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Catastrophic Risk, Climate Change, and Disaster Law

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Abstract

Disaster law promises to become an increasingly important subject over the course of this century. Climate change will increase the frequency of extreme weather events, while more people and property will be at risk due to population growth, coastal development and economic growth. Depending on the extent of climate change, the risks vary from serious to catastrophic. In dealing with these increased levels of risk, the entire disaster cycle must be considered, from pre-disaster risk mitigation to emergency response, followed by insurance and compensation, and rebuilding (and then by another potential disaster). This article provides a framework for considering these issues and sets forth five grand challenges for scholars and policymakers. These challenges require improvement in key areas: techniques for planning in the face of uncertainty; property and land-use rules; sensitivity to issues of social justice; the international framework for emergency disaster response; and mechanisms for risk spreading.

I. *Introduction*

Disasters, both natural and human-induced, are an increasingly common feature of 21st century life. The situation is almost certain to worsen. Yet, despite some improvements, we remain gravely unprepared for the more dangerous world we are about to enter. There's an urgent need around the world to examine and reform the interlocking structures of governance and regulation that pertain to disasters.

There is no question about the seriousness of current disaster risks. Considering just a single country, the US, disaster costs have averaged US$12 billion per year over the past half-century.[1] From 1980–2004, the

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1 Carolyn Kousky, 'Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters, their Determinants, and Risk Reduction Options' (RFF Discussion Paper 12–28, July 2012). Kousky discusses the data and methodological issues involved in such estimates in detail: at 11–13.

US experienced 62 weather events, which caused more than US$1 billion dollars in damages.[2] Averages are misleading, however: Hurricane Katrina alone caused about US$100 billion in direct damage.[3] Losses are highly skewed, with the top 20 per cent of disasters accounting for 80 per cent of the damages.[4] These mega-disasters pose unique challenges to legal systems, not just in the US, but all around the world.

Planning for disaster is a significant activity, but is not at the top of the government's agenda. Prime ministers and presidents receive regular briefings on national security, but not on disaster preparations. In the brave new world before us, that could change. Disaster management may be on its way to becoming one of the major priorities for leaders around the world. A key reason, of course, is climate change.

II. *Climate Change and Disaster Risk*

There is a tendency to think of climate change as happening in the future, but it is already beginning to show significant effects. With rare exceptions, recent years rank at the top of the list of the warmest global temperatures[5] and, depending on future emissions and climate sensitivity, the world will end up two to seven degrees Celsius warmer than it is today.[6] Temperature change in the arctic is estimated to be about twice as large.[7]

Even warming of two degrees Celsius, which now seems virtually inevitable, would leave the earth warmer than it has been in millions of years.[8] Extreme events such as fires, floods and heat waves will become more widespread.[9] Adaptation to these impending changes poses serious challenges.[10] '[T]hus a critical issue for adaptation is the degree to which frequency, intensity, and persistence of extreme events change.'[11] Countries such as Bangladesh could

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2 James Miskel, *Disasters Response and Homeland Security: What Works, What Doesn't* (Stanford University Press, 2008) 25.

3 Ibid 99.

4 Kousky, above note 1, 16.

5 David Archer and Stefan Rahmstorf, *The Climate Crisis: An Introductory Guide to Climate Change* (Cambridge University Press, 2010) 43.

6 Ibid 129.

7 Ibid 133.

8 Ibid 225.

9 Ibid 174; Heidi Cullen, *The Weather of the Future: Heat Waves, Extreme Storms, and Other Scenes from a Climate-Changed Planet* (HarperCollins, 2010). On the flooding issues, see Howard C Kunreuther and Erwann O Michel-Kerjan, *At War with the Weather: Managing Large-Scale Risks in a New Era of Catastrophes* (MIT Press, 2009) 11–12 (impact of climate change on catastrophic weather events).

10 These challenges are discussed in Tim Bonyhady, Andrew Macintosh and Jan McDonald (eds), *Adaptation to Climate Change: Law and Policy* (Federation Press, 2010); US Government Accountability Office, *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions* (7 October 209) <http://www.gao.gov/products/GAO-10-113>.

11 William E Easterling III, Brian H Hurd and Joel B Smith, *Coping with Global Climate Change: The Role of Adaptation in the United States* (June 2004) Center for Climate and Energy Solutions, 17 <http://www.pewclimate.org/global-warming-in-depth/all_reports/adaptation>.

lose substantial portions of their land areas, including crucial agricultural lands.[12] In the meantime, much of Africa will be subject to serious droughts, with adverse effects on agriculture.[13]

Effects are likely to be even greater if the planet warms by four degrees Celsius, which is a likely outcome if emissions continue to rise. According to the World Bank:

> The 4°C scenarios are devastating: the inundation of coastal cities; increasing risks for food production potentially leading to higher malnutrition rates; many dry regions becoming dryer, wet regions wetter; unprecedented heat waves in many regions, especially in the tropics; substantially exacerbated water scarcity in many regions; increased frequency of high-intensity tropical cyclones; and irreversible loss of biodiversity, including coral reef systems.
>
> And most importantly, a 4°C world is so different from the current one that it comes with high uncertainty and new risks that threaten our ability to anticipate and plan for future adaptation needs.[14]

The World Bank predicts dryer conditions in many parts of the world, including Australia. Sea-level rise could reach one metre above current levels[15] and monthly temperature averages (including nights) of 40 degrees Celsius are predicted for Australia.[16] Meanwhile, according to the Climate Institute, a three- to four-degree Celsius increase would mean a 20 per cent increase in bushfire risk[17] and would require major relocation of infrastructure.[18]

Climate change does not merely intensify the potential for local disasters, but may also turn out to be a global disaster in its own right, as Harvard economist Martin Weitzman has emphasised. He estimated the odds of a temperature increase over 10 degrees Celsius at about five per cent.[19] As Weitzman points out, 'such high temperatures have not existed for hundreds of millions of years and such a rate of global temperature change might be unprecedented even on a timescale of billions of years'.[20]

Weitzman sees 'a nonnegligible probability of worldwide catastrophe'.[21] Even if we put aside the possibility of worldwide disaster that Weitzman highlights, it is clear that climate change entails an increase in various kinds of

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12 Andrew Guzman, *Overheated: The Human Cost of Climate Change* (Oxford University Press) 62–3.

13 Ibid 121–6.

14 World Bank, 'Turn Down the Heat: Why a 4°C Warmer World Must be Avoided' (World Bank, November 2012), ix <http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf>.

15 Ibid 29.

16 Ibid 40.

17 The Climate Institute, *Coming Ready or Not: Managing Climate Risks to Australia's Infrastructure* (2012), 9 <http://www.climateinstitute.org.au/verve/_resources/TCI_ComingReadyorNot_ClimateRiskstoInfrastructure_October2012.pdf>.

18 Ibid 28.

19 Martin L Weitzman, 'On Modeling and Interpreting the Economics of Catastrophic Climate Change' (2009) 91 *Review of Economics and Statistics* 1, 1.

20 Ibid.

21 Ibid.

local disasters, such as droughts and floods.[22] There is an urgent need to limit greenhouse gas emissions if we are to avoid unacceptable risks of catastrophe.

III. *The Disaster Cycle as an Organising Principle for Disaster Law*

Disaster risks involve a host of laws. To name just a few: land-use rules govern where people live and to what risks they are exposed. Infrastructure is governed by complex laws about the grid, the water system and transportation — and this in turn relates to disaster damage and recovery. Insurance law helps determine what resources are available for recovery. International law influences responses to major disasters, especially in developing countries. The list goes on.

Fortunately, disaster law has become the subject of an expanding body of legal scholarship. A growing community of legal researchers recognises 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 that seeks to inform and improve disaster-related decision-making, as evidenced by recent books[23] and a rapidly expanding number of law review articles.

In my view, the most useful organising principle is a simple idea called the 'disaster cycle'. The disaster cycle consists of mitigation, emergency response, compensation, and rebuilding, with the latter completing the circle by including (or failing to include) mitigation measures.[24] Climate change poses new challenges at every stage of the cycle.

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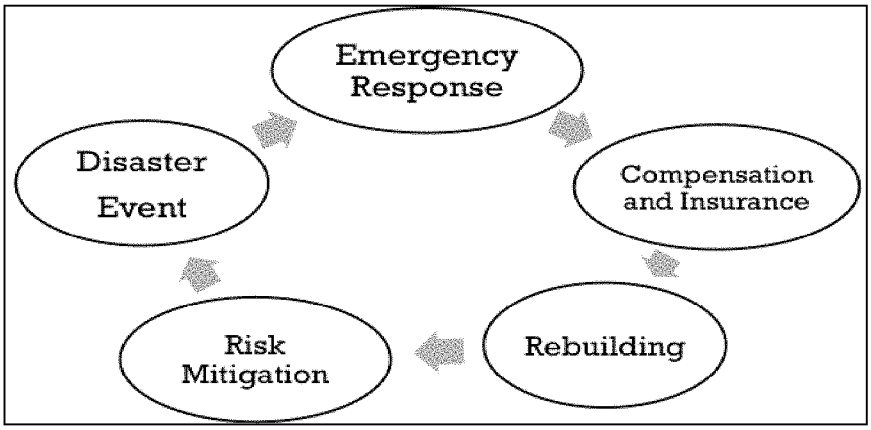
[22] For instance, 2012 'saw one of the worst droughts in a generation in much of the United States', while in European and Russia, some regions saw the worst droughts in several decades: Joshua Elliott et al, 'Predicting Agricultural Impacts of Large-scale Drought: 2012 and the Case for Better Modeling' (Working Paper No 131, Centre for Climate Change Economics and Policy; Working Paper No 111, Grantham Research Institute on Climate Change and the Environment, April 2013) Centre for Climate Change Economics and Policy <http://www.cccep.ac.uk/Publications/Working-papers/Papers/130-139/WP131-agricultural-impacts-drought-2012-modeling.pdf>.

[23] Andrea de Guttry, Marco Gestri and Garbriella Venturini (eds), *International Disaster Response Law* (Springer, 2012); Daniel A Farber, Jim Chen, Robert Verchick and Lisa Sun, *Disaster Law and Policy* (Aspen, 2nd ed, 2009); John R Nolon and Daniel B Rodriguez (eds), *Losing Ground: A Nation on Edge* (Environmental Law Institute, 2007); Robert R M Verchick, *Facing Catastrophe: Environmental Action for a Post-Katrina World* (Harvard University Press, 2010).

[24] Farber et al, above note 23, 3.



A. *The cycle of disaster law*

Each stage of the cycle of disaster is part of society's risk-management portfolio. In the popular mind, the focus may be on the drama of the disaster itself and the immediate emergency response. But the other stages of the cycle are equally important.

Using the disaster cycle as a framework has the advantage of putting the emergency response, which usually gets the lion's share of attention, into context. Botched risk mitigation can amplify the impact of the later disaster — for instance, Hurricane Katrina would have caused far fewer deaths if the New Orleans flood control system had been properly designed. What happens *after* the disaster event — compensation mechanisms and rebuilding — is as important as the emergency response in determining the severity of the impact on many victims. Making communities resilient to disaster involves much more than rapid emergency response:

> A variety of tools exist to manage disaster risk including tangible structural (construction-related) measures such as levees and dams, disaster-resistant construction, and well-enforced building codes, and nonstructural (nonconstruction-related) measures such as natural defenses, insurance, zoning ordinances, and economic incentives. Structural and nonstructural measures are complementary and can be used in conjunction with one another.[25]

1. *Mitigation of disaster risks*

If we begin with the situation *before* the disaster, successes and failures in risk mitigation can be the difference between a routine disruption and a major catastrophe.

[25] National Resource Council, *Disaster Resilience: A National Imperative* (National Academies Press, 2012) 3.

The damage wrought by a natural event — extreme weather or earthquakes, for example — is linked with human activity. It is almost a cliché in the field that there is no such thing as a truly 'natural' disaster. Physical 'phenomena are a necessary component of risk, but they are only the starting point in addressing safety concerns'; calculating and planning for disaster risks must account for 'acts of nature, … weaknesses of human nature, and ... side effects of technology'.[26]

The most important single step to reduce disaster risks is to cut carbon emissions in order to limit the extent of climate change. In ratifying the UNFCCC,[27] developed countries — including the US — committed to regulating greenhouse gases.[28] Two provisions of the UNFCCC are particularly relevant. First, under art 3(3), the parties adopt the principle that they should take 'precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects'. Second, under art 4(1)(b), the parties agree to 'formulate, implement, publish and regularly update … measures to mitigate climate change by addressing anthropogenic emissions by sources'. In particular, developed countries such as the US commit to adopting 'national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs'.[29] Even without a specific agreement on mitigation measures, the UNFCCC obligates nations to make a good-faith effort to address emissions, individually and together.

Action to reduce emissions is urgently needed. Scientists have recently stressed the importance of timing in climate policy:

> [A]chieving the same 60% chance of success with action starting in 2020 would require a 2020 carbon price of around US$150 per tonne of carbon dioxide equivalent (CO_2e) — more than double the $60 per tonne CO_2e required if action begins in 2015. However, delaying emissions limits from 2020 to 2025 would bring the chance of success down to 34%, and the authors found no scenario in which a feasible increase in carbon price or improvements in energy technology could make up for these five years of delay.[30]

The study also suggests that there has been some convergence of the views of economists and that we can achieve emissions limitations without paying an undue economic price:

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26 Daniel A Farber et al, 'Reinventing Flood Control' (2006) 81 *Tulane Law Review* 1085, 1090.

27 *United Nations Framework Convention on Climate Change*, opened for signature 9 May 1992, 1771 UNTS 107 (entered into force 21 March 1994).

28 UNFCCC, *Status of Ratification of the Convention* (2013) <http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php>.

29 The UNFCCC also contemplates international cooperation. Article 4(2)(a) provides that: 'Parties may implement such policies and measures jointly with other Parties and may assist other Parties in contributing to the achievement of the objective of the Convention'.

30 Steve Hatfield-Dodds, 'Climate Change: All in the Timing' (2013) 493 *Nature* 35.

> That literature is characterized by two underappreciated points of consensus. First, the key protagonists in the debate over the British government's 2006 Stern Review … now all agree that action to limit temperature rise to 2 °C (or emissions to 450 parts per million CO2e) would provide net benefits; this represents a quiet reversal in the position of economist William Nordhaus, who was initially critical of the review. Second, economic analysis shows that ambitious global action to limit emissions is fully consistent with strong economic growth and improvements in living standards.[31]

Although mitigation is key to reducing the disaster risks associated with climate change, some degree of climate change is inevitable, and we must begin planning for adaptation.

International law has also begun to address the need to reduce disaster risks as part of the process of adapting to climate change. In art III(14) of the *Cancun Agreement*, the Conference of the Parties calls on 'all Parties to enhance action on adaptation … taking into account their common but differentiated responsibilities and respective capabilities by undertaking [specified actions]'.[32] The term 'adaptation' has nuances that vary among different writers, but the UNFCCC website provides a useful working definition:

> Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.[33]

Risk mitigation involves many different types of activities. It can encompass the construction of new infrastructure, such as levees or dams for flood control. It can also include land-use controls to separate people spatially from high-risk areas or to preserve buffer areas. It can also include hardening infrastructure to make it more resilient.

One of the great weaknesses in infrastructure planning is unwillingness to imagine the full scope of potential disaster risks. Although it involved an earthquake rather than a climate-related event, the Fukushima nuclear accident is a particularly striking example of how organisations may blind themselves to risks. The reactors were situated on a small bluff, which was thought to provide sufficient protection from tsunamis. History indicated otherwise: there is a historical record of a huge tsunami in July of 869, and geological evidence indicating a thousand-year return cycle.[34] Indeed, in 2008, experts at TEPCO had performed some preliminary modelling suggesting that the tsunami hazard was

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31 Ibid.

32 Decision 1/CP.16, 'The Cancun Agreements: Outcome of the Work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention' in *Report of the Conference of the Parties on its Sixteenth Session, held in Cancun from 29 November to 10 December 2010*, UN Doc FCCC/CP/2010/7/Add.1 (15 March 2011).

33 UNFCCC, *FOCUS: Adaptation* (2013) <http://unfccc.int/focus/adaptation/items/6999.php>.

34 Rodney C Ewing, Jeroen Ritsema and David J Brenner, 'Fukushima: What Don't We Know?' (2011) *Bulletin of the Atomic Sciences* <http://pages.citebite.com/k6f7y9d2hpoa>.

much greater than its previous estimate.[35] Until 2006, the government did not even discuss tsunamis in its safety guidelines, and even then it insisted that the 'robust sealed containment structure around the reactor itself would prevent any damage to the nuclear part of the reactor from a tsunami … No radiological hazard would be likely'.[36]

The Japanese government continued to underestimate risks from seismic events despite a 2007 earthquake at the Kashiwazaki-Kariwa Nuclear Power Plant that was over twice as strong as projections and resulted in harm that company officials said was 'beyond our imagination'.[37] This event should have been a warning about the unreliability of seismic predictions, the potential for unprecedented harm mechanisms and the need to widen 'imagination' beyond the comfort zone of well-documented risks. Yet officials and industry continued as if they had a full understanding of all the risks, rather than realising the need for additional precaution.

Scenario analysis is one method of pushing decision-makers beyond their comfort zones by making them contemplate situations in which their own assumptions might fail.[38] Robert Verchick has emphasised the importance of scenario analysis — and of the act of imagination required to construct and consider these scenarios — in the face of uncertainty.[39] As he explains, scenario analysis avoids the pitfall of projecting a single probable future when vastly different outcomes are possible; it broadens knowledge by requiring more holistic projections; forces planners to consider changes within society as well as outside circumstances; and, most importantly, it 'forces decision-makers to use their imaginations'.[40] However, it is important to not build scenarios merely around the potential future that is considered most probable.

Two other methods of scenario planning are particularly promising. One is known as assumption-based planning ('ABP'), which:

> was designed to make a plan more resistant to significant change, and to help an organization to identify when to adapt the plan … It begins by assuming that there is a proposed plan, or that there is a plan already in operation. It then tries to

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35 James M Acton and Mark Hibbs, *Why Fukushima was Preventable* (6 March 2012) Carnegie Endowment for International Peace, 13 <http://carnegieendowment.org/2012/03/06/why-fukushima-was-preventable>.

36 Charles Perrow, 'Fukushima, Risk, and Probability: Expect the Unexpected' (2011) *Bulletin of the Atomic Scientists* <http://thebulletin.org/fukushima-risk-and-probability-expect-unexpected-0>.

37 Ashwin Kumar and M V Ramana, 'Nuclear Safety Lessons from Japan's Summer Earthquake' (2007) *Bulletin of the Atomic Scientists* <http://thebulletin.org/nuclear-safety-lessons-japans-summer-earthquake>.

38 For information about implementing scenario planning, see Alfred Marcus, *Strategic Foresight: A New Look at Scenarios* (Palgrave Macmillan, 2009).

39 Verchick, above note 23, 239–49.

40 Ibid 224–43.

> protect the plan from failing, by examining each of the underlying assumptions, and seeing what would happen to the plan if that assumption were not to be true.[41]

An alternative, computerised approach generates large numbers of scenarios in order to isolate the features of plans that make them most resilient across a wide range of events.[42]

It is also important to not focus too narrowly on protective infrastructure as a response to disaster risks.[43] For instance, coastal wetlands can play a buffering role against storm surges.[44] A careful meta-study showed that salt marshes weaken incoming waves and help stabilise shorelines.[45] Experts agree that flood protection must include higher-density development in safer areas, no-build zones and green infrastructure.[46] The European Union's 2007 *Flood Directive*[47] is said to 'provide an example of a coherent risk-management policy for floods'.[48]

2. *The emergency response*

The significance of the emergency response needs no explanation. Different nations will have different internal systems for disaster response, but there is also a need for much stronger international mechanisms. We are going to be seeing more major disasters that individual countries may be unable to manage. Developing countries will be especially in need of assistance.

International disaster relief has a long history, dating back at least to the great earthquake that destroyed Lisbon in 1755.[49] By 1921, the Red Cross

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41 Warren E Walker, Marjolijn Haasnoot and Jan H Kwakkel, 'Adapt or Perish: A Review of Planning Approaches for Adaptation under Deep Uncertainty' (2013) 5 *Sustainability* 955, 959. More specifically:

> ABP identifies the assumptions upon which the success of the plan most heavily rests (the *'load-bearing'* assumptions) and the assumptions that are most *vulnerable* to being overturned by future events. Assumptions that are both load-bearing and vulnerable are the most likely to produce nasty surprises as the plan unfolds. To deal with potential surprises, ABP produces three things: signposts, shaping options, and hedging actions. A *signpost* is an event or threshold that, if detected, signifies that a vulnerable assumption is being broken or is dangerously weak, and that some action should be taken. A *shaping action* is an action that is intended to help protect an uncertain assumption — to control the future as much as possible. A *hedging action* prepares for the possibility that an assumption will fail, despite the shaping actions (at 959–60).

42 Ibid 959–69. These are part of a family of approaches to adaptive decision-making under uncertainty that are beginning to be used in practice for the Thames Estuary in the UK, the Rhine-Meuse delta in the Netherlands, the Port of Los Angeles and New York City: at 972.

43 A Dan Tarlock, 'United States Flood Control Policy: The Incomplete Transition from the Illusion of Total Protection to Risk Management' (2012) 23 *Duke Environmental Law & Policy Forum* 151.

44 Christine C Shepard, Caitlin M Crain and Michael W Beck, *The Protective Role of Coastal Marshes: A Systematic Review and Meta-analysis* (2011) 6 PLoS ONE 1.

45 Ibid.

46 Tarlock, above note 43, 171.

47 *Council Directive 2007/60/EC of 23 October 2007 on the Assessment and Management of Flood Risks* [2007] OJ L 288/27.

48 Ibid 155.

49 Alejandra de Urioste, 'When Will Help Be on the Way? The Status of International Disaster Response Law' (2006) 15 *Tulane Journal of International and Comparative Law* 180, 183.

recommended an international convention on disasters, which led to the creation of an International Relief Union — which alas did not survive World War II.[50] The International Relief Union's successor was the UN Disaster Relief Coordinator, later subsumed into the Office for the Coordination of Humanitarian Affairs.[51]

Despite this, the Red Cross still sees a 'yawning gap' in international law regarding disaster response.[52] Some of the problems can be seen in the massive international response to the South-East Asia tsunami, which involved more than 200 NGOs and a dozen governments. In the resulting confusion, communication was poor and efforts were duplicated or lack of shared expertise led to failures in assistance.[53] Adequate coordination mechanisms still do not exist.[54] As the International Red Cross has said: 'At the dawn of the 21st century, a cohesive approach to international disaster law is not much farther along than it was at the start of the 20th.'[55]

3. *Compensation and rebuilding*

After an emergency has passed, insurance, tort law and government disaster assistance provide ways of spreading and shifting risks. When we cannot (or simply *have* not attempted to) mitigate risks before the event, these compensation mechanisms help blunt their impact and, even if we have avoided the risks through swift response afterwards, they help prepare for reconstruction or rebuilding.

Post-disaster compensation generally has one of three sources: private insurance, government aid or the tort system.[56] Private insurance is often unavailable or fails to provide prompt and efficient compensation. Problems include the frequent unavailability of separate private insurance for catastrophic risks or exclusion of catastrophic risks from insurance coverage, and the difficulty of handling very large numbers of claims creates significant hurdles. The second method of compensation, litigation against responsible parties, also has its limitations, and faces barriers even in developed countries like the US and Japan. Third is the possibility of obtaining compensation from the governments or international organisations. Liability and government-supported insurance

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50 Ibid 184.

51 Ibid 186.

52 Ibid.

53 Ibid 194–5.

54 Giovanni De Siervo, 'Actors, Activities, and Coordination in Emergencies', in de Guttry, Gestri and Venturini, above note 23.

55 International Federation of Red Cross and Red Crescent Societies, *World Disasters Report* (2000), 157. In the interest of brevity, I will refer to this organisation as the Red Cross, but with no desire to slight the Red Crescent component of the Federation.

56 These issues are discussed in detail, in a multi-national comparison, by Robert L Rabin and Suzanne A Bratis, 'United States' in Michael Faure and Ton Hartlief (eds), *Financial Compensation for Victims of Catastrophes: A Comparative Approach* (Springer, 2006) 303, 356. The remainder of the paragraph in the text presents some of their findings.

may also be combined.[57] Climate change makes the future less predictable. That really complicates the insurance situation, since it's harder to know what to charge for premiums. This will put more stress on funding mechanisms outside of the private sector.

The point of compensation is to give people the resources to begin to rebuild their lives. For wealthier countries, the process is largely internal, apart from the contribution of the international reinsurance market to risk spreading. Poorer countries need more assistance.

International mechanisms are beginning to emerge to a limited extent to assist countries hit by natural disasters.[58] The International Monetary Fund ('IMF') can make special funding available to countries if a disaster disrupts their balance of payments.[59] The IMF has 'provided resources in cases of earthquakes, drought, hurricanes, floods, and cyclones'.[60] The IMF provisions are too complex to describe here. Indeed, according to one informed observer, some of those provisions are 'formulated with such complexity and detail, and at such length, that members, unable to understand all the intricacies of this policy, have been deterred from resorting to it'.[61] The IMF's sister institution, the World Bank, has also been involved in disaster funding. Examples are provided by the creation of 'special purpose funds' by the Bank for reconstruction efforts in Indonesia (after the Southeast Asian Tsunami) and Haiti.[62] Financing by the IMF, World Bank and other financial institutions still suffers from the lack of any coordinating mechanism.[63]

Funding for international disaster relief will become an increasing issue. We are sure to hear claims for increased contributions by wealthier countries that are also high emitters — not just developed countries, but also emerging economies such as China.

Rebuilding has significance in its own right, but it is also in some sense just the beginning of a new cycle, inasmuch as it incorporates mitigation efforts for the next disaster down the road. The emergency response feeds into the recovery phase, as evacuees become permanent migrants or return to their homes.

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57 W Kip Viscusi and Richard J Zeckhauser, 'Deterring and Compensating Oil Spill Catastrophes: The Need for Strict and Two-Tier Liability' (2011) 64 *Vanderbilt Law Review* 1717–65 (suggesting a combination of private liability and tax-supported compensation for damages that exceed the defendant's financial capacity).

58 See Giovanna Adinolfi, 'The Role of International Financial Institutions' in de Guttry, Gestri and Venturini, above note 23.

59 Joseph Gold, 'Natural Disasters and Other Emergencies Beyond Control: Assistance by the IMF' (1990) 24 *International Law* 621.

60 Ibid 633.

61 Ibid 639.

62 Jenny R Hernandez and Anne D Johnson, 'A Call to Respond: the International Community's Obligation to Mitigate the Impact of Natural Disasters' (2011) 25 *Emory International Law Review* 1087, 1093.

63 Adinolfi, above note 58, 622–5.

Rebuilding does not just involve physical infrastructure, but also the creation of new social and legal infrastructure to increase resilience. It offers the opportunity for improved urban design and for relocation away from high-risk areas, an issue not yet covered by international law..[64] It also provides an incentive to improve disaster response mechanisms through improved training and organisational reforms.

Rebuilding *should* create an opportunity to think about mitigation: changes in land use and infrastructure in order to reduce the expected harm from disasters. With it, the cycle begins again.

4. *Rethinking how we plan for the disaster cycle*

The disaster cycle is not merely a convenient way of ordering events; it is important because no one stage can be considered in isolation. For instance, suppose we're trying to decide how much to invest in risk mitigation. The answer may depend on expectations about emergency response. If planners assume that a future flood will set in motion successful evacuation, then the flood won't involve risk to life. Based on this expectation, planners may not think it's as important to invest in levees or seawalls. To take another example, the existence of a tsunami warning system could lead urban planners to allow more development near the coast. Of course, that may undermine the utility of the system.

On the other hand, if planners assume that levees or seawalls will be successful, they won't spend much time planning for evacuation. Overconfidence in sea walls and levees may have contributed to additional deaths from floods in Japan and New Orleans.

The most important feature of the disaster cycle is that the loop is closed. It is always tempting to downplay the risk of future disasters after a disaster has taken place. For instance, we might like to believe that US Gulf Coast will never be hit by another Katrina or that Australia will never experience another multi-year severe drought. But risks of this kind do not disappear. Every disaster merely begins the cycle again, calling for a new round of risk mitigation.

IV. *Five Grand Challenges for a Dangerous Century*

If we are to prepare for the increasingly bumpy road ahead, we need to first think our way through some very difficult problems. There are five challenges for researchers and policy analysts, as follows.

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[64] D Hodgkinson and L Young, 'In the Face of Looming Catastrophe: A Convention for Climate Change Displaced Persons' (August 2012) CCDP Convention <http://www.ccdpconvention.com/documents/Updated per cent20treaty per cent20proposal.pdf>.

A. *Challenge 1: Finding techniques for planning in the face of uncertainty*

In its 2008 framework for climate adaptation,[65] the British government called for the use of scenarios in drought planning by local governments, one with a 50 per cent probability and a more extreme one with a 10 per cent probability.[66] In the US, some local authorities are also beginning to use scenario planning.[67]

Computerised scenario generation is a promising new approach.[68] RAND's Robust Decision Making ('RDM') technique provides a systematic way of exploring large numbers of possible policies to identify robust solutions.[69] During each stage of the analysis, RDM 'uses visualization and statistical analysis to identify policies … that perform well over many possible' situations.[70] It then uses data mining techniques to identify the future conditions under which such policies fail.[71] New policies are then designed to cope with those weaknesses, and the process is repeated for the revised set of policies. As the process continues, policies become robust under an increasing range of circumstances, and the remaining vulnerabilities are pinpointed for decision-makers.[72] 'RDM evaluates policy models once for each combination of candidate policy and plausible future state of the world to create large ensembles of futures.'[73] The analysis may include a few hundred to hundreds of thousands of cases.[74] In the context of long-term, global issues, the goal of this analysis is

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65 Her Majesty's Government, 'Adapting to Climate Change in England: A Framework for Action' (2008) DEFRA <http://archive.defra.gov.uk/environment/climate/documents/adapting-to-climate-change.pdf>.

66 Ibid 29.

67 The San Francisco Bay Conservation and Development Commission is using scenario planning to address sea level rise: see <http://www.bcdc.ca.gov/planning/climate_change/climate_change.shtml> (staff recommendations can be found under 'Proposed Plan Amendments'). The New York Sea Level Rise Task Force is taking a similar approach <http://www.dec.ny.gov/energy/45202.html>.

68 See David G Groves, *New Methods for Identifying Robust Long-Term Water Resources Management Strategies for California* 12 (RAND Corporation, 2006) <http://www.rand.org/pubs/rgs_dissertations/2006/RAND_RGSD196.pdf> (mentioning the use of computers for data visualisation, statistical analysis and data mining in RDM); David G Groves et al, *Presenting Uncertainty about Climate Change to Water-Resource Managers: A Summary of Workshops with the Inland Empire Utilities Agency* (RAND Corp, 2008), 74 <http://www.rand.org/pubs/technical_reports/2008/RAND_TR505.pdf> (evaluating the performance of scenario analysis during water-management workshops held by the RAND Corporation and the Inland Empire Utilities Agency).

69 This is a more formalised version of the familiar technique of scenario analysis. For a description of scenario analysis, see James A Dewar, *Assumption-Based Planning: A Tool for Reducing Avoidable Surprises* (Cambridge University Press, 2002) 130–41.

70 Groves, above note 68, 125.

71 Ibid.

72 See David G Groves and Robert J Lempert, 'A New Analytic Method for Finding Policy-Relevant Scenarios' (2007) 17 *Global Environmental Change* 78.

73 Groves, above note 68, 125.

74 Ibid.

to 'produce consensus on some sensible course of short-term action among the many different parties to a decision'.[75]

B. *Challenge 2: Rethinking property rights and land use planning*

Floodplains are going to be moving, as rain patterns change and as sea levels rise. Places once safe to live — or only moderately dangerous — are no longer going to be safe. But our property system assumes that ownership is forever. How can we manage a retreat from rising waters, consistent with property rights?[76] Climate change will lead to higher sea levels and increased coastal erosion, resulting in the landward movement of beaches. In the US, rolling easements are one response;[77] where, essentially, the public right to beach access and preservation moves inward along with the sea.[78] Within the US, some courts have recognised such easements.[79]

C. *Challenge 3: Confronting issues of social justice in climate adaptation and disaster preparation*

Climate change will disproportionately affect vulnerable individuals[80] and 'poorer regions and countries, that is, those who have generally contributed the least to human-induced climate change'.[81] It is not surprising that relatively

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75 Robert J Lempert, Steven W Popper and Steven C Bankes, *Shaping the Next One Hundred Years: New Methods for Quantitative Long-Term Policy Analysis* (RAND Corporation, 2003) 43–4.

76 Blake Hudson, 'Coastal Land Loss and the Mitigation-Adaptation Dilemma: Between Scylla and Charybdis' (2012) 73 *Louisiana Law Review* 31.

77 Meg Caldwell and Craig Holt Segall, 'No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access along the California Coast' (2007) 34 *Ecology Law Quarterly* 533, 566–76.

78 Ibid.

79 See *Concerned Citizens of Brunswick County Taxpayers Association v North Carolina*, 404 SE 2d 677 (NC, 1991). Note, however, that the Texas Supreme Court recently limited the rolling easement doctrine, holding that 'an avulsive event that moves mean high tide line and vegetation line suddenly, causing former dry beach to become part of State-owned wet beach, does not automatically deprive private property owner, through "rolling" easement, of her right to exclude public from new dry beach', at least given the history of property laws applying to the specific local: *Severance v Patterson*, 370 SW 3d 705, 708–9 (Tex, 2012).

80 Stephen Humphreys, *Climate Change and Human Rights: A Rough Guide* (International Council on Human Rights Policy, 2008) 3. According to Eakin and Pratt:

> Studies on adaptive capacity, in many cases, challenge existing social and economic orders by illustrating that adaptation by the most vulnerable social classes may require redistribution of resources and improved access to finance, land, technology, water, and other assets, as well as enhanced access to decision making and governance.

Hallie C Eakin and Anthony Pratt, 'Are Adaptation Studies Effective, and What Can Enhance their Practical Impact?' (2011) 2 *Wiley Interdisciplinary Reviews: Climate Change* 141. London's adaptation planning explicitly recognises risks to vulnerable groups: see Greater London Authority, *The Draft Climate Change Adaptation Strategy for London: Public Consultation Draft* (Greater London Authority, 2010) <http://legacy.london.gov.uk/mayor/priorities/docs/Climate_change_adaptation_080210.pdf>.

81 The Office of the UN High Commissioner for Human Rights also discusses the 'human rights implications of response measures': see Human Rights Council, *Report of the Office of the*

disempowered groups would be the most vulnerable to climate change, as well as to other risks. As in other contexts, we must be ready to address 'the failure of law to provide vulnerable people with the protections and benefits they need to lead safe and productive lives'.[82]

This is partly an issue of equity between nations. National disasters are very expensive in developed countries, but storms, droughts and floods other than tsunamis rarely cause mass fatalities. In developing countries, economic harm is less because there is less valuable property to destroy, but human impacts are much more severe than in developed countries. In the context of climate change, there is a special obligation for high-emitting countries to help poorer, low-emitting countries prepare for disasters and rebuild — given that our own actions have helped increase disaster risks in those countries. We are still struggling to design mechanisms that will finance the necessary disaster preparations and this needs much more work.

Within countries, as well as between countries, equity remains a problem. Countries need to consider whether there is a need for better mechanisms in domestic law to ensure that disadvantaged groups aren't shortchanged in disaster preparation and planning. We also need to think about how international law could be used to help prod laggard countries, perhaps utilising the mechanisms of international human rights law.

Arguments for a human right to disaster prevention and relief also support recognition of a right to resilient infrastructure, which could legally be used to ask action from the state or, at least, to claim priority in the allocation of international adaptation aid.[83] The rationale for recognising a right to resilience derives ultimately from art 3 of the *Universal Declaration of Human Rights*,[84] which provides that '[e]veryone has the right to life, liberty, and security of person'. Article 25 provides every person with a right to security and protection of basic needs 'in the event of … circumstances beyond his control'. Climate change is certainly an event beyond any individual's control, as are disasters such as floods or droughts caused by climate change. Indeed, some scholars have recently argued in favour of recognition of a human right to climate adaptation.[85] They suggest that recognition of this right could help prioritise adaptation funding.[86] This line of argument is promising, but we are a long way from implementation of such a right to climate adaptation or, more specifically, to resilient infrastructure.

United Nations High Commissioner for Human Rights on the Relationship between Climate Change and Human Rights, 10th sess, UN Doc A/HRC/10/61 (15 January 2009).

82 Verchick, above n 23, 128.

83 See Annalisa Creta, 'A (Human) Right to Humanitarian Assistance in Disaster Situations? Surveying Public International Law' in de Guttry, Gestri and Venturini, above note 23; George Kent, 'The Human Right to Disaster Mitigation and Relief' (2001) 3 *Environmental Hazards* 137, 137.

84 GA Res 217A (III), UN GAOR, 3rd sess, 183rd plen mtg, UN Doc A/810 (10 December 1948).

85 Margaux J Hall and David C Weiss, 'Avoiding Adaptation Apartheid: Climate Change Adaptation and Human Rights Law'(2012) 37 *Yale Journal of International Law* 309, 331–5.

86 Ibid 360.

Other human rights claims could be more focused. Impacted groups, especially those who lack the resources to protect themselves from climate change, may pick up and move. For instance, as agriculture becomes more difficult or riskier, rural populations may move elsewhere. Particular attention has been given to the rights of persons who are displaced as a result of climate change, inasmuch as migration is a well-established response to disasters and other adverse events[87] that will increase with climate change:

> many people refer to this class of persons as 'climate migrants' or 'environmentally displaced persons', and seek protection for them through other legal avenues, primarily through domestic law and proposed expansions to the international climate regime. These efforts, however, have proven controversial and largely unsuccessful, leaving these people with minimal legal protections and reliant on inadequate sources of climate change adaptation assistance for relief.[88]

There have been proposals for an international convention to protect these individuals, at least when they cross national borders.[89] Some writers have gone further and called for an international convention that covers internal displacement.[90]

Finally, within countries, the most vulnerable populations are often those who are disadvantaged in other respects or subject to discrimination, but sensitivity to the needs of those groups is often lacking in disaster management.[91]

D. *Challenge 4: Creating coherent international laws governing emergency transnational emergency responses*

There has been recognition for at least a century that we need a coherent framework for international disaster relief, yet no such framework exists. This may partly be true because nations are wary of making open-ended commitments to provide relief. But a starting point could be the creation of something like an international equivalent of Emergency Management Australia, which could coordinate public and private actors. Such an agency would need to be able to access information about available resources very quickly, determine the willingness of nations and major private organisations to supply such resources,

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87 See Leah Platt Boustan, Matthew E Kahn and Paul W Rhode, 'Moving to Higher Ground: Migration Response to Natural Disasters in the Early Twentieth Century' (2012) 102 *American Economic Review* 238, 238.

88 Cinnamon Carlarne, 'Risky Business: The Ups and Downs of Mixing Economics, Security and Climate Change' (2009) 10 *Melbourne Journal of International Law* 439, 464.

89 B Mayer, 'The International Legal Challenges of Climate-Induced Migration: Proposal for an International Legal Framework' (2011) 22 *Colorado Journal of International Environmental Law and Policy* 357; Bonnie Docherty and Tyler Giannini, 'Confronting a Rising Tide: A Proposal for a Convention on Climate Change Refugees' (2009) 33 *Harvard Environmental Law Review* 349.

90 Hodgkinson and Young, above note 64.

91 Mariangela Bizzarri, 'Protection of Vulnerable Groups in Natural and Man-Made Disasters' in de Guttry, Gestri and Venturini, above note 23.

and then manage the logistics. This would be a technical challenge, involving extensive data collection and information processing, but would also require that a management structure be in place and that data channels be clearly established in advance.

E. *Challenge 5: Creating new forms of risk spreading*

Disaster victims will suffer from the confluence of several factors. The first is our historical and ongoing emission of carbon, resulting in climate change and increased risk. The second is bad disaster preparation, sometimes by themselves and sometimes by others. The third is simply bad luck — they may just be in the wrong place and the wrong time. We can't pass laws to ban bad luck, but we can use insurance systems to spread losses and make them more bearable.

Major disasters already pose challenges to insurance, whether private or public. Losses cluster, making it harder for companies to spread risks and even sometimes threatening liquidity. At the high end, the risks may be difficult for insurers to handle, and reinsurance may be difficult to obtain. It is tempting for governments to step in, but, at least in the US, this too has been problematic:

> The federal flood-insurance program was flawed from the start, and its problems have progressively worsened. In combination with the construction of flood control projects, a federal flood-insurance program encourages over-building high-risk areas … The costs of the 2005 hurricane season, which were primarily due to Hurricane Katrina, added eighteen billion dollars of debt to the program even though it was already running in the red.[92]

A recent report by the US National Resource Council advocates changing the flood insurance program to more realistically deal with residual risk for areas behind levees, to communicate risk levels more effectively and to eliminate some favoured categories of insured property that receive subsidised rates.[93] Climate change makes these problems more pressing by upping the ante. It also adds to another difficulty for insurance design: the odds are constantly shifting because climate change is an ongoing process. This makes it all the more difficult to set premiums (for private insurers) and plan budgets (for public ones). The challenge here is to design new forms of private and social insurance that spread risks, provide predictability and maintain safety incentives.

V. *Conclusion*

For several reasons, disaster law promises to become an increasingly important subject over the course of this century and beyond. Climate change will increase the frequency of extreme weather events, while more people and property will be at risk due to population growth, coastal development and economic growth. Depending on the location and the extent of future climate change, the risks vary from serious to catastrophic. Current decisions about growth, land use, and

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[92] Tarlock, above note 43, 169.

[93] National Resource Council, *Levees and the National Flood Insurance Program: Improving Policies and Practices* (National Academy Press, 2013).

carbon emissions may make the future riskier for much of the world's population.

These developments heighten the importance of improving domestic and international institutions for disaster management. It is a mistake to focus exclusively on the drama of immediate post-disaster emergencies. Instead, the entire disaster cycle must be considered, from pre-disaster risk mitigation to emergency response, followed by insurance and compensation, and rebuilding (and then by another potential disaster). Such a holistic approach to disasters is necessary in order to craft viable long-term strategies for dealing with an increasingly risky world.

This article has attempted to provide a framework based on the concept of the disaster cycle for considering these issues. It also sets out five grand challenges for scholars and policymakers. These challenges require improvement in key areas: techniques for planning in the face of uncertainty; property and land-use rules; sensitivity to issues of social justice; the international framework for emergency disaster response; and mechanisms for risk spreading. Attention to these grand challenges now may help society fend off avoidable future tragedies later.