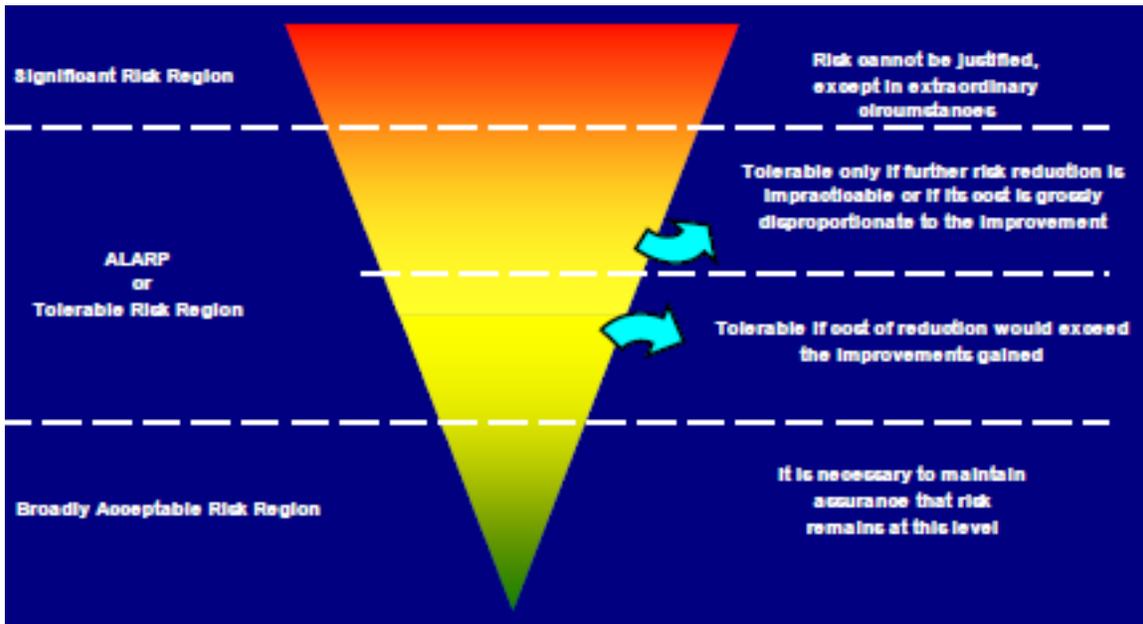
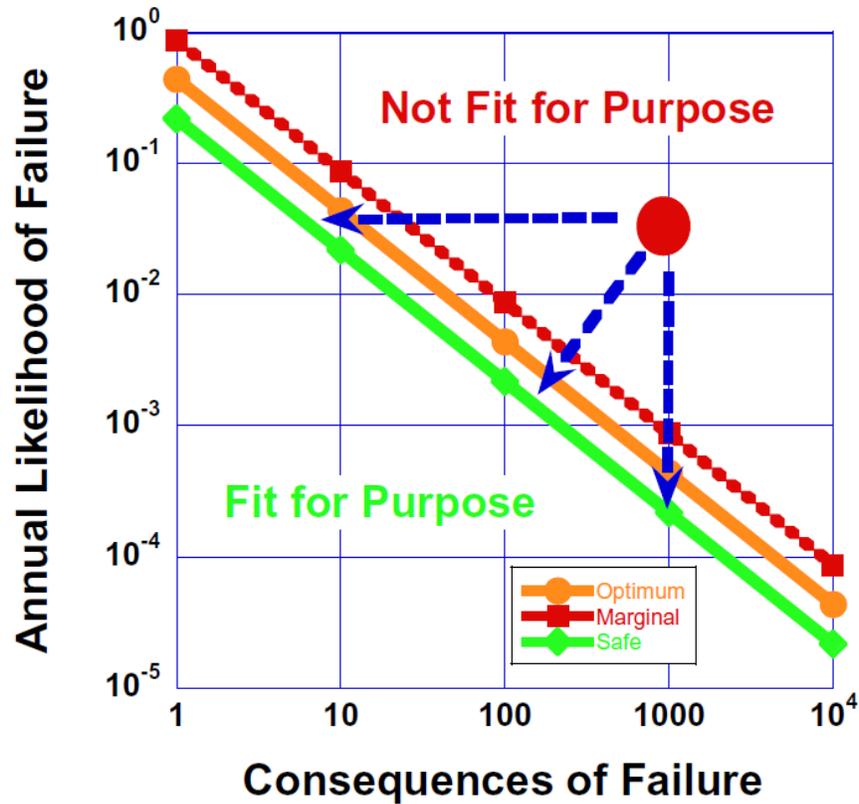
## Conclusion

This examination of the preventative measures, responses, and results of these two disasters, reveals many implications for the future. The richest and the poorest countries in the world each experienced their respective worst disasters; however, both are regions that experience such disasters quite often. There is little excuse for them to be so ill-prepared to handle such disasters. The responses to Hurricane Katrina was enough to curb any significant outbreaks or epidemics of infectious disease; however, these responses were costly and after-the-fact. The response to the earthquake in Haiti, though well-organized and well-financed, could not stop these outbreaks; as a result, more than 1,500 people have already died, with almost 30,000 hospitalized from the outbreak of a single disease. Neither country, developed nor developing, employed any effective preventative or preparedness measures to reduce the impact of the disaster from the very beginning. One report from the National Institute of Health, published in the Canadian Medical Association Journal in 2008, warns of the need for preventative measures regarding infectious diseases and natural disasters. North America is expected to experience marked changes in weather patterns in the next few decades, including a much higher frequency of extreme weather events, and the incidence of waterborne infectious diseases is expected to increase dramatically as a result of this climate change. In developing countries, the increase in the burden of disease is expected to be much more significant; however, according to the report, “the fact that infectious diseases do not respect national borders highlight the need for multinational and collaborative scientific efforts to control disease”(Greer et al, 2008). While of course we must try to modify our behaviors to impede the onset of climate change, that cannot be our only method of prevention against these coming changes. Disaster-prone areas must strengthen their public health infrastructure regarding disease surveillance, food and water safety, outbreak response, and physical water, wastewater, and disaster protection infrastructure (Greer et al, 2008). On a humanitarian level, these methods of prevention and preparedness can save thousands of lives in mitigating the immediate effects and consequences of such natural disasters. Once again, as Professor Bea said: “There are no Natural Disasters” (Bea, 2010). There are the disaster prone regions of the world, and there is human action, reaction, and lack

there of. "*Mieux vaut prévenir que guérir*"; this proverb is true on an individual level, a community level, and a global level. International collaboration and innovation for prevention and preparedness is now more important than ever before. We cannot control the disasters; we can begin to control the damages with our disaster prevention, preparedness, and response.

# Appendix I

Theory of Prudent Investment in Prevention - Professor Robert Bea, PhD.



Source: Personal Files of Professor Robert Bea, PhD.

## Appendix II

### Selected Diseases and Conditions reported in Hurricane Katrina evacuees and rescuers in the 3 weeks immediately after the storm

TABLE. Number of cases of selected diseases and conditions reported in evacuees and rescue workers during the 3 weeks immediately after Hurricane Katrina made landfall — multiple states, August–September 2005

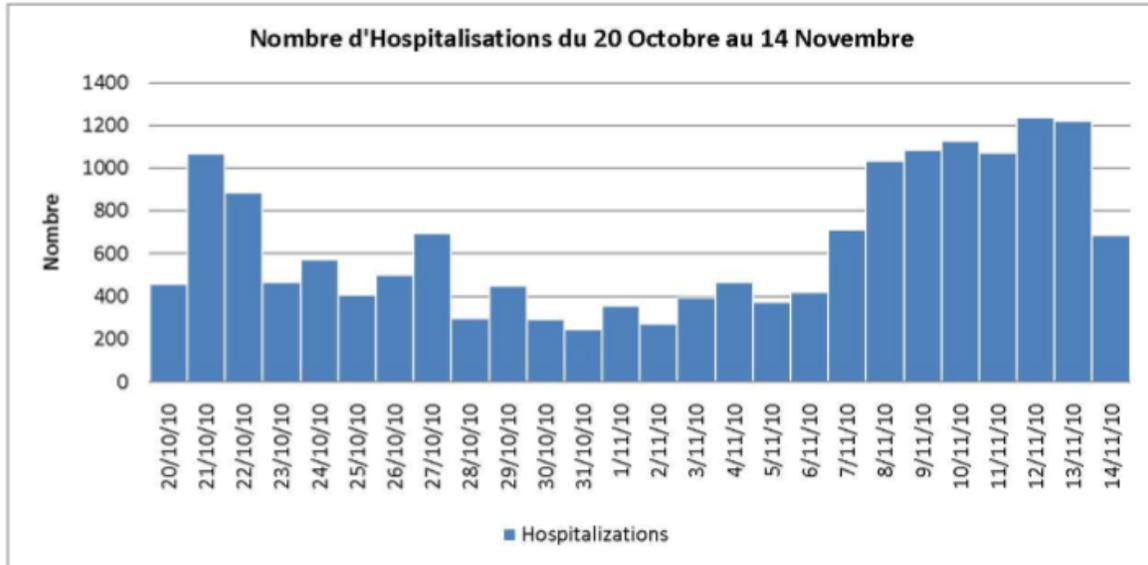
Disease/Condition*	No. of cases	States reporting	Population
<b>Dermatologic conditions</b>			
<i>Infectious</i>			
Methicillin-resistant <i>Staphylococcus aureus</i> infections	30 (3 confirmed)	Texas	Evacuees
<i>Vibrio vulnificus</i> and <i>V. parahaemolyticus</i> wound infections	24 (6 deaths)	Arkansas, Arizona, Georgia, Louisiana, Mississippi, Oklahoma, Texas	Evacuees
Tinea corporis	17	Mississippi	Rescue workers
<i>Noninfectious</i>			
Arthropod bites (likely mite)	97	Louisiana	Rescue workers
<b>Diarrheal disease</b>			
Acute gastroenteritis, some attributed to norovirus	Approximately 1,000	Louisiana, Mississippi, Tennessee, Texas	Evacuees
Nontoxigenic <i>V. cholerae</i> O1	6	Arizona, Georgia, Mississippi, Oklahoma, Tennessee	Evacuees
Nontyphoidal <i>Salmonella</i>	1	Mississippi	Evacuee
<b>Respiratory disease</b>			
Pertussis	1	Tennessee	Evacuee
Respiratory syncytial virus	1	Texas	Evacuee
Streptococcal pharyngitis	1	Texas	Evacuee
Tuberculosis	1	Pennsylvania	Evacuee
<b>Other condition</b>			
Presumed viral conjunctivitis	Approximately 200	Louisiana	Evacuees

\* Other diseases and conditions, for which the number of cases was unknown, included scabies; circumferential lesions at waist; contact dermatitis; erythematous, papular, pustular rash consistent with folliculitis; immersion foot; prickly heat; influenza-like illness and upper respiratory infections; and head lice.

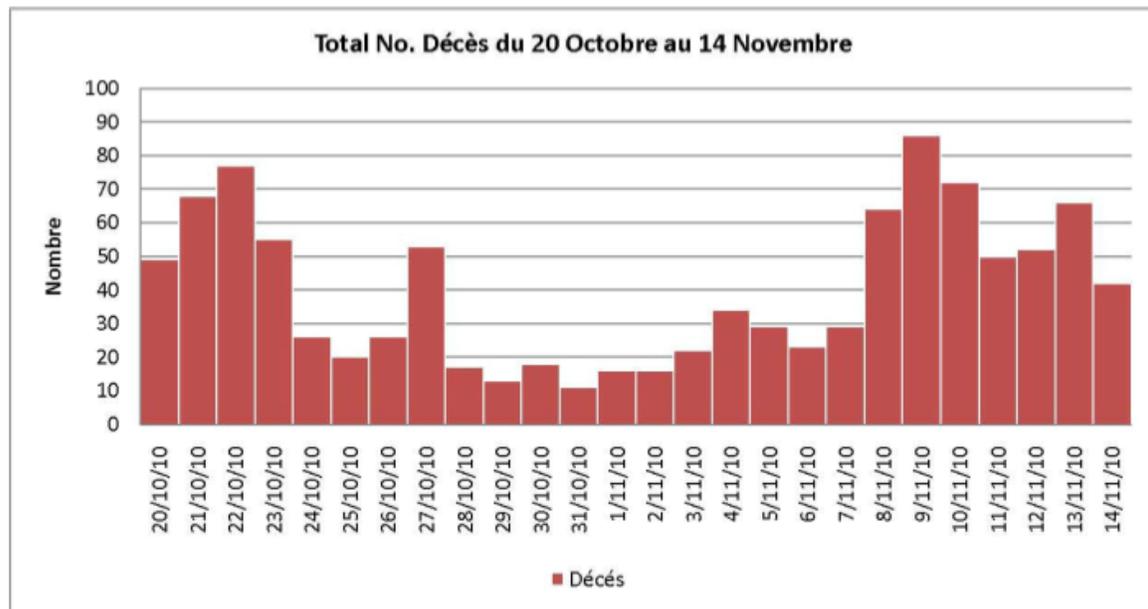
Source: “Infectious Disease and Dermatologic Conditions in Evacuees and Rescue Workers After Hurricane Katrina.” Mortality and Morbidity Weekly Report. 26 September 2005.

## Appendix III

Cholera hospitalizations and deaths between October 20 and November 14 - both increasing drastically in the days after Hurricane Tomas, November 5



Number of cholera hospitalizations: October 20 - November 14

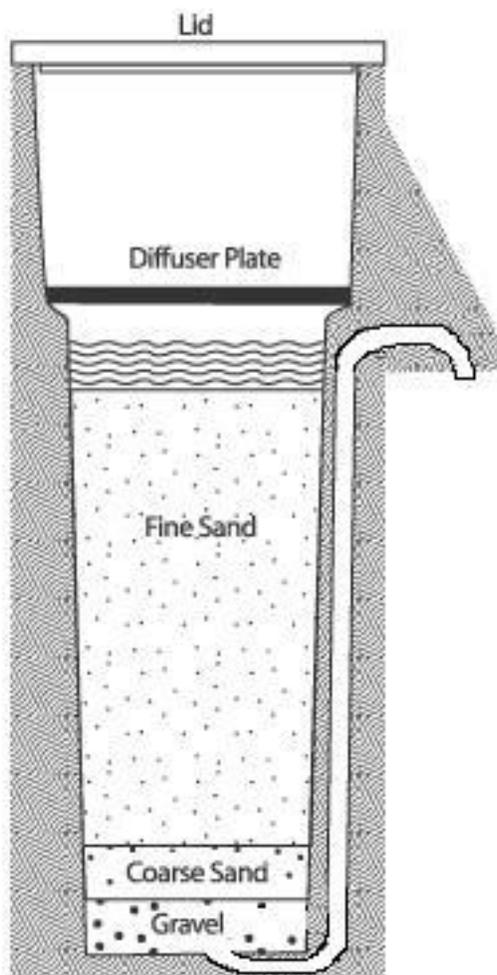


Number of cholera deaths: October 20 - November 14

Source: "Health Cluster Bulletin - Cholera Outbreak in Haiti - #2." [Pan American Health Organization](#). November 16 2010.

## Appendix IV

### Biosand filter used by Green Cross International - Canada in their response in Haiti



The biosand filter is a very low-cost, efficient technology that has existed for decades for people who live in areas with no access to naturally safe or treated water. Fine and coarse sand and gravel are layered in either a concrete or plastic barrel. Contaminated and untreated water from rain, surface, or ground surfaces is poured through the filter, passing through a plate that diffuses the stream and blocks large contaminants. The water is then collected in a PVC collection pipe. These filters remove between 95-99% of organic contaminants and can produce between 20 and 60 liters of water per hour, depending on the size. These filters can reduce the incidence of diarrheal illness by up to 40% and incidence of waterborne disease by 93%. Maintenance is required, but in the form of a simple stirring or skimming tool of the top layer of sand in order to remove any clogging of the sand. They are very easy to use and are already in use in many households in Haiti.

Source: Coe, John. "Green Cross Appeal for Haiti." Green Cross Canada. 2010.

## Appendix V: Interviews

### V.A: Interview with Professor Robert Bea of the University of California at Berkeley and author of a major review of the levee system of New Orleans - November 16, 2010

**Malam:** *Please discuss your theory of “prudent investment in prevention.” Are people too prudent when it comes to investment in prevention, as in do you feel there is not enough investment in prevention? In the US? Worldwide?*

**Bea:** The 'prudent investment in prevention' (PIP) is a key topic in the work I have done before, during, and after Katrina. The PIP has two important effects on Risk: investments can lower the likelihoods (probabilities, Pf) and consequences (Cf) of 'failures'. About 30 years ago, I developed an analytical expression that connects the invested costs (Ci), Cf, and Pf.

The 'optimum' (minimum total costs)  $Pfo = 0.4348 / (Cf / \Delta Ci) \times pvf$ . The 'marginal'  $Pfm = 2 Pfo$ . the 'safe Pfs =  $0.5 \times Pfo$

Delta Ci is the cost required to lower Pf by an order of magnitude.

Pvf is an annual monetary discount. For long life systems,  $pvf = 1 / \text{net discount rate}$ . example if net discount rate is 10% per year, then  $pvf = 10$  years (typical for industrial commercial systems). If net discount rate is 1 % per year, then  $pvf = 100$  years (typical for societal systems).

The consequence scale shown below is  $(Cf / \Delta Ci) \times pvf$ . The diagram is divided into two sectors: Fit for Purpose, and Not Fit for Purpose. (*See figure above*).

If Cf is high, then Pf must be low. if  $\Delta Ci$  is high (initial costs of prevention) are very high, then Pf must be higher. If the pvf is large, then Pf must be low. The consequence scale shown below is  $(Cf / \Delta Ci) \times pvf$ .

The three lines are Pfs (green), Pfo (orange), and Pfm (red). These three lines describe the 'legal' ALARP (As Low As Reasonably Practicable) region (see second figure below).

If a system falls in the Not Fit for Purpose sector, then either Pf can be reduced, Consequences of Failure reduced (e.g. reduce Cf), or a combination. Here is how deliberations concerning PIP can be focused.

Investments in prevention require a long-term view of the future. The American public generally seems to be focused on the short-term view. The political process encourages this view given our short re-election cycles. The commercial - industrial process also encourages this view given stockholder requirements for immediate growth and return on investments.

Flood protection systems require continuous maintenance and improvement. Yet, our congressional funding process is focused on the Water Resources Development Act that is addressed every two years. This process is focused on short term projects. thus, coherent SYSTEMS are not developed, and there are no provisions for long term developments.

This is not the process used in the Netherlands or Japan for flood - water protection.

**M:** *It is often hard to get any funding or attention for such programs until AFTER the disaster has hit - why do you think this is the case?*

**Bea:** The American public is clearly 'reactionary'.....this goes back to the days the U.S. was founded.....we must be 'hurt' before we take action to fix the hurt.

**M:** *How do you think this global mentality must change to have a more effective influence on disaster prevention, preparedness, and response?*

**Bea:** Some changes have begun...largely in parts of Europe....focused on global climate changes....which are inevitable.....the climate has been changing since there was a climate to change.....we are beginning to understand and mobilize reactions to what we understand.

**M:** *Do you feel that New Orleans could have been better prepared to protect against Hurricane Katrina, both on a general level and specifically relating to the water system?*

**Bea:** Yes. I have said that if everything that was authorized following Hurricane Betsy had been in place and worked, we would have had a few missing shingles, broken glass and tree limbs - not a devastated city.

**M:** *What do you think could and should be done in New Orleans to increase the capacity to prevent destruction of the city?*

**Bea:** Occupy only what can be adequately protected after it has been protected. Adequate means that the degree of protection matches the potential consequences of failure of that protection.

**M:** *Why do you think these actions have not been taken?*

**Bea:** The U.S. is not willing to make the necessary short-term and long-term investments to provide the adequate protection.

**M:** *Has the issue of the Levee boards being separate from the Water & Sewage board been solved?*

**Bea:** No. The interagency conflicts persist.

**M:** *Is the governance of the levees in any better shape?*

**Bea:** Some, not a lot. The state failed to provide sufficient funding to support the flood protection authorities.

**M:** *What must be done and what effect do you think it will have?*

**Bea:** If the city wants adequate flood protection, then the city is going to have to take responsibility to develop and maintain that protection. This means mobilizing local, state, and federal support. The city is still in a "throw me something mister" mentality.

**M:** *Do you feel like the state of Louisiana has taken enough responsibility for the rebuilding of the levees?*

**Bea:** No

**M:** *Is the Louisiana Corps of Engineers now a more significant participant?*

**Bea:** Yes

**M:** *As of June 2006 you said that one year after the storm, though the system is "fundamentally stronger", it is not "significantly stronger." Now, four years later, are you satisfied with the improvements and changes made on the levees?*

**Bea:** No. The levels of protection do not match the consequences of failure. Thus, people need to "build high and strong" - rather than depend on the existing flood protection system.

**M:** *Do you feel like the levee system is significantly stronger?*

**Bea:** Yes.

**M:** *Do you feel that New Orleans would be safe if confronted with another Katrina-sized storm?*

**Bea:** Yes...if it was a 'near miss' like Katrina. if it was a 'direct hit' with the eye of the storm passing just to the west of the center of the city (not east as it did during Katrina), then i am not so sure that the system would be able to withstand a surge in the range of 25 feet with the associated wave action from the Gulf.

## **V.B: Interview with Mr John Coo, head of Green Cross International, Canada Branch - November 14, 2010**

**Malam:** *You hope to develop a program that researches these natural disasters in order to prepare disaster-prone areas of the world to have better prevention and response methods in the future. In the briefing on "Environmental Disaster Response", you mention how due to climate change this is now more important than ever. However, it is often hard to get any funding or attention for such things until AFTER the disaster has hit - why do you think this is the case, and how do you think this global mentality must change to have a more effective influence on disaster prevention, preparedness, and response? What is Green Cross International doing in particular to change this global mentality?*

**Coo:** Some funders respond only after a disaster has hit - like the general public and governments responding to citizen concern. Other funders - like international development institutions and foundation - are prepared to fund research and preventative measures. We will need both kinds of funding. One challenge will be to set up a system to capitalize on public attention about natural disasters, like humanitarian organizations do.

**M:** *Do you feel that New Orleans could have been better prepared to respond Hurricane Katrina, both on a general level and specifically relating to the water system? What do you think could be done in New Orleans and other disaster-prone areas to increase the capacity to prevent destruction of these water systems or to develop a more timely response to the destruction of these water systems?*

**Coo:** I have not had the opportunity to study the New Orleans case (that would be part of phase 1 of my project) but from what I have heard, yes, they could have been better prepared. They allowed the natural systems that provided buffers and resilience to be eroded over time (like bayous, swamps). Coastal areas need understand the role of natural defenses and revisit the changes they have permitted or encouraged to those natural landscapes to see what must be replanted or built back. Another example of this is hillside deforestation in Haiti. So they also have to examine how major rainfalls or flooding will affect run-off and what that run-off will contain. For example, in New Orleans, when the floodwaters came in, they flooded a bunch of gas and oil storage facilities and sucked that industrial contamination back out to sea as the waters receded. It was weeks before anyone was paying any attention to that. But that was an obvious potential problem and easily predicted.

**M:** *Taking into account Haiti's history and socioeconomic status, could Haiti have been more prepared to handle the earthquake, both on a broad level and specifically relating to the water system? What can be done now to better prepare Haiti for such disasters in the future?*

**Coo:** Haiti is a harder case because it never had the resources to address these problems. The potential problems were obvious enough, but if they are living hand-to-mouth even in good times, they are not going to be investing in preventative measures. In the short and medium term that level of planning and preparedness will only come from the international community. Given the problems of building large scale infrastructure in Haiti, one solution to minimizing water problems in future disasters is to build resilience by having independent, local water provision and purification. For example, if every house in a village had a water filter like the ones we provide (biosand) then so long as they can draw water somewhere, they can treat it themselves. If a storm washes out local roads, or knocks down power lines or destroys 50% of the buildings, the other 50% will still be able to treat their water. Small scale, locally housed, non-interdependent systems bring resilience to disaster-prone areas. The same thing is true in conflict zones. One of the first things military strategists do (after hitting military targets) is to destroy civic and industrial infrastructure (power generation and transmission, hydro dams, bridges). So inter-dependence makes them vulnerable. Local, independent systems (solar power, wind, small-scale water treatment) makes them resilient.

**M:** *Water-borne infectious diseases were already a major issue in Haiti due to the inadequate water and sanitation coverage. Do you think the earthquake, with its widespread destruction of the water system, has given Haiti an opportunity to build it back a more effective and efficient water system?*

**Coo:** It has laid the problem bare. Ironically, the early response for water provision, large scale reverse-osmosis plants, has added to the problem, in that the population has learned to identify that as the best water solution. But reverse-osmosis is expensive and complex and involves bagging and trucking water, so is not really sustainable. Now it will be hard to wean people off the ultra-high quality water solutions they have been receiving. However, many agencies see this problem and are seeking more sustainable solutions. So yes, there is an opportunity to build back a more effective water system, and maybe more efficient - well certainly more cost-efficient than what is going on now. However, we must try to avoid being drawn into defining efficiency solely in terms of low-cost. Resilience has to be factored into the equation.

**M:** *Is the bio-sand filter initiative projected to be a permanent installation for everyday use or solely for after disasters? Why is this the most effective method for water filtration in Haiti? Do you think citizens of Haiti likely use these filtration systems effectively? Is this method of water disaster response applicable to other disaster-prone regions of the world, such as New Orleans? What other methods did you consider?*

**Coo:** Yes the biosand filter system is intended to be a medium to long-term solution, but perhaps not permanent. A proper well is a better permanent solution, but often even these are contaminated, especially after a disaster. Even rainwater harvested sometimes needs treatment. So maybe they will be a permanent part of the solution. The reason they are good for Haiti and many other places is that they can be locally made, with 95% local materials and minimal training and facilities. Yes Haitians can

use the filters effectively and have been for many years in many parts of the country (and in many African countries). Are they a solution for developed countries, like the US? I am not sure. People are used to municipal water services and will be hesitant to use low-tech filtration solutions. In most industrialized countries probably short-term, high-tech solutions are good in a disaster situation and infrastructure can be rebuilt in reasonable time.

**M:** *Which do you feel is a more cost-effective epidemic-prevention method - a massive vaccination campaign or a massive water filtration campaign?*

**Coo:** That is beyond my expertise, but I suspect it is very dependent on the specific situation. And no one in development/humanitarian assistance wants to set up competing needs - both are important.

**M:** *Do you believe that effective preparedness against disasters could help pull Haiti out of poverty? Without an annual struggle of recovering from tropical storms and with more confidence that Haiti would be able to survive a disaster, would Haiti be able to work more successfully towards sustainability?*

**Coo:** It will be a huge job, but yes, proper preparedness, response and rebuilding can help pull Haiti out of poverty. When people live on the margins, as so many in Haiti do, they are vulnerable in every way. Their daily life is precarious - flimsy shelters and food and water systems that are easily destroyed by natural disasters - even minor ones. This, coupled with their marginal economic existence means that any set-back can be devastating and undo years of trying to pull themselves up out of poverty. And then they have to go back to subsistence living. If that happens a couple of times to someone they may just give up on the idea of trying to elevate themselves, saving and building a business, because it will just be swept away again by the elements, fate or government. They have to believe that working hard to improve their lot will have a long-term benefit.

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