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Disaster law and emerging issues in Brazil

Direito dos desastres e questões emergentes no Brasil

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Abstract

Scholars around the world are beginning to focus on the role of the legal system in preparing for such events and responding to them after they occur. This article offers an introduction to the field of disaster law with a particular focus on the United States and Brazil. The article begins with an overview of disaster law and explains some unifying themes. These themes connect risk mitigation, emergency response, compensation, and rebuilding after disasters. The remainder of the article focuses on one crucial insight: harm from disasters is almost always caused or at least worsened by failure to regulate risks in advance using land use law or environmental law. Disaster law will become even more important in the future due to climate change and other developments, such as population growth and expanded populations living near coasts and estuaries.

Key words: Natural disasters, nuclear power, pollution, oil spills, climate change, risk management.

Resumo

Estudiosos de todo o mundo estão começando a focar no papel do jurídico na preparação para esses eventos e na reação a eles depois de sua ocorrência. Este artigo oferece uma introdução ao campo do Direito dos desastres com um foco particular nos Estados Unidos e no Brasil. O artigo começa com uma visão geral do Direito dos desastres e explica alguns temas unificadores. Estes temas conectam a mitigação de riscos, a resposta de emergência, a indenização e a reconstrução após catástrofes. O restante do artigo foca uma percepção crucial: o dano das catástrofes é quase sempre causado ou no mínimo agravado por falta de regulação antecipada de riscos pelo direito fundiário e pelo direito ambiental. O Direito dos desastres tornar-se-á ainda mais importante no futuro devido à mudança climática e outros desdobramentos, como o crescimento populacional e o aumento das populações vivendo próximas a costas e estuários.

Palavras-chave: catástrofes naturais, energia nuclear, poluição, derramamentos de óleo, mudança climática, gestão de riscos.

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Introduction

The last few decades have been punctuated by natural disasters and manmade accidents. The disasters include severe tsunamis, cyclones and hurricanes, while notable accidents include nuclear meltdowns and massive oil spills. Legal scholars around the world are beginning to focus on the role of the legal system in preparing for such events and responding to them after they occur. This article offers an overview of the field of disaster law with a particular focus on the United States and Brazil.

Traditionally, Brazil has not been heavily exposed to natural disasters, but insurance companies say that this situation is changing:

> Natural disasters will likely become more frequent in Brazil and also more costly in terms of human lives and government expenditures, said Fabio Corrias, Swiss Re's head of corporate solutions for Brazil and the rest of the Southern Cone.
> Brazil has traditionally had a very low exposure to natural disasters, but during the last five years the frequency of events such as heavy rains, floods and avalanches has increased, Corrias told a conference in Sao Paulo hosted by the Swiss reinsurer.
> The latest such events occurred in January this year in the states of Sao Paulo and Rio de Janeiro, when floods killed more than 800 people and left some 6,000 homeless.
> Corrias noted that due to lack of insurance and reinsurance, this event cost the public sector US$460mn in emergency spending.
> The area most exposed to natural disasters in Brazil is the south east due to high population density, Corrias said (Rindebro, 2011).

The Brazilian legal system is still adapting to these new issues arising from disasters.

One of those issues is risk mitigation. For instance, lack of preparation may have contributed to hundreds of deaths from landslides:

> The hillside areas around Rio lacked early warning systems or effective community organizations that might have helped residents to wake one another as the rains intensified last Tuesday night, disaster experts and residents said. Most people are believed to have died early Wednesday morning as they slept, when water-loosened earth swept their houses away (Kahn, 2011).

Illustrating the connection between disaster risks and inadequate regulation, weak control of urban settlement was also a contributing factor in the Rio landslides:

> Rio de Janeiro State officials have cited irregular occupation of areas at risk of floods and landslides as the main reason that so many have been dying. Carlos Minc, Rio's environment secretary, said Thursday that the state's civil defense authority urgently needed to relocate residents in high-risk areas (Kahn, 2011, quoting Brazilian sources).

This article attempts to provide a framework for thinking about these emerging issues in Brazil, without being so presumptuous as to suggest the correct solutions for the Brazilian legal system. It is tempting to think that disasters are either natural events completely outside of human control or are unavoidable accidents. But human beings can plan ahead to reduce the probability of many disasters and reduce their harm, as well as establishing procedures for rebuilding afterwards. Legal scholars in the United States and elsewhere are beginning to focus on disaster law as a field of study. Hopefully, some of the lessons may be useful in the Brazilian context.

Disasters strike unpredictably enough that we are somehow always surprised and never quite prepared. The risks are also diverse and the harms are distinctive: an earthquake is not a hurricane, and a hurricane is not an oil spill. But there is a deep underlying predictability to disasters. Nothing is more predictable than the fact that some day again a major hurricane will hit a U.S. or Caribbean city; that heat waves will hit cities; or that poorly regulated but dangerous industries will have devastating accidents. It is also predictable that, if we do not address climate change, coastal cities around the world will be at greater risk and heat waves will be more devastating. It is heartening that the legal academy is beginning to pay attention to these risks in a serious way, but much more needs to be done.[2]

Part I of this article provides an overview of disaster law and explains some unifying themes. These themes connect risk mitigation, emergency response, compensation, and rebuilding after disasters. The remainder of the article focuses on one crucial insight: harm from disasters is almost always caused or at least worsened by failure to regulate risks in advance using land use law or environmental law. These regulatory failures set the stage for widespread harm but often are not appreciated in advance of the event.

[2] Although this article focuses on the legal literature, disasters are also the subject of a robust and growing body of work in economics and policy analysis. See, e.g., Kunreuther and Useem (2009).

Part II illustrates this point with examples from around the world, including Brazil. Examples include floods and landslides, nuclear reactor meltdowns, oil spills, and heat waves. In each case, lack of adequate control of risks—a failure of the regulatory state—contributed to the tragic outcome.

Part III then focuses on a particular regulatory failure: the failure of the international community to control climate change. This failure will increase many kinds of disaster risks, whether in developed countries like the United States, or developing countries such as Brazil. Disaster law will become even more important in the future due to climate change and other developments, such as population growth and expanded populations living near coasts and estuaries.

Disasters and the Legal System

Hurricane Katrina sparked interest by U.S. legal scholars in disaster law. More than any other disaster in American history, Hurricane Katrina brought into sharp relief the limitations in the law's capacity to anticipate and respond to catastrophic events. With problems ranging from the amplification of already-entrenched social injustices and the exhaustion and failure of compensation systems, to the paralysis on the ground resulting from ambiguous divisions of disaster management responsibilities among state and federal governments, Katrina and its aftermath made manifest the American legal regime's inability to handle disaster risks effectively (see American Bar Association, 2007).

The legal system plays a central role in disaster prevention, response, and management.[3] For disaster experts, Hurricane Katrina was merely a further confirmation that the law is woefully unprepared to handle disasters. A growing community of researchers recognizes this problem and is formulating solutions under the rubric of disaster law. This emerging legal academic field encompasses a wide-ranging, interdisciplinary body of research seeking to inform and improve disaster-related decision-making, as evidenced by recent books[4] and a rapidly expanding number of law review articles.[5]

The emergence of disaster law in the U.S. may be compared to the birth of environmental law in the late 1960s and early 1970s, when a small group of practitioners and professors recognized the dire need for a coordinated legal approach to a sprawling and life-threatening problem (Lazarus, 2004, p. 47). Their efforts created a new field of legal studies;[6] the task and the potential of disaster law are no less critical in the current tumultuous era.

Before plunging into a study of disaster law, however, we need to first identify the distinctive traits of natural and manmade disasters. Section A addresses the definitional issue. With this clearer definition of the subject matter, Section B then sets forth a framework for understanding the legal and policy issues about disasters, the "circle of disaster management."

What is a "Disaster"?

The common conception of disaster focuses on events that are sudden, significant, and natural. But "disaster" is in practice a malleable term.[7] The suddenness criterion emphasizes the emergency period, but an important consideration in defining the field is whether prevention and development of resilience before the event, and compensation and rebuilding after the event, are to be included. With respect to *naturalness*, it has been argued that there is actually "no such thing as a natural disaster."[8] The second factor, significance, is to some extent in the eye of the beholder. The third factor, naturalness, turns out to be somewhat misleading. Physical "phenomena are a necessary component of risk, but they are only the starting point in addressing safety concerns"—to be fully effective, the work of calculating and planning for disaster risk must account for "acts of nature, [...] weaknesses of human nature, and [...] side effects of technology" (Farber *et al.*, 2010, p. 3; 2006, p. 1085, 1090). In this Article, we will also consider technological disasters – accidents that affect ecosystems or

[3] These issues are the subject of Farber *et al.* (2010).
[4] Farber *et al.* (2010); Nolon and Rodriguez (2007); Verchick (2010); Hunter (2008).
[5] We can get some sense of the expansion from a Westlaw search ("flood insurance", "levees", "oil spill", "forest fire", "natural disaster"). For 2000-2005, the search produced 23 documents; for 2006-2011, the search produced 105 documents (search of JLR database on July 17, 2011). A search for "Hurricane Katrina" in the same database on January 28, 2011 produced 3302 documents, of which 125 had the term in their titles.
[6] The conference resulted in the formation of the Environmental Law Institute (Lazarus, 2004, p. 48).
[7] Dauber (1998, p. 967, 971). "Although the category 'disaster' at first may seem unproblematic, I suggest that we should see its definition and boundaries as precisely what is at stake in many contests over the allocation of federal resources."
[8] Smith (2006). "It is generally accepted among environmental geographers that there is no such thing as a natural disaster. In every phase and aspect of a disaster—causes, vulnerability, preparedness, results and response, and reconstruction—the contours of disaster and the difference between who lives and who dies is to a greater or lesser extent a social calculus."

large populations. There are also hybrids, where natural events cause technological accidents, which in turn intensify damage from the disaster.

The issue of "suddenness" deserves special attention. Air pollution provides an example of how analysis of risk can be distorted by focusing on the suddenness of an event. Although air pollution is often considered a chronic problem, acute episodes are also possible. Consider the London pollution incident of 1952. Beginning on December 4, 1952, winds over the Thames valley began to die down just as a temperature inversion was developing (Wise, 1968, p. 15-16). The next morning, as emissions from coal fire stations and domestic chimneys entered the atmosphere, the morning fog had become massively polluted, and by early evening that day, the death toll had begun (Wise, 1968, p. 16). The killer smog lasted only four days, but in that short time nearly one out of every two thousand residents of London died (Wise, 1968, p. 16). The severity of the 1952 smog is hard to fathom today. Even police cars were forced off the streets because of the lack of visibility (Wise, 1968, p. 124). An observer reported that a bride's dress had been turned "nearly black," because she and the groom "had been compelled to walk a considerable distance, from the church to the Underground station," no taxis being available (Wise, 1968, p. 131).

Although this was a sudden episode, it reflected a chronic problem, and we would be led astray if we focused only on that episode. The "Killer Fog" of 1952 was the culmination of centuries of serious pollution, which as early as 1578 had resulted in a royal proclamation banning the burning of coal while Parliament was in session (Wise, 1968, p. 19). Reformers had struggled in vain for action against air pollution; "the problem of Britain's polluted atmosphere was no nearer a solution than it had been at the turn of the century" (Wise, 1968, p. 50).

Fortunately, no Brazilian city has suffered a similar pollution crisis. But the health effects of air pollution are still appreciable.[9] According to one Brazilian study:

> In relation to respiratory mortality in the elderly, it is estimated that over 600 deaths/year are attributable to the current mean PM10, corresponding to 4.9% of the total respiratory mortality observed in these cities.
> For children under five years of age, an estimated total of approximately 47 deaths from respiratory causes are attributable to PM10 levels, representing 5.5% of all respiratory deaths recorded during the period.
> It is also estimated that the observed PM10 levels in these Brazilian state capitals are responsible for 5.2% of hospital admissions from respiratory causes among children and 8.3% among the elderly, totaling 4,581 admissions per year in the seven cities (Marcilio and Gouveia, 2007, p. S532).

The findings of this Brazilian study also illustrate the complexity of the concept of a "disaster." If the same number of deaths occurred in one place in a week or two, that would undoubtedly be considered a disaster. But from the point of view of the victims, it makes no difference whether the same number of deaths and illnesses are found in only one city or in the seven covered in the study, or whether the ill effects are spread over a year or concentrated in one week. Thus, we can be led astray in thinking that a disaster, as an acute episode, is fundamentally different than an equally harmful chronic condition.

Although the field of disaster law does not have sharp boundaries, the core cases are fairly clear. Hurricanes, floods, and earthquakes are clearly natural disasters, despite the importance of human factors in determining the extent of harm. Humans play a more direct role in oil and chemical spills or nuclear accidents, but the difference between "natural disasters" and "human accidents" is not fundamental. Consequently, both will be discussed in this article.

Given a better understanding of the nature of disasters, we next need to map the legal and policy issues and their interrelationships. Part B provides a roadmap to disaster issues.

The Cycle of Disaster Law

Presently, disasters and their applicable legal regimes are addressed within broad areas of legal study and practice, most notably tort, contracts, administrative, and constitutional law. Issues such as liability and risk-sharing, breach of contract (with possible defenses of commercial impracticability or frustration of purpose), and federalism each bear upon disaster response and management. Disaster issues span insurance law, tort law, and administrative law, which are normally considered very different fields. This section considers the ways in which these disparate issues interconnect in the distinctive context of disasters. What most char-

[9] A comprehensive study in 2011 showed that health effects are significant even when current Brazilian air pollution limits are met. See Olmo (2011, p. 681). Air pollution problems are significant even in smaller cities. A 2006 study showed that air pollution episodes resulted in increased hospitalization for pneumonia in São José dos Campos. See Nascimento *et al.* (2006).

acterizes the field is the "cycle of disaster law": a set of strategies including "mitigation, emergency response, compensation, and rebuilding," with rebuilding completing the circle by including or failing to include mitigation measures (Farber *et al.*, 2010, p. 3).

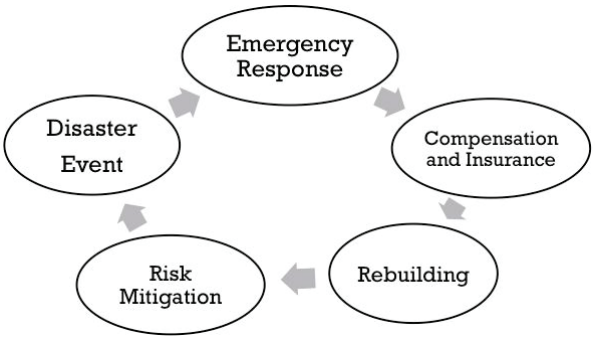

Figure 1. The Cycle of Disaster Law.

Risk Mitigation. Part II and Part III of this article focus on mitigation. It is important to realize that the risk of harm from disasters is not outside of human control. With proper planning, the risk of flooding can be reduced, nuclear reactors and offshore oil rigs can be made safer, and climate change can be limited.

Disasters are often caused or exacerbated by failures in environmental protection. In a recent book, Professor Robert Verchick highlights the importance of what he calls natural infrastructure – that is, the role of nature "as a substructure in human flourishing" in providing essential services such as protection against floods, carbon sequestration, and food supplies like fisheries (Verchick, 2010, p. 22). As Professor Verchick explains, "an infrastructure perspective helps remind us that natural goods and services come as part of larger, interconnected systems" (Verchick, 2010, p. 23). Damaged built-infrastructure can damage the environment; damaged natural infrastructure can lead to or amplify natural disasters.

Emergency Response. Combined with the disaster event itself, this is the most dramatic phase of the disaster cycle. Here, the legal structure can provide clear lines of authority to respond to emergency conditions and can mandate the appropriate planning and training. For example, it is important to determine the role of the military in responding to disasters versus civilian authorities.

Compensation. Although most of the public's attention goes to prevention and emergency response, victim compensation is a central focus of disaster law. The legal system provides a mix of public and private sector methods for compensating victims of natural disasters. Each of the methods that have been used to provide compensation for catastrophic risks has its limitations.

The first method of compensation is private insurance. However, the unavailability of insurance for catastrophic risks (due to expense or underwriting risks, exclusion of catastrophic risks by contract, and the difficulty of handling very large numbers of claims) create significant hurdles. Insurance is not commonly considered as a way of dealing with risks in the area of environmental law, perhaps because the harm relates to health rather than property. But it may not always be feasible to eliminate environmental risks, and insurance could provide a useful backup.

The second method of compensation, litigation against responsible private parties, also has its limitations: the need for proof of negligence or other basis for liability; limits on the financial assets and insurance coverage of potential defendants; and other judicial doctrines limiting recovery. But in some cases liability can result in extraordinary damage awards.

Third is the possibility of obtaining compensation from the government through various routes: tort claims against federal or state government for negligence (subject to immunity defenses); claims under special compensation schemes for particular disasters; and claims based on constitutional provisions requiring compensation for the taking (or in some states, damaging) of property. In addition, the United States government provides flood insurance.[10] The U.S. has no similar system of insurance for other hazards.

Instead, the United States has a makeshift assembly of jerry-rigged components:

> In the final analysis, the U.S. has what might well be termed a patchwork system for providing financial compensation for catastrophic loss. [...] Inevitably, in such a multifaceted milieu, where the tendency has been to develop discrete schemes in response to particularized categories of disasters (or rely on general welfare schemes that were enacted without disaster relief in mind), there will be ongoing fine-tuning of the system and a continuing dialogue over the efficacy of the measures in place (Rabin and Bratis, 2006, p. 303, 356).

[10] For a discussion of the system and issues about its functioning, see Michel-Kerjan (2010, p. 165).

Rebuilding and Restoration. When buildings are harmed or destroyed by a disaster, they must be rebuilt or space must be found for the same activities elsewhere. Often, rebuilding in the same place may be unwise and land use controls may be warranted. When this is not feasible, building requirements can be used to increase safety. Natural resources damaged by disasters such as oil spills may recover naturally, but they may also require clean-up efforts or active restoration to replace damaged plants and animals.

These phases of the "cycle of disaster law" are related to each other. In the context of disaster law, legal rules interact in unique ways. For example, the availability of insurance coverage and public benefits after a disaster may affect pre-disaster mitigation measures—it follows that issues in land use, disaster response, mitigation, and compensation cannot be considered in isolation. Individual courses on land use, torts, insurance, administrative law, etc., cannot adequately treat the interactions between these areas of law.

Complex interactions and structures characterize both the "cycle of disaster law" and also its components. Risk involves a network of interconnected strategies, while disaster response involves careful institutional design, and recovery involves the interplay between funding mechanisms (some private, some state or federal) and local government efforts. Other fields of law may touch on parts of the puzzle (state and local government law, insurance law, land use law, tort law) but miss the larger picture.

Finally, disaster law as a whole is unified by the concept of risk management. Each stage of the cycle of disaster law—mitigation, emergency response, insurance/liability compensation, government assistance, rebuilding—is part of this risk management portfolio. Mitigation efforts attempt to lessen the potential impact of disaster events before the fact, while disaster response attempts to do so afterwards. Insurance, tort, and government disaster assistance provide ways of spreading and shifting risks. Rebuilding is in some sense just the mitigation phase for the next disaster down the road.

Risk management techniques for disasters are interwoven. For instance, the prospect of generous disaster assistance creates moral hazard, which in turn may necessitate government intervention to ensure adequate mitigation. In turn, adequate mitigation before the fact reduces the need for disaster assistance or insurance after the event. Disaster response can have a similar relationship with mitigation, but then reduces the need for post-disaster assistance or other forms of risk spreading. To complete the cycle, post-disaster assistance, insurance, and other forms of compensation help shape post-disaster rebuilding and the degree to which future disaster risks are mitigated. Thus, there is tight linkage between various risk management strategies, providing a conceptual framework for disaster law.

Part II will focus on the risk mitigation phase of disasters and what happens in the absence of mitigation, when regulatory failures create accident risks or amplify risks from natural disasters. This is perhaps the most overlooked aspect of the circle of disaster management. Yet, this phase may have the greatest potential for reducing the human toll from disasters.

Disaster Risks and Regulatory Failure

People tend to think of a disaster as a physical phenomenon stemming from natural events or complex engineering projects such as a nuclear reactor. Such physical phenomena are a necessary component of risk, but they are only the starting point in addressing safety concerns. Whether a risk materializes and the extent of the resulting harm are almost always mediated by human actions. Those actions, in turn, take place inside organizations with their own histories and cultures. To understand risk, we need to see the human context as well as the physical events that cause harm. Only then can we begin to determine the appropriate response to risk.

Disasters are dramatic events, but we need to look past the events themselves to learn more about the sources of risk and their mitigation. Doing so reveals that disasters are not simply accidents or Acts of God—they also involve the failure of the legal system to effectively address risks. Thus, disaster law (dealing with disaster preparation, response, and recovery) is closely linked with regulatory law (especially dealing specifically with land use planning and control of environmental risks). That link between disaster harms and regulatory failure is the subject of the following four case studies. As we will then discuss in Part III, climate change will vastly strengthen this linkage between environmental law and disaster law.

We typically think of regulatory law as addressing long-term problems such as air and water pollution, climate change, and biodiversity. In contrast, we think of disasters as being sudden events, although as discussed earlier this is a contestable idea. But the two are intimately related: disasters are often the result of long-term failure of regulations, while pollution incidents like the 1952 London Killer Fog can be sudden and dev-

astating. The connections between chronic regulatory failures are explored below in the context of nuclear accidents, oil spills, heat waves, and floods. As discussed earlier, although some of these events are often called natural disasters and others are called accidents, the fundamental policy issues are similar.

Nuclear Accidents

The story begins with a catastrophic natural event. At 2:46 pm Japan standard time on March 11, 2011 (9:46pm PST on March 10), a 9.0 earthquake struck off the east coast of Honshu, Japan, 109 miles ENE of Fukushima and 231 miles NE of Tokyo (USGS, 2011). The earthquake also triggered a large tsunami that overwhelmed seawalls and contributed to massive destruction (Onishi, 2011). The tsunami waves spanned a great height; the maximum height was 127 feet at Aneyoshi, Miyako (International Atomic Energy Agency, 2011). As of July 14, more than fifteen thousand people were known to be dead; over five thousand people were still missing. More than 227,000 buildings have totally or partially collapsed; and 3,559 roads, 77 bridges, and 29 railways have been damaged (National Police Agency of Japan, 2011). As of June 30, 116,213 people had been evacuated (Ministry of Foreign Affairs of Japan, 2011). Economic losses from the earthquake are estimated at $210 billion, making it the costliest natural disaster on record; the overall economic loss for Hurricane Katrina was $125 billion (Munich Re, 2011).

The earthquake itself was outside of human control, but the regulatory dimension of the disaster involves nuclear power, which turned out to be inadequately regulated for the emergency. During the earthquake, the Fukushima Dai-ichi lost outside power—connection to the electrical grid. Backup diesel generators came on at this time. The Dai-ni plant did not lose power, but did face degraded safety systems (International Atomic Energy Agency, 2011). About 46 minutes after the quake, the first waves of a large tsunami reached the Fukushima Dai-ichi power station. The tsunami reached about 14 meters (45 feet) at the Dai-ichi power station, overwhelming the 6-meter (18-foot) seawall. The IAEA report provides a vivid sense of the post-tsunami state at the nuclear plant:

> The tsunami and associated large debris caused widespread destruction of many buildings, doors, roads, tanks and other site infrastructure at Fukushima Dai-ichi, including loss of heat sinks. The operators were faced with a catastrophic, unprecedented emergency scenario with no power, reactor control or instrumentation, and in addition, severely affected communications systems both within and external to the site. They had to work in darkness with almost no instrumentation and control systems to secure the safety of six reactors, six nuclear fuel pools, a common fuel pool and dry cask storage facilities (International Atomic Energy Agency, 2011, p. 11-12).

Explosions occurred at units 1-4; the explosions at units 1-3 were caused by a build-up of hydrogen and the cause for the explosion at unit 4 remains unknown. Diesel generators at unit 6 remained functional in the aftermath of the tsunami and workers were able to use it to achieve a cold shutdown[11] at units 5 and 6. Units 1-3 have still not yet achieved cold shutdown. Nuclear Emergency Situations have been declared for both the Fukushima Dai-ichi and Fukushima Dai-ni power stations resulting in evacuations and emergency measures.[12]

As the 2011 tsunami and its aftermath illustrate, the interdependency of modern societies makes them especially prone to disruption by disasters, as damage to basic networks interferes with the delivery of key services. But overly optimistic regulators, who failed to take into account the need for more rigorous regulation of nuclear plants, may have contributed to the disaster.

It is important to keep in mind the possibility of catastrophic events when designing and siting potentially dangerous facilities such as nuclear reactors. Long time periods between such events may give a false sense of security. It might seem ridiculous to worry about an event that only occurs once every thousand years. But this means that there is one chance in a thousand that the event will happen in any given year. If a facility will be in operation for fifty years, which is not impossible for many nuclear reactors, then there is a 5% chance (50 x 1/1000) that the event will strike during the lifetime of the facility. If the consequences would be sufficiently severe, that is a possibility worth considering when planning the facility.

Oil and Chemical Spills

The largest recent oil spill was the Deepwater Horizon BP oil spill of 2010. On April 20, 2010, while drilling at the Macondo Prospect about 83 kilometers

[11] Cold shutdown is achieved after several days once the reactor is no longer critical (temperatures below 200° F)—even after the cooling rods are inserted and fission stops, the radioactive products continue to generate significant heat.
[12] See the May 17th update of the TEPCO *Roadmap towards Restoration* here: http://www.tepco.co.jp/en/press/corp-com/release/betu11_e/images/110517e3.pdf

southeast of Louisiana, an explosion on the Deepwater Horizon caused by a blowout killed 11 of 126 crewmen (Associated Press, 2010b). Two days later, despite efforts to put out the blaze on the oil rig, the Deepwater Horizon sank in 1500 meters of water.[13] Throughout the end of April, May, and June, estimates of the flow of oil increased from 1,000 barrels of crude per day (bpd), to 5000 bpd, to as many as 60,000 bpd (Gillis, 2010). On July 15, BP finally stopped the flow of oil for the first time in nearly three months (Gillis, 2010). And about three weeks later, on August 4, BP executed a successful 'static kill,' and a cement plug introduced on September 19 left the well effectively dead and the crisis officially over (Gillis, 2010). Environmental and economy recovery, however, will take much longer. It is unclear to what extent oil will continue to wash up on the Gulf coast, whether species such as the dwarf seahorse can overcome the loss of so much of their habitat, and whether dispersants used during cleanup efforts may have unforeseen consequences on the environment.[14]

In terms of the "root causes" of the blowout, the Presidential Commission investigating the accident identified management failures by industry and a dysfunctional regulatory system (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2010, p. 122-127). The accident "resulted from clear mistakes made in the first instance by BP, Halliburton, and Transocean, and by government officials who, relying too much on industry's assertions of the safety of their operations, failed to create and apply a program of regulatory oversight that would have properly minimized the risks of deepwater drilling" (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2010, p. 127). Thus, the oil spill fundamentally stemmed from a failure of environmental regulation as well as negligence by private firms.

Brazil also suffered a major recent oil spill. On November 7, 2011, a pressure spike occurred during the drilling of an exploratory well at a depth of 1000 meters about 120 kilometers offshore. According to Chevron, although the well was immediately sealed, leakage began from the seabed nearby and continued for four days.[15] Chevron was fined 50 million reals, and it was reported that authorities were considering indictments against employees who were involved in the leak (Carroll and Spinetto, 2011). In addition, a federal prosecutor filed a lawsuit for $11 billion in damages against Chevron alleging that "Chevron and Transocean were not capable of controlling the damages caused by the leakage" and that there was "evidence of a lack of planning and environmental management by the companies."[16] Concerns have also been expressed about the risk assessments used for drilling operations offshore of Brazil.[17]

As was also true of the Fukushima accident, oil spills may be in some sense accidental, but they may also reflect organizational and regulatory failures. Harm to the environment stemming from these accidents is not simply a random event but a reflection of failures by society to mitigate the risks appropriately.

Heat Waves

A heat wave may seem like the least manmade of events. The summer of 2003 was the hottest in Europe for at least five hundred years (Larsen, 2006). An anticyclone (high pressure area) sat over Western Europe, preventing cooler air from the Atlantic from entering (UNEP, 2003). Temperatures reached extraordinary heights. The summer weather in Geneva was similar to the normal summer in Rio de Janeiro (UNEP, 2003). Temperatures in parts of Italy in August were over eight degrees centigrade warmer than the preceding year; in Portugal, temperatures were over forty degrees for many days, while London had its first recorded temperatures over thirty-eight degrees in history (Larsen, 2006).

The prolonged heat was catastrophic. Estimates of the total number of deaths begin at thirty thousand and run as high as fifty thousand (Larsen, 2006). In Paris alone, there were over twelve hundred deaths (Cadot *et al.*, 2007, p. 466-468). The estimate for France as a whole was over fourteen thousand (Cadot *et al.*, 2007, p. 466-468). The biggest risk factors were "being a woman 75

[13] The Guardian (2010). For a detailed discussion of the events leading up to the spill, see National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2010, p. 89-122).
[14] Gillis (2010). The difficulties encountered in closing the well are discussed in National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2010, p. 129-170).
[15] Chevron, Frade Response-Background, http://chevron.com/fraderesponse/background.
[16] Reuters (2011). For a discussion of the contrasting roles of environmental criminal law in the United States and Brazil, see Blomquist (2011, p. 83, 88-92) and McAllister (2008, p. 4).
[17] Vidal (2010). "The platform is now operating 125km off the coast of Brazil in 1,798 metres (5,900 feet) of water—deeper than BP's Deepwater rig that exploded in April and led to the disastrous oil spill in the Gulf of Mexico. [T]he 14-page environment report prepared by the [bank financing the drilling operations] makes no mention of blowouts or the equipment needed to prevent them. Ministers have edited out all ECDG's comments assessing the risks involved in deep-sea drilling in the Atlantic."

years old and older and living alone at home" (Cadot *et al.*, 2007, p. 466-468). In addition to its health impacts, the heat wave also impacted agriculture and caused numerous forest fires, destroying over 640,000 hectares of forest (roughly 2500 square miles, an area about the size of Delaware) (UNEP, 2003).

The heat wave was extreme compared to historical temperatures, but less abnormal compared to recent decades because of the long-term increase of very hot days in Europe (Rebetez *et al.*, 2006, p. 569-577). Although it is impossible to say whether climate change "caused" this particular heat wave, it is possible to ask whether climate change increased the likelihood of such a heat wave. Scientists have concluded that "past human influence has more than doubled the risk of European mean summer temperatures as hot as 2003" and that "the likelihood of such events [is] projected to increase 100-fold over the next four decades."[18]

Flooding

Flooding is a familiar risk, but the dangers may be underestimated because of this familiarity. Hurricane Katrina illustrates the seriousness of flood risks and the way that failures of risk management turned a relatively routine event into a catastrophe. The impacts were severe: "killing more than 1,500, leaving hundreds of thousands homeless, and ravaging one of America's most storied cities," not to mention billions of dollars in property damage (United States Senate Committee On Homeland Security And Governmental Affairs, 2006, 1-1 to 1-14, 2-1 to 2-2). Property damage estimates approach $100 billion (United States Senate Committee On Homeland Security And Governmental Affairs, 2006, 1-1). The New Orleans flood represented the technological failure of inadequate flood control measures against a predictable, risky and potentially lethal event.[19]

After floods in 1927, the U.S. built levees along the Mississippi that have prevented silt from reaching Louisiana wetlands (McQuaid and Schleifstein, 2006, p. 70-86). Since the construction of these levees, wetlands have been starved of sediment, causing them to "become waterlogged, sink and die" (McQuaid and Schleifstein, 2006, p. 70-86). The silt ends up uselessly collecting at the bottom of the Gulf of Mexico. Thus, efforts to reduce flooding in the Mississippi River basin have increased the risk of flooding along the coast of the Gulf of Mexico.

After Hurricane Katrina, it became apparent that the disappearance of the wetlands increased disaster risks to the region. Wetlands absorb the impact of storms, slowing them down once they make landfall (Sullivan, 2005). For every 12 kilometers of wetlands, storm surges are reduced one meter (Sullivan, 2005). However, New Orleans is now increasingly exposed to violent storms because so many of the wetlands have collapsed, in part due to the levee system that surrounds the city (Sullivan, 2005). In addition, barrier islands provide protection for "half a million people from violent storms, along with an international commercial-industrial complex worth billions" (Verchick, 2010, p. 34). Yet these barrier islands are rapidly disappearing (Verchick, 2010, p. 34-35).

Although whether climate change contributed to Hurricane Katrina is unclear, the Intergovernmental Panel on Climate Change considers it likely that climate change will lead to future Katrinas. According to the IPCC, "it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical SSTs" (IPCC, 2007, p. 15). We know with somewhat more confidence that climate change will destroy the wetlands that buffer storm surges. Sea level rise is one of the most predictable consequences of climate change.[20] Apart from the unknown contribution from melting ice sheets in Greenland and Antarctica,[21] the simple change in temperature of the oceans will contribute to thermal expansion, just as increased temperature causes the mercury in a thermometer to rise.[22] This rise in sea level will result in loss of coastal lands,[23] increased exposure to flood damage, not to mention such other harms as salt water intrusion into estuaries and drinking water supplies.[24]

The Katrina disaster illustrates the close relationship between disaster law and land use planning. A key method of mitigating disaster risks is to avoid

[18] Stott *et al.* (2004, p. 610). Fortunately, nothing of this severity has struck Brazil, although one heat wave in 2010 killed over thirty people. See Associated Press (2010a).
[19] For an overview of the failures in planning the levee system, see McQuaid and Schleifstein (2006, p. 70-86).
[20] See, e.g., Hasselman *et al.* (2003, p. 1923, Figure 2) (predicting a two meter increase in sea level under a "business as usual" scenario by 2100; but only 20 centimeters under an optimum regulatory strategy).
[21] On the potential for catastrophic melting in these areas, see Stern (2007, p. 16) and IPCC (2007, p. 16).
[22] Changes in ocean temperature will also affect fish stocks. See Portner and Knust (2007, p. 95).
[23] Pittock (2005) gives examples, including China (p. 264), India, Pakistan, Bangladesh (p. 268), and the United States (p. 278).
[24] See Kolbert (2006, p. 123-124) (British governmental study indicating that what are now hundred-year floods could become routine by late in this century). See also Pittock (2005, p. 118) (stating that without adaptive measures, annual flood losses would increase from – 1-24 billion in different scenarios).

putting people and key facilities in harm's way. Moreover, land use controls can help maintain key buffers like coastal wetlands as a form of natural infrastructure.

Brazil has not suffered a storm of the scale of Katrina, but storms and flooding remain serious problems:

> Torrential rains inundated a heavily populated, steep-sloped area about 40 miles north of Rio de Janeiro on Tuesday and Wednesday, triggering flash floods and mudslides that have claimed at least 511 lives. Rainfall amounts of approximately 300 mm (12 inches) fell in just a few hours in the hardest-hit regions, Teresopolis and Nova Friburgo. Many more people are missing, and the death toll is expected to go much higher once rescuers reach remote villages that have been cut off from communications. The death toll makes the January 2011 floods Brazil's worst single-day natural disaster in its history. Brazil suffers hundreds of deaths each year due to flooding and mudslides, but the past 12 months have been particularly devastating. Flooding and landslides near Rio in April last year killed 246 people and did about $13 billion in damage, and at least 85 people perished last January during a similar event (Romm, 2011).

As noted earlier, these losses are not simply unavoidable acts of nature; they also reflect lack of preparation. As one Brazilian expert explained, "The important thing is to plan [...] Zoning and urban planning are needed, and must take climatic aspects into account" (Frayssinet, 2009). Moreover, the victims are likely to be the poor, who cannot afford to live in safer areas (Frayssinet, 2009).

Hurricane Katrina also illustrates the link between disasters and inequality. Equality issues were impossible to miss during the Hurricane Katrina disaster. Consider the New Orleans Superdome, which offered shelter of last resort: "The Dome was a brewing public health disaster. [T]he number of people inside had doubled in twenty-four hours, becoming a virtual city of twenty-thousand, overwhelmingly poor and African American" (McQuaid and Schleifstein, 2006, p. 235). For days, it was "clear to anyone watching television that the majority of people trapped in New Orleans were African Americans, most from the low end of the income spectrum" (McQuaid and Schleifstein, 2006, p. 300). For "much of New Orleans' white population had departed before the storm hit, while the remainder lived in areas closer to dry land and found it easier to escape" (McQuaid and Schleifstein, 2006, p. 300). Ultimately, the Congressional Research Service found that "an estimated 272,000 black people were displaced by flooding or damage, accounting for 73% of the population affected by the storm in the parish" (Gabe, 2005, p. 14, 16-17).

The connection of race and poverty with evacuation rates was not unique to Katrina. As the National Research Council found:

> [R]esearch has shown that different racial, ethnic, income, and special needs groups respond in different ways to warning information and evacuation orders. [...] Lower-income groups, inner-city residents, and elderly persons are more likely to have to rely on public transportation, rather than personal vehicles, in order to evacuate (Committee on Disaster Research in the Social Sciences, National Research Council, Future Challenges and Opportunities, 2006, p. 129).

Both globally and within the United States, "social injustice contributes so heavily to the incidence and intensity of natural disasters that the quest for equality may be regarded as a valuable tool for improving disaster preparedness, response, mitigation, compensation, and rebuilding" (Farber *et al.*, 2010, p. 204).

In all four of these disaster examples—nuclear risks, oil spills, heat waves, and flooding—we see a close relationship between a sudden catastrophic event and a long-term environmental problem or regulatory failure. Good environmental law decreases the likelihood and severity of natural disasters. Failure to protect the environment has the converse effect. The greatest environmental problem of our time is climate change. Part III shows how climate change will bring environmental issues and even disaster law closer together.

Climate Change: Planning for A Slow-Moving Disaster

Environmental law and disaster law encounter each other most fully in the arena of climate change. Climate change happens over a period of many years, but the effects may be as severe as any natural disaster. Climate change is already underway. With rare exceptions, recent years rank at the top of the list of the warmest global temperatures (Archer and Rahmstorf, 2010, p. 43), and depending on future emissions and climate sensitivity, the world will end up 2–7 °C warmer than it is today (Archer and Rahmstorf, 2010, p. 129). Temperature change in the arctic will be about twice as large (Archer and Rahmstorf, 2010, p. 133). Even warming of 2 °C, which may be the best we can hope for, would leave the earth warmer than it has been in millions of years (Archer and Rahmstorf, 2010, p. 225).

Other changes are also foreseeable around the world. Snow cover will decrease in most areas (Archer and Rahmstorf, 2010, p. 147), and oceans will become

increasingly acidic (Archer and Rahmstorf, 2010, p. 148). Even moderate climate change will trigger significant extinctions (Archer and Rahmstorf, 2010, p. 162), and extreme events such as fires, floods, and heat waves will become more widespread.[25] Adaptation to these impending changes poses serious challenges.[26] "Extreme events such as floods and drought cause extensive damage to many parts of society, and thus a critical issue for adaptation is the degree to which frequency, intensity, and persistence of extreme events change" (Easterling III *et al*., 2004, p. 17).

The effects of climate change have been modeled in detail for the United States. The U.S. will experience significant temperature changes.[27] Temperatures are expected to rise everywhere, but more inland than in coastal or southern areas in the continental United States, with the greatest increases in Northern Alaska (U.S. Global Change Research Program, 2010, p. 29). In the Southeast United States, even though absolute changes will be smaller, the baseline is high, resulting in many more very hot days later in this century (U.S. Global Change Research Program, 2010, p. 112). In the Midwest, urban life will be burdened by increasing heat waves and decreased air quality (U.S. Global Change Research Program, 2010, p. 117).

Sea level rise due to climate change may cause dramatic losses in wetlands in the United States (Lazaroff, 2002). Two-thirds of all U.S. coastal wetlands would be lost with a one-meter rise in sea level (Lazaroff, 2002, p. 84). This loss would be in addition to extensive past losses of wetlands in Louisiana (Lazaroff, 2002, p. 84), and continued loss of lands. The salinity of remaining wetlands, estuaries and tidal rivers would also change (Lazaroff, 2002, p. 114). Hurricanes, which may increase in intensity, result in further loss of coastal lands; Hurricane Katrina, for example, eliminated over two hundred square miles (roughly 500 km^2) of wetlands (Lazaroff, 2002, p. 115). What used to be a one hundred-year flood in New York City is now an eighty-year flood, and may be a twenty-year flood by mid-century (Cullen, 2010, p. 238). Correspondingly, even more severe floods will become more frequent. Changes stemming from sea level rise will not necessarily be gradual. There could be sudden loss of protective lands that buffer storm surges or in abrupt intrusions of salt water into aquifers (U.S. Global Change Research Program, 2010, p. 115).

Sea level rise will also cause other harms in the United States. Because the slope of coastal areas on the Atlantic and Gulf Coasts is low, a forty-centimeter rise in sea level could result in as much as sixty meters of beach erosion and may cost billions of dollars (Grossman, 2003, p. 12-14). Finally, as noted earlier, sea level rise can result in widespread salt intrusion into aquifers, as well as severe beach erosion, wetlands loss, and flooding (U.S. Global Change Research Program, 2010, p. 114).

Although the predictions are subject to uncertainty, climate change also appears to be a serious issue for Brazil:

> Brazil is vulnerable to climate change, not least due to its fragile, biologically diverse ecosystems. The tropical rain forest in the Amazon and the Pantanal wetland are of particular concern. [...] There is also concern that coral reefs along Brazilian coastlines could suffer from the effects of climate change.
> Changing rainfall patterns, especially in the drought-affected northeastern region of the country, will mean poorer water resources and a reduced water supply. [...] Floods, which are already a serious problem for various regions, may increase. Coastal areas, where the bulk of the population and economic activities are concentrated, will be vulnerable to rising sea levels (La Rovere and Pereira, 2007).

According to a report commissioned by the European Commission:

> After the long period of drought in 2005, omputerized forecasting systems detected that the integrity of the Amazon rainforests could be affected by the processes of savannah expansion. Over the past decades, increases in temperature and erratic rainfall have led to a massive reversal in carbon absorption. Trees are dying out more rapidly where the droughts have been most intense (AGRIFOR Consult, 2009, p. 14).

A recent report by the Hadley Centre in Britain reports that sea level rise could have a major impact on Brazil:

> One study places Brazil within the top 15 countries simulated to show an increased exposure from SLR [sea level rise] relative to present in the 2070s, based upon a global assessment of 136 port cities. A 10% intensification of the current 1-in-100-year storm surge

[25] These challenges are discussed in Bonyhady *et al.* (2010); U.S. Government Accountability Office (2010).
[26] For an overview of the failures in planning the levee system, see McQuaid and Schleifstein (2006, p. 70-86).
[27] The most recent information about U.S. climate impacts can be found in U.S. Global Change Research Program (2010) (hereinafter U.S. Impacts).

> combined with a 1m SLR could affect around 15% of Brazil's coastal land area and 30% of the coastal population (Met Office Hadley Center, 2011, p. 121).

Given these risks, it is not too soon for major countries such as the United States and Brazil to begin planning to deal with the effects of climate change. The U.S. government is just beginning to seriously address adaptation issues, following most of a decade in which climate change issues of all kinds were ignored or downplayed. President Obama appointed a task force composed of key federal agencies to investigate adaptation. The Task Force's Report is a solid step forward in preparing the US to deal with the challenges of climate change (The White House Council On Environmental Quality, 2010). There are three key recommendations relating to domestic adaptation measures at the federal level.

First, according to the Report, adaptation needs to become a standard part of agency planning (The White House Council On Environmental Quality, 2010, p. 10, 25-26). The plans should focus on ecosystems rather than either individual species or governmental jurisdictions (The White House Council On Environmental Quality, 2010, p. 22). An important recommendation is that adaptation plans should prioritize the most vulnerable people, places, and infrastructure (The White House Council On Environmental Quality, 2010, p. 11):

> Adaptation plans should prioritize helping people, places, and infrastructure that are most vulnerable to climate impacts. They should also be designed and implemented with meaningful involvement from all parts of society. Issues of inequality and environmental justice associated with climate change impacts and adaptation should be addressed (The White House Council On Environmental Quality, 2010, p. 21).

This recommendation has obvious relevance for disaster planning as well.

Second, the government needs to ensure that scientific information about the impacts of climate change is easily accessible (The White House Council On Environmental Quality, 2010, p. 30-33). Without solid scientific information, public and private sector decision-makers cannot plan intelligently. This effort would build on the US Geologic Survey and its National Climate Assessment (The White House Council On Environmental Quality, 2010, p. 23, 49). There is a similar need for public information regarding disaster risks.

Third, the government needs to address climate impacts that cut across agency jurisdictions and missions (The White House Council On Environmental Quality, 2010, p. 34). Unfortunately, this is the case for many of the main impacts, such as those that threaten water resources (The White House Council On Environmental Quality, 2010, p. 35-36), public health (The White House Council On Environmental Quality, 2010, p. 37-38), oceans and coasts (The White House Council On Environmental Quality, 2010, p. 42-43), and communities (The White House Council On Environmental Quality, 2010, p. 39-40). Some important arenas for agency action are to improve water-use efficiency (The White House Council On Environmental Quality, 2010, p. 36), strengthen public health systems (The White House Council On Environmental Quality, 2010, p. 38), integrate climate risks into insurance (The White House Council On Environmental Quality, 2010, p. 41), and develop an open-source risk assessment model (The White House Council On Environmental Quality, 2010, p. 21).

Some of these recommendations are relevant only for the United States, but others provide useful guidance in other countries such as Brazil. Disaster planning is increasingly connected with adaptation planning. In the coming era, disasters will result from interlinked changes in physical and ecological systems due to climate change. Thus, disaster planning will need to be part of a broader effort that takes into account climate change, natural capital, and societal resilience.

The events discussed in this article—nuclear accidents, floods, oil spills, heat waves, and severe air pollution—can all be classified as environmental disasters. We can consider an environmental disaster to be one that destroys important environmental amenities or one in which harm to human interests is mediated by an environmental change. The BP oil spill easily fits both criteria: it was harmful to natural ecological systems, and the harm was mediated by water pollution. The 2003 European heat wave also damaged natural systems, and it was at least made much more likely by human changes in the Earth's atmosphere. The tsunami was not caused by human activities, but the ensuing nuclear reactor failures were as much a failure of effective regulation as they were the effect of the tsunami itself.

In the era of climate change, environmental law will no longer be able to marginalize disaster law as a distant cousin. Disasters, both natural and human-induced, are an increasingly common feature of 21st century life; appropriate legal guidance can ensure that disasters are anticipated and contained in a comprehensive and equitable manner. Disaster law is a complex, multi-faceted, and rapidly expanding body of thought, one that addresses the dire need for a systematic, thoughtful approach to managing the chaos of disasters.

Over time, scholars hopefully will further refine and explore the wide variety of avenues for research within the field, and will continue to influence disaster prevention, response and management policy for the better. Disasters are a global problem, and the solutions must be equally transnational.

References

AGRIFOR CONSULT. 2009. *Climate Change in Latin America*. Available at: http://ec.europa.eu/europeaid/where/latin-america/regional-cooperation/documents/climate_change_in_latin_america_en.pdf. Access on: 06/08/2012.

AMERICAN BAR ASSOCIATION. 2007. Section of Litigation Report to the House of Delegates Recommendation [regarding Major Disasters]. Available at: http://www.abanet.org/leadership/2007/annual/docs/hundredthirteen.doc. Access on: 06/08/2012.

ARCHER, D.; RAHMSTORF, S. 2010. *The Climate Crisis: An Introductory Guide to Climate Change*. Cambridge, Cambridge University Press, 260 p.

ASSOCIATED PRESS. 2010. Brazilian Heat Wave Kills 32 Elderly People. Available at: http://www.foxnews.com/story/0,2933,585425,00.html. Access on: 06/08/2012.

ASSOCIATED PRESS. 2010. Deepwater Horizon Oil Rig Fire Leaves 11 Missing. Available at: http://www.guardian.co.uk/world/2010/apr/21/deepwater-horizon-oil-rig-fire. Access on: 06/08/2012.

BLOMQUIST, R.F. 2011. The Logic and Limits of Environmental Criminal Law in the Global Setting: Brazil and The United States - Comparisons, Contrasts, and Questions in Search of a Robust Theory. *Tulane Environmental Law Journal*, **25**(1):83-98.

BONYHADY, T.; MACINTOSH, A.; MCDONALD, J. 2010. *Adaptation to climate change: law and policy*. Annandale, The Federation Press, 287 p.

CADOT, E.; RODWIN, V.G.; SPIRA, A. 2007. In the Heat of the Summer: Lessons from the Heat Waves in Paris. *Journal of Urban Health*, **84**(4):466-468. http://dx.doi.org/10.1007/s11524-007-9161-y

CARROLL, J.; SPINETTO, J.P. 2011. Chevron, Transocean Face Brazil Indictment Over Oil Leak. *Bloomberg*. Available at: http://www.bloomberg.com/news/2011-12-22/chevron-executives-face-brazil-indictments-over-offshore-leaks.html. Access on: 06/08/2012.

COMMITTEE ON DISASTER RESEARCH IN THE SOCIAL SCIENCES, NATIONAL RESEARCH COUNCIL, FUTURE CHALLENGES AND OPPORTUNITIES. 2006. *Facing Hazards and Disasters: Understanding Human Dimensions*. Available at: http://www.nap.edu/catalog/11671.html Access on: 06/08/2012.

CULLEN, H. 2010. *The Weather of the Future: Heat Waves, Extreme Storms, and Other Scenes from a Climate-Changed Planet.* New York, Harper Collins Publishers, 352 p.

DAUBER, M.L. 1998. Let Me Be Next Time 'Tried By Fire': Disaster Relief and the Origins of the American Welfare State. *Northwestern University Law Review,* **92**(3):967-971.

EASTERLING III, W.E.; HURED, B.H.; SMITH, J.B. 2004. *Coping with Global Climate Change: The Role of Adaptation in the United States*. Available at: http://www.pewclimate.org/global-warming-in-depth/all_reports/adaptation. Access on: 06/08/2012.

FARBER, D.A.; CHEN, J.; VERCHICK, R.R.M.; SUN, L.G. 2010. *Disaster Law and Policy*. 2nd ed., New York, Aspen Publishers, 496 p.

FARBER, D.A.; BEA, R.G.; ROBERTS, K.; WENK, E.; INKABI, K. 2006. Reinventing Flood Control. *Tulane Law Review*, **81**(4):1085-1128.

FRAYSSINET, F. 2009. Flooding Highlights Lack of Disaster Preparation. *Interpress Service News Agency*. Available at: http://www.ipsnews.net/africa/nota.asp?idnews=46819. Access on: 06/08/2012.

GABE, T. 2005. *Gene Falk and Maggie McCarty, Hurricane Katrina: Social-Demographic Characteristics of Impacted Areas* (Nov. 4) (Cong. Res. Serv. Order Code RL33141).

GILLIS, J. 2010. Estimates of Oil Flow Jump Higher. *N.Y. Times*. Available at: http://www.nytimes.com/2010/06/16/us/16spill.html?scp=8&sq=&st=nyt. Access on: 06/08/2012.

GROSSMAN, D. 2003. Warming Up to a Not-So-Radical Idea: Tort-Based Climate Change Litigation. *Columbia Journal of Environmental Law*, **28**(1):1-62.

HASSELMANN, K.; LATIF, M.; HOOSS, G.; AZAR, C.; EDENHOFER, O.; JAEGER, C.C.; JOHANNESSEN, O.M.; KEMFERT, C.; WELP, M.; WOKAUN, A. 2003. The Challenge of Long-Term Climate Change. *Science*, **302**(5652):1923-1925. http://dx.doi.org/10.1126/science.1090858

HUNTER, N.D. 2008. *The law of emergencies: public health and disaster management*. Burlington, Mass, Butterworth-Heinemann, 381 p.

INTERNATIONAL ATOMIC ENERGY AGENCY. 2011. Mission Report: The Great East Japan Earthquake Expert Mission, May 24-June 2. Available at: http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf. Access on: 06/08/2012.

IPCC. 2007. Summary for Policymakers. *In:* S. SOLOMON; D. QIN; M. MANNING, Z. CHEN; M. MARQUIS; K.B. AVERYT; M. TIGNOR; H.L. MILLER (eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge/New York, Cambridge University Press, p. 1-18.

KAHN, M. 2011. Adapting to Natural Disaster Risk: The Case of Brazil's Flood. *Environmental and Urban Economics*. Available at: http://greeneconomics.blogspot.com/2011/01/adapting-to-natural-disaster-risk-case.html. Access on: 06/08/2012.

KOLBERT, E. 2006. *Field Notes from a Catastrophe: Man, Nature, and Climate Change*. New York, Bloomsbury USA, 240 p.

KUNREUTHER, H.; MICHEL-KERJAN, E. 2009. *At war with the weather managing large-scale risks in a new era of catastrophes*. London, MIT Press, 416 p.

KUNREUTHER, H.; USEEM, M. 2009. *Learning from catastrophes: strategies for reaction and response*. Upper Saddle River, Wharton School Pub., 332 p.

LA ROVERE, E.L.; PEREIRA, A.S. 2007. *Brazil and Climate Change: A Country Profile*. Available at: http://www.scidev.net/en/policy-briefs/brazil-climate-change-a-country-profile.html. Access on: 06/08/2012.

LARSEN, J. 2006. Setting the Record Straight: More than 52,000 Europeans Died from Heat in Summer 2003. *Earth Policy Institute* (July 28). Available at: http://www.earth-policy.org/index.php?/plan_b_updates/2006/update56. Access on: 06/08/2012.

LAZAROFF, C. 2002. *Climate Change Could Devastate U.S. Wetlands* (January 29). Available at: http://www.ens-newswire.com/ens/jan2002/2002-01-29-06.asp. Access on: 06/08/2012.

LAZARUS, R.J. 2004. *The Making of Environmental Law*. Chicago, University of Chicago Press, 335 p.

MARCILIO, I.; GOUVEIA, N. 2007. Quantifying the Impact of Air Pollution on the Urban Population of Brazil. *Cadernos de Saúde Pública*, **23**(4):S529-S536.

MCALLISTER, L.K. 2008. *Making Law Matter: Environmental Protection & Legal Institutions in Brazil.* Stanford, Stanford University Press, 288 p.

MCQUAID, J.; SCHLEIFSTEIN, M. 2006. *Path of Destruction: The Devastation of New Orleans and the Coming Age of Superstorms.* New York, Little, Brown & Company, 384 p.

MET OFFICE HADLEY CENTRE. 2011. *Climate: Observations, Projects and Impacts*. Available at: http://www.metoffice.gov.uk/media/pdf/t/r/UK.pdf. Access on 06/08/2012.

MICHEL-KERJAN, E.O. 2010. Catastrophe Economics: The National Flood Insurance Program. *Journal of Economic Perspectives,* **24**(4):165-186. http://dx.doi.org/10.1257/jep.24.4.165

MINISTRY OF FOREIGN AFFAIRS OF JAPAN. 2011. The Great East Japan Earthquake. Available at: http://www.mofa.go.jp/j_info/visit/incidents/index.html. Access on: 06/08/2012.

MUNICH RE. 2011. Press Release. Accumulation of Very Severe Natural Catastrophes Makes 2011 a Year of Unprecedented Losses. Available at: http://www.munichre.com/en/media_relations/press_releases/2011/2011_07_12_press_release.aspx Access on: 06/08/2012.

NASCIMENTO, L.F.C.; PEREIRA. L.A.; BRAGA, A.L.; MÓDOLO, M.C.; CARVALHO, J.A. 2006. Effects of Air Pollution on Children's Health in a City in Southeastern Brazil. *Revista de Saúde Pública*, **40**(1):77-82. http://dx.doi.org/10.1590/S0034-89102006000100013

NATIONAL COMMISSION ON THE BP DEEPWATER HORIZON OIL SPILL AND OFFSHORE DRILLING. 2010. *Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling*. Available at: http://www.oilspillcommission.gov/final-report. Access on: 06/08/2012.

NATIONAL POLICE AGENCY OF JAPAN. 2011. Damage Situation and Police Countermeasures Associated with 2011 Tohoku District – off the Pacific Ocean Earthquake. Available at: www.npa.go.jp/archive/keibi/biki/higaijokyo_e.pdf. Access on: 06/08/2012.

NOLON, J.R.; RODRIGUEZ, D. B. 2007. *Losing ground: a nation on edge*. Washington, D.C., Environmental Law Institute, 491 p.

OLMO, N.R.S. 2011. A Review of Low-Level Air Pollution and Adverse Effects on Human Health: Implications for Epidemiological Studies and Public Policy. *Clinics*, **66**(4):681-690. http://dx.doi.org/10.1590/S1807-59322011000400025

ONISHI, N. 2011. Seawalls Offered Little Protection Against Tsunami's Crushing Waves. *N.Y.Times*. Available at: www.nytimes.com/2011/03/14/world/asia/14seawalls.html?pagewanted=all. Access on: 06/08/2012.

PITTOCK, A.B. 2005. *Climate Change: Turning Up the Heat.* London, Earthscan, 328 p.

PORTNER, H.O.; KNUST, R. 2007. Climate Change Affects Marine Fishes Through the Oxygen Limitation of Thermal Toleration. *Science*, **315**(5808):95-97. http://dx.doi.org/10.1126/science.1135471

RABIN, R.L.; BRATIS, S.A. 2006. United States. *In:* M. FAURE; T. HARTLIEF (ed.), *Financial Compensation for Victims of Catastrophes: A Comparative Approach*. Vienna, Austria, Springer. http://dx.doi.org/10.1007/3-211-33775-X_10

REBETEZ, M.; MAYER, H.; DUPONT, O.; SCHINDLER, D.; GARTNER, K.; KROPPE, J.P.; MENZEL, A. 2006. Heat and Drought 2003 in Europe: A Climate Synthesis. *Annals of Forest Science*, **63**(6):569-577. http://dx.doi.org/10.1051/forest:2006043

REUTERS. 2011. *Chevron, Transocean in $11 billion Brazil Oil Suit* (Dec. 14). Available at: http://www.reuters.com/article/2011/12/15/us-chevron-transocean-idUSTRE7BE03B20111215. Access on: 06/08/2012.

RINDEBRO, U. 2011. Natural Disasters Likely to Become More Frequent, Costly – Swiss Re – Brazil. *Business News Americas*. Available at: http://www.bnamericas.com/news/insurance/natural-disasters-likely-to-become-more-frequent-costly-swiss-re. Access on: 06/08/2012.

ROMM, J. 2011. Brazil's Deadliest Natural Disaster in History. *Think-Progress*. http://thinkprogress.org/romm/2011/01/16/207348/brazilian-floods-brazil-deadliest-natural-disaster-in-history/?mobile=nc. Access on: 06/08/2012.

SMITH, N. 2006. There's No Such Thing as a Natural Disaster. Available at: http://understandingkatrina.ssrc.org/Smith. Access on: 06/08/2012.

STERN, N. 2007. *The Economics of Climate Change*. Cambridge, Cambridge University Press, 712 p.

STOTT, P.A.; STONE, D.A.; ALLEN, M.R. 2004. Human Contribution to the European Heatwave of 2003. *Nature*, **432**:610-614. http://dx.doi.org/10.1038/nature03089

SULLIVAN, B. 2005. Wetlands Erosion Raises Hurricane Risks. *msnbc.com*. Available at: http://www.msnbc.msn.com/id/9118570/. Access on 06/08/2012.

THE GUARDIAN. 2010. *BP Oil Spill Timeline*. Available at: http://www.guardian.co.uk/environment/2010/jun/29/bp-oil-spill-timeline-deepwater-horizon. Access on: 06/08/2012.

THE WHITE HOUSE COUNCIL ON ENVIRONMENTAL QUALITY. 2010. *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy*. Available at: http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf. Access on: 05/24/2011.

U.S. GLOBAL CHANGE RESEARCH PROGRAM. 2010. *Global Climate Change Impacts in the United States*. (U.S. Impacts). Available at: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts. Access on: 06/08/2012.

U.S. GOVERNMENT ACCOUNTABILITY OFFICE. 2010. *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*, Available at: http://www.gao.gov/products/GAO-10-113. Access on: 06/08/2012.

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP). 2003. Impacts of Summer 2003 Heat Wave in Europe. *Environment Alert Bulletin*. Available at: http://www.preventionweb.net/files/1145_ewheatwave.en.pdf. Access on 6/8/2012.

UNITED STATES SENATE COMMITTEE ON HOMELAND SECURITY AND GOVERNMENTAL AFFAIRS. 2006. *Hurricane Katrina: A Nation Still Unprepared*. Available at: http://www.gpo.gov/fdsys/pkg/CRPT-109srpt322/pdf/CRPT-109srpt322.pdf. Access on: 06/08/2012.

USGS. 2011. Earthquake Hazards Program, Magnitude 9.0 – Near the East Coast of Honshu, Japan. Available at: http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usc0001xgp/. Access on: 06/08/2012.

VERCHICK, R.R.M. 2010. *Facing Catastrophe: Environmental Action for a Post-Katrina World*. Cambridge, Harvard University Press, 336 p.

VIDAL, J. 2010. UK Backing Loans for 'Risky' Offshore Oil Drilling in Brazil. *Guardian* Available at: http://www.guardian.co.uk/environment/2010/jun/30/uk-loans-brazil-offshore-drilling?INTCMP=SRCH. Access on: 06/08/2012.

WISE, W. 1968. *Killer Smog: The World's Worst Air Pollution Disaster*. Lincoln, Nebraska, iUniverse, 188 p.

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