Introduction to the *Research Handbook on Climate Disaster Law*

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Why Climate Disaster Law and what is it? Building on the work of other Disaster Law scholars,[1] Climate Disaster Law[2] applies to disasters which are climate related and means a portfolio of legal rules which deal with: prevention, emergency response, recovery and rebuilding, and compensating victims. The Intergovernmental Panel on Climate Change (IPCC) defines climate disasters as:

> severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.[3]

The IPCC's 2013 Working Group I *Fifth Assessment Report*,[4] and the 2012 *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX)[5] evaluate how hazards, like natural climate variability and anthropogenic climate change, influence the climate extremes that contribute to disasters when they intersect with the exposure and vulnerability of human society and natural ecosystems to these extremes. Although the IPCC states that attribution of changes in individual climate events to anthropogenic forcing is complicated,[6] there is sufficient evidence to suggest that climate extremes such as heat waves, record high temperatures and, in many regions, heavy precipitation have changed due to climate change in the past half century. Climate disasters can also result from a series of non-extreme events which occur in combination with social vulnerabilities and exposure to risks.[7]

The IPCC is careful to explain that there is not a "one-to-one" relationship between extreme weather events and disasters. Rather, extreme events will lead to disaster "if:

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[1] For publications on Disaster Law see, e.g., Daniel A. Farber, James Ming Chen, Robert R.M. Verchick, & Lisa Grow Sun, Disaster Law and Policy (2015); Disaster Law (Daniel A. Farber & Michael G. Faure eds., 2010).

[2] For the first-ever use of this term and an extensive discussion of it see Rosemary Lyster, Climate Justice and Disaster Law (2015).

[3] IPCC, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change 33 (C.B. Field, et al. eds., 2012), *available at* https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf.

[4] *See* IPCC, Climate Change 2013: The Physical Science Basis. Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Thomas F. Stocker, et al. eds. 2013), *available at* https://www.ipcc.ch/report/ar5/wg1/.

[5] IPCC, *supra* note 3.

[6] IPCC, *supra* note 4, at 368.

[7] *Id.*

1) communities are exposed to those events; and 2) exposure to potentially damaging extreme events is accompanied by a high level of vulnerability (a predisposition for loss and damage)."[8] The resilience of people exposed to extreme events can be increased if policies to avoid, prepare for, respond to, and recover from the risks of disaster are adopted. However, when thresholds or tipping points associated with social and/or natural systems are exceeded, limits to resilience will be reached, posing severe challenges for adaptation. In any case, the escalating impacts associated with extreme weather events are due to several factors, including climate change, the growth of urban development and population density in exposed areas, and a higher concentration of assets and values at risk.[9] However, the IPCC acknowledges with *high confidence* that economic losses from weather- and climate-related disasters have increased, although with large spatial and inter-annual variability.[10]

The likelihood of future extremes has been dealt with comprehensively by the IPCC in two major reports: the 2012 *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*[11] and Working Group II's *Fifth Assessment Report* entitled *Climate Change 2014: Impacts, Adaptation and Vulnerability.*[12] These reports evaluate the risks of climate change for human and natural systems and how they can be managed through adaptation and mitigation.

But in a 2017 paper published by the U.S. National Academy of Sciences, Yangyang Xu and Veerabhadran Ramanathan are circumspect about whether the Paris Agreement will be successful in limiting global temperature rise to "well below 2°C," given the many uncertainties in emissions scenarios, climate, and carbon cycle feedback.[13] This leads them to interpret the Paris Agreement in terms of three climate-risk categories and bring in considerations of low-probability (5 percent) high-impact (LPHI) warming in addition to the central (50 percent probability) value. The authors define warming scenarios as follows: >1.5°C as dangerous; >3°C as catastrophic; and >5°C as unknown, implying beyond catastrophic, including existential threats. With unchecked emissions, the warming has a 50 percent probability of reaching dangerous levels (>1.5°C), with the LPHI warming becoming catastrophic (>3°C) by 2050. Within eight decades, the warming has a 50 percent probability of subjecting the global population to catastrophic (>3°C) unknown risks (>5°C) and a 5 percent probability of being fully in the unknown risk category, which also includes existential threats for everyone. These scenarios suggest that emissions of CO_2 and short-lived climate pollutants (SLCPs) (methane, tropospheric ozone, black carbon, and hydrofluorocarbons (HFCs)) should peak immediately and trend downward by 2020. Aggressive policies will be required to achieve carbon neutrality

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[8] *Id.*

[9] Alberto Monti, *Climate Change and Weather-related Disasters: What Role for Insurance, Reinsurance and Financial Sectors?*, 15 Hastings West and Northwest J. of Envtl L. & Pol'y 151 (2009).

[10] IPCC, *supra* note 3, at 269.

[11] *Id.*

[12] IPCC, *Summary for Policymakers*, in IPCC, *supra* note 3.

[13] Yangyang Xu and Veerabhadran Ramanathan, *Well Below 2°C: Mitigation Strategies for Avoiding Dangerous to Catastrophic Climate Changes,* Proc. of the Nat'l Acad. of Sci. (2017), *available at* http://www.pnas.org/content/early/2017/09/14/1618481114.full#ref-30.

and climate stability. The authors recommend a three-lever strategy to limit the central warming below the dangerous level and the LPHI below the catastrophic level, both in the near term (<2050) and in the long term (2100). The strategies are: the carbon neutral (CN) lever to achieve zero net emissions of CO_2, the super pollutant (SP) lever to mitigate SLCPs, and the carbon extraction and sequestration (CES) lever to sequester CO_2 and thin the atmospheric CO_2 blanket.

The authors note that over 220 years (from 1750 to 1970) society emitted the first trillion tons of CO_2 and the next trillion tons over only another 40 years (1970–2010). Under current emissions trends, the third trillion tons will be emitted by 2030 and the fourth trillion tons before 2050. Even if the Paris Intended Nationally Determined Contributions (INDCs) are implemented rigorously and verifiably, the third trillion tons will be added by 2035. In contrast, earlier studies have identified that cumulative CO_2 emissions must be limited to less than 3.7 trillion tons to have any chance of limiting the warming below 2°C.[14] While reducing the carbon intensity of the economy is a very potent mitigation measure and, by itself, can reduce the 2100 CO_2 warming by 0.9°C from 3.5 to 2.6°C, concentrations of SLCPs must also be substantially reduced beginning in 2020, relying on technological measures that are mostly available. However, to limit the LPHI warming below dangerous levels, the CES lever must extract as much as 1 trillion tons of CO_2 out of the atmosphere before 2100 in order to both limit net CO_2 emissions to 2.2 trillion tons and move towards a cooling trend. Ultimately, the CO_2 that is already in the atmosphere must be thinned. While the CN and SP levers can help mitigate the 50 percent probability warming targets, they are inadequate to mitigate the LPHI warming. Given the near-term risk of exceeding the dangerous to catastrophic thresholds, the timing for pulling these levers is a crucial issue. Ideally, these levers should be pulled immediately.

In its *Fifth Assessment Report* the IPCC also referred to geoengineering, including technologies such as Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR), for the first time. However, the IPCC is more cautious, stating that modeling indicates that SRM methods, if feasible, could substantially offset a global temperature rise. But such methods would also modify the global water cycle and would do nothing to reduce ocean acidification. Also, if SRM were terminated for any reason, global surface temperatures would rise very rapidly to values consistent with the greenhouse gas (GHG) forcing (*high confidence*). The IPCC concludes that CDR and SRM methods carry side-effects and long-term consequences on a global scale.[15] Consequently, there is no certainty that these technologies, especially SRM, will be deployed and stave off the predicted dangerous and catastrophic consequences of climate change.

WHY CLIMATE DISASTERS AND NOT NATURAL DISASTERS?

One might reasonably ask why we need a separate category of law devoted to *climate* disaster. Can't the laws addressing natural disaster address this too? Just add climate and

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[14] M. Meinshausen, et al., *Greenhouse-Gas Emission Targets for Limiting Global Warming to 2 Degrees C.,* 458 Nature 1158 (2009).

[15] IPCC, *supra* note 4, at 29.

stir. Unfortunately, the science and empirical evidence suggest not. First, as we will see, the large majority of disasters are susceptible in some way to changes in the global climate including atmospheric, land-based, and ocean temperatures. To understand the risks involved with such events and the plausible policy responses, climate-change thinking must be built into the analysis. You might not need climate data to know your city needs new storm drains. But you might need that data — along with specialized decision-making tools — to know how big you should make them and whether after 10 years they will work at all. Secondly, even where garden-variety disaster planning might do the trick, ignoring the role of climate change leads us to ignore the moral responsibility we have to move as quickly as we can to a carbon-free economy.

As to the empirical evidence, the World Economic Forum's *Global Risks Report 2017* identifies extreme weather events, natural disasters, and the failure of climate change mitigation and adaptation as three of the top five global risks in terms of impact and likelihoods.[16] Moreover, the *World Disasters Report 2016: Resilience: Saving Lives Today, Investing for Tomorrow*[17] has quantified the type of phenomenon leading to disaster, the amount of estimated damage, and the number of people affected by disasters of all types between 2006 and 2015. Disaster was triggered by 3,439 either climatological, hydrological, or meteorological hazards, compared with 315 geophysical hazards.[18] The total loss from the first set of hazards is US$926,506 million compared with dry mass movements (US$8 million), earthquakes (US$471,031 million), and volcanic activity (US$1,081 million). The total number of people affected by the first set of hazards is 1,829,677,000 compared with dry mass movements (4,000), earthquakes (85,001,000) and volcanic activities (2,018,000). Over the last 20 years, 90 percent of disasters have been caused by floods, storms, heat waves, and other weather-related events. Weather-related disasters claimed 606,000 lives, an average of some 30,000 per annum, with an additional 4.1 billion people injured, or left homeless or in need of emergency assistance. These figures seem to justify a specific focus on climate disasters, as defined above.

Meanwhile, the 2016 *Global Report on Internal Displacement*,[19] which quantifies internal displacements between the years 2008 and 2015 in terms of hazard, finds that weather-related hazards averaged 21.5 million displacements per year, while

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[16] World Economic Forum, Global Risks Report 2017 (2017), *available at* http://reports.weforum.org/global-risks-2017/.

[17] Adriana Allen et al., International Federation of Red Cross and Red Crescent Societies, World Disasters Report: Resilience: Saving Lives Today, Investing for Tomorrow (Khurshid Alam, et al. eds., 2016), *available at* http://www.redcross.org.au/files/IFRC-World_Disasters_Report_2016.pdf.

[18] According to the taxonomy used in the report, climatological hazards include drought (with associated food insecurities), glacial lake outburst, and wild fire; hydrological hazards include floods, landslides (hydrological origin), and wave action; and meteorological hazards include extreme temperature, fog, and storms. *Id.* Each of these types of hazards can theoretically be influenced by global warming. Geophysical hazards, which include earthquakes, volcanic activity, and dry-mass movement, *id.*, do not, in most circumstances, appear to be influenced by global warming.

[19] 2016 Global Report on Internal Displacement (2016), *available at* http://www.internal-displacement.org/globalreport2016/.

geophysical hazards averaged 3.9 million displacements per year. Of the weather-related hazards, 64 percent of displacements were attributable to flood, 35 percent to storms, 0.4 percent to wet mass movements, 0.2 percent to wildfire, and 0.6 percent to extreme temperatures. If we look at the impacts of extreme and slow-onset events on a Small Island Developing State (SIDS) such as Tuvalu we find that, between 2005 and 2015, 95 percent of households were affected by climate disasters, both on Fanafuti (which houses 56 percent of the population) and the outer-lying islands. Furthermore:

- Cyclones affected 72 percent of households in Fanafuti and 74 percent on the outer-lying islands.
- Drought and irregular rains affected 91 percent of households on Fanafuti and 86 percent on the outer-lying islands.
- Floods affected 46 percent of households on Fanafuti and 62 percent on the outer-lying islands.
- Salt water intrusion affected 56 percent of households on Fanafuti and 70 percent on the outer-lying islands.
- Sea-level rise affected 79 percent of households on Fanafuti and 64 percent on the outer-lying islands.
- Storm surge affected 46 percent of households on Fanafuti and 63 percent on the outer-lying islands.[20]

Phenomena like hammering rains or cyclonic storms are, of course, manifestations of weather, not climate.[21] But because (as we'll see) accumulating evidence supports a causal relationship between human-induced climate change and extreme weather events, policymakers must pay special attention to climate impacts.

THE MANY FACES (AND COSTS) OF CLIMATE DISASTERS

In recent times, the world has witnessed a series of climate extremes that are at the limits of modern human experience. These include catastrophic floods in the summer of 2010 in China and Pakistan (the worst in Pakistan's history)[22] and a mudslide (triggered by flood) in Brazil that killed more than 600 people, making it one of the deadliest natural disasters in that country's history.[23] In 2011, a disastrous flood in Thailand produced

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[20] Andrea Milan, United Nations University Institute for Environment and Human Security Tuvalu: Climate Change and Migration 36 (November 2016), *available at* http://www.unescap.org/sites/default/files/Online_No_18_Tuvalu_Report_161207_.pdf.

[21] The difference between weather and climate involves the time frame. Weather describes "conditions of the atmosphere over a short period of time." *What's the Difference Between Weather and Climate?*, U.S. National Aeronautic and Space Administration (NASA), *available at* https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html. Climate describes atmospheric behavior "over relatively long periods of time." *Id.*

[22] Natural Catastrophes and Man-Made Disaster in 2010: A Year of Devastating and Costly Events 8 (2010) *available at* http://www.swissre.com/sigma/?year=2011#inline.

[23] Abhas Jha et al., World Bank, Five Feet High and Rising: Cities and Flooding in the 21st Century 13 (2011) *available at* http://library1.nida.ac.th/worldbankf/fulltext/wps05648.pdf;

US$30 billion of damage, which amounted to 8.68 percent of the gross domestic product (GDP).[24] When you add the impact on international supply chains the total loss balloons to US$45.7 billion, making it one of the five costliest disasters in modern history.[25]

The damage caused by cyclonic storms in just the last five years is astounding. In 2017 Puerto Rico and the U.S. Virgin Islands were slammed by two consecutive hurricanes, Irma and Maria, the second of which left 3.5 million people in Puerto Rico "without clean water, communications, or electricity, amid damaged buildings and floodwaters", leading health experts (as of this writing) fearing a possible outbreak of water-borne disease.[26] The aforementioned Irma took a later "left hook" along the western coast of Florida, leaving a trail of flooded streets, flattened houses, and an estimated price tag of US$100 billion.[27] Less than a month before, Hurricane Harvey drowned the city of Houston with 50 inches of rain ("a volume of rainwater four miles square and two miles tall"), causing an estimated US$180 billion in damage.[28]

And that was just the year 2017 within the jurisdiction of the United States. The year before Hurricane Matthew tore through Haiti as a Category 4 storm, causing a massive cholera outbreak and economic damage amounting to one-third of the nation's gross national product.[29] At least a thousand people died.[30] In 2013 Super Typhoon Haiyan roared across the Philippines as one of the strongest cyclones ever recorded, well above traditional norms.[31] The storm's tsunami-like surge claimed 6,300 lives and displaced

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see also Faith Ka Shun Chan, et al., *Flood Risk in Asia's Urban Mega-Deltas: Driver, Impacts and Response*, 3(1) Env't & Urbanization Asia 41 (2012).

[24] *See* Lloyd's Global Underinsurance Report (2012), *available at* http://www.lloyds.com/~/media/Files/News%20and%20Insight/360%20Risk%20Insight/Global_Underinsurance_Report_311012.pdf.

[25] 2011 Thailand Floods Event Recap Report (2012), *available at* http://thoughtleadership.aonbenfield.com/Documents/20120314_impact_forecasting_thailand_flood_event_recap.pdf at 3.

[26] Adam Rogers, *After Hurricane Maria, Could Puerto Rico Be at Risk of Cholera?*, Wired (Sept. 29, 2017), *available at* https://www.wired.com/story/puerto-rico-health/ (reporting that possibility of a cholera outbreak seems low, according to the U.S. Centers for Disease Control, but that outbreaks of other water-borne disease are possible).

[27] Aaron Mak, The Latest Reports of Damage in the Parts of Florida Hit Hardest by Irma, Slate (Sept. 12, 2017), *available at* http://www.slate.com/blogs/the_slatest/2017/09/12/damage_reports_from_areas_of_florida_hit_hardest_by_hurricane_irma.html.

[28] Victor B. Flatt & Rob Verchick, Opinion, *Burying Our Head in Sand on Climate Change No Longer an Option*, Houston Chronicle (Sept. 28, 2017), *available at* http://www.houstonchronicle.com/opinion/outlook/article/Burying-our-head-in-sand-on-climate-change-no-12238961.php; Marianna Parraga & Gary McWilliams, *Funding Battle Looms as Texas Sees Harvey Damage at Up to $180 Billion*, Reuters (Sept. 3, 2017), *available at* https://www.reuters.com/article/us-storm-harvey/funding-battle-looms-as-texas-sees-harvey-damage-at-up-to-180-billion-idUSKCN1BE0TL.

[29] Jacqueline Charles, *Six Months after Hurricane Matthew, Food, Shelter Still Scarce in Haiti*, Miami Herald (Apr. 12, 2017), *available at* http://www.miamiherald.com/news/nation-world/world/americas/haiti/article144280949.html; Joseph Guyler Delva, *Hurricane Matthew Toll in Haiti Rises to 1,000, Dead Buried in Mass Graves*, Reuters (Oct. 9, 2016), *available at* https://www.reuters.com/article/us-storm-matthew-haiti/hurricane-matthew-toll-in-haiti-rises-to-1000-dead-buried-in-mass-graves-idUSKCN12A02W.

[30] Delva, *supra* note 29.

[31] Mark Fischetti, *Was Typhoon Haiyan a Record Storm?,* Scientific American (Nov. 12, 2013), *available at* https://blogs.scientificamerican.com/observations/was-typhoon-haiyan-a-record-storm/.

millions.[32] Experiences like these have left some experts wondering if, given climate change, it is time to consider adding a "Category 6" to the top end of the Saffir-Simpson Hurricane Wind Scale.[33]

As Dan Farber has noted,[34] the European summer of 2003 was the worst natural disaster to strike the developed world in modern history. It was the hottest summer in at least 500 years and claimed 70,000 lives.[35] In 2012, the record heat wave in and around Moscow and extensive peat bog and forest fires claimed 56,000 lives.[36] One-third of Russia's grain was lost, driving up food prices worldwide.[37] Xu and Ramanathan, meanwhile, suggest the likelihood of extreme events, including heat waves, may have increased 10-fold in recent decades,[38] while the major finding of a recent study is that currently about 13.6 percent of land area with a population of 30.6 percent is exposed to deadly heat.[39] According to this study, a 2°C warming would double the land area subject to deadly heat and expose 48 percent of the population. A 4°C warming by 2100 would subject 47 percent of the land area and almost 74 percent of the world population to deadly heat, posing potential existential risks to humans and mammals alike unless massive adaptation measures are implemented.

Meanwhile, if the number of heat waves increases, as climate models predict, the probability of wildfires will be higher. For example, the 2016 Fort McMurray fire in Canada resulted in insured losses of US$2.9 billion, which, according to Munich Re, makes it both the world's costliest forest fire on record and the costliest natural disaster in the history of the Canadian insurance market. Although it is likely that El Niño contributed to the mild temperatures and dry conditions during the winter of 2015/16, Munich Re cautions that the recent wildfire in Canada could well be indicative of the impacts of climate change in the future.[40]

The IPCC notes that in many regions the quantity and quality of water resources have been affected because of changing precipitation or melting snow and ice (*medium confidence*). The proportion of the population currently experiencing water scarcity and

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[32] Per Liljas, *Tacloban Survived the World's Strongest Recorded Storm, but Only Just*, Time (Nov. 6, 2014), *available at* http://time.com/3554112/tacloban-yolanda-supertyphoon-typhoon-haiyan-anniversary/.

[33] Sally Brown, Opinion, *Is It Time to Create a Category 6 for Hurricanes?*, MarketWatch (Sept. 11, 2017), *available at* http://www.marketwatch.com/story/is-it-time-to-create-a-category-6-for-hurricanes-2017-09-11.

[34] Daniel A. Farber, *Adapting to Climate Change: Who Should Pay?* 23 J. of Land Use 1 (2007).

[35] Anastasia Telesetsky, *Insurance as a Mitigation Mechanism: Managing International Greenhouse Gas Emissions through Nationwide Mandatory Climate Change Catastrophe Insurance* 27 Pace Envt'l L. Rev. 691, 692 (2010).

[36] Weathering Climate Change: Insurance Solutions for More Resilient Communities 1 (2010), *available at* http://www.swissre.com/library/archive/Weathering_climate_change_Insurance_solutions_for_more_resilient_communities.html.

[37] *Id.* at 13.

[38] Global Climate in 2011–2015 (2016), *available at* http://ane4bf-datap1.s3-eu-west-1.amazonaws.com/wmocms/s3fs-public/1179_EN.pdf?WevaJ8QIS5ntCjcWd7OYyZfhIDKuews9.

[39] M.E. Mann, *Defining Dangerous Anthropogenic Interference*, 106 Proc. Nat'l Acad. Sci. 4065 (2009).

[40] Natural Catastrophes 2016 Analyses, Assessments, Positions 2017, Issue 23-26 (2016), *available at* https://www.munichre.com/site/touch-publications/get/documents_E-271800065/mr/assetpool.shared/Documents/5_Touch/_Publications/TOPICS_GEO_2016-en.pdf.

affected by major river floods will increase with the level of warming in the twenty-first century.[41] Meanwhile, the United Nations Convention to Combat Desertification (UNCCD)[42] states that up to 54 countries, with a combined population of four billion people, or 40 percent of the projected global population, could face water stress or scarcity by 2050.[43] The increased frequency and intensity of droughts and flash floods is destroying the land — the Earth's main fresh water store. Degraded land, affected by climate change, needs to be restored to protect the underground sources needed by present and future generations. Failing this it will be difficult to diffuse ethnic tensions or reverse migration flows.[44] Xu and Ramanathan focus on the poorest three billion people, living mainly in tropical rural areas and whose contribution to CO_2 emission is 5 percent compared with the wealthiest one billion people, who have contributed 50 percent. These three billion people are likely to see their subsistence-farming livelihoods severely damaged, if not destroyed, by a one- to five-year megadrought, heat waves, or heavy floods. Those who live in coastal areas face a 1–2-meter rise in sea level (likely with warming of more than 3°C), which, without migration and relocation, poses an existential threat. With warming of more than 4°C, several hundred million people would be subject to famine.[45]

An extensive body of literature on the displacement and migration of people away from areas impacted by climate change has emerged over the past three decades. Extreme and slow-onset events and disasters are undercutting development efforts where many affected communities are already poor and vulnerable.[46] Indeed, they threaten, both now and in the future, to see millions of people on the move, principally internally but also across international borders.[47] By 2020, an estimated 60 million people could be on the move from the desertified[48] areas of sub-Saharan Africa towards North Africa and Europe.[49] In *Global Report on Human Settlements 2011: Cities and Climate Change*,[50] UN Habitat estimated that by 2050 climate change will displace as many as 200 million people. Meanwhile, Bodansky, Brunnee, and Rajamani[51] state that "guestimates" about the scale

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[41] Weathering Climate Change, *supra* note 36, at 3.

[42] Land-based Adaptation and Resilience: Powered by Nature 3 (2014), *available at* http://www.unccd.int/Lists/SiteDocumentLibrary/Publications/Land_Based_Adaptation_ENG%20Sall_web.pdf.

[43] *Id.* at 6.

[44] *See* Catherine Fitzgibbon & Alexandra Crosskey, Disaster risk reduction management in the drylands in the Horn of Africa 4 (2013), *available at* http://globalallianceforaction.com/docs/Disaster%20risk%20reduction%20management.pdf.

[45] B.P. Dasgupta & V. Ramanathan, *Pursuit of the Common Good*, 345 Science 1457 (2014).

[46] *See* Kelly Levin, et al., U.N. Development Programme, U.N. Environment Programme, World Bank, Decision Making in a Changing Climate: Adaptation Challenges and Choices 29 (2013), *available at* http://pdf.wri.org/world_resources_report_2010-2011.pdf.

[47] *Id*. at 13.

[48] Desertification: The Invisible Frontline (2014), *available at* http://www.unccd.int/Lists/SiteDocumentLibrary/Publications/Desertification_The%20invisible_frontline.pdf.

[49] Fitzgibbon & Crosskey, *supra* note 44, at 7.

[50] Naison D. Mutizwa-Mangiza, et al., UN-HABITAT, Cities and Climate Change: Global Report on Human Settlements (2011), *available at* http://www.unhabitat.org/content.asp?cid=9599&catid=7&typeid=46&subMenuId=0.

[51] Daniel Bodansky, Jutta Brunnee, & Lavanya Rajamani, International Climate Change Law 313 (2017).

of displacement vary from "25 million at the conservative end, to 1 billion in the middle, and 2 billion at the high end."[52]

Moving to biodiversity and ecosystems, in response to climate change, many terrestrial, freshwater and marine species have shifted their geographical ranges,[53] seasonal activities, migration patterns, abundances and interactions (*high confidence*). During the past millions of years far slower rates of climate change, compared with anthropogenic climate change, have caused significant ecosystem shifts and species extinctions (*high confidence*).[54] As climate change interacts with habitat modification, overexploitation, pollution, and invasive species, extinction risk is present in all scenarios (*high confidence*).[55] Within this century, medium-to-high emissions concentration scenarios pose a high risk of abrupt and irreversible regional-scale change in the composition, structure, and function of terrestrial and freshwater ecosystems, including wetlands (*medium confidence*). For medium-to-high scenarios, ocean acidification poses substantial risks to marine ecosystems, especially polar ecosystems and coral reefs (*medium-to-high confidence*).[56] In recognition of this, the Conference of the Parties (COP) to the Convention on the Conservation of Biological Diversity has recently called on all Parties to "identify, monitor and address the impacts of climate change and ocean acidification on biodiversity and ecosystem services, and assess the future risks for biodiversity and the provision of ecosystem services using the latest available vulnerability and impact assessment frameworks and guidelines."[57]

I. Attributing Climate Change to Specific Events

Attributing changes in individual climate events to anthropogenic forcing is complicated.[58] But there is sufficient evidence to suggest that climate extremes such as heat waves, record high temperatures, and, in many regions, heavy precipitation have changed in the last 50 years because of climate change. When trying to attribute losses to climate change, losses over time must be controlled for exposure and vulnerability as most studies attribute the losses to the exposure of people and assets in high-risk areas and to underlying societal trends, such as the demographic, economic, political, and social factors which shape vulnerability to impacts.[59]

Most climate attribution analysis involves using statistical methods to compare climate models and observed changes in the climate system. Such studies can help policymakers understand what future conditions, influenced by climate change, might look like and plan accordingly. Attribution analysis is generally more difficult at regional scales than at

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[52] *Id.*

[53] For a diagrammatic representation of the maximum speeds at which species can move across landscapes (based on observation and models) see IPCC, *supra* note 3, 15Fig.SPM.

[54] *Id.* at 4.

[55] *Id.* at 15.

[56] *Id.* at 17.

[57] Decision X/33. Biodiversity and climate change, UNEP/CBD/COP/DEC/X/33, October 29, 2010, *available at* http://www.umt.edu/ethics/resourcecenter/imx/legaldocs2/CBD%20COP%2010%20decision%20x.

[58] IPCC, *supra* note 3, at 368.

[59] *Id.*

global ones.[60] That is in part because the magnitude of variability is higher at smaller scales (it's harder to "average out" the natural swings) and because "there is less spatial pattern information at the regional scale that can be used to distinguish contributions from various forcings."[61] That poses a challenge, since most adaptation planners necessarily work at the regional and local levels.

As a general matter, experts find evidence that it is "*extremely likely*" that "more than half of the global mean temperature increase since 1951 was caused by human influence on climate."[62] The IPCC's 2013 *Fifth Assessment Report* on physical science found attributable human contributions for warming over all continents except Antarctica, including changes in daily temperature extremes, changes in ocean temperatures, loss of Arctic sea ice, reduction of snow cover in the northern hemisphere, a rise in mean sea level, and ocean acidification.[63] The *Fifth Assessment* also reported medium confidence that human activities were increasing atmospheric-specific humidity, zonal mean precipitation in much of the northern hemisphere, and intensification of heavy precipitation over land masses.[64] But the *Fifth Assessment* announced weaker attribution conclusions that it had in the past about the connection between climate change and tropical cyclones and drought.[65]

The science of event attribution is advancing quickly. As of this writing one of the most recent and comprehensive surveys of attribution science is contained in the U.S. Global Change Research Center's (USGCRP) draft *Special Scientific Report*.[66] Although it was finalized by its scientist-authors, the report has not yet been officially released by the Trump Administration. Out of concern that its statements might be altered by the President's political staff, the report was leaked to the media in August 2017 and has since gained the attention of climate researchers around the world.[67]

The USGCRP's report generally endorses the conclusions of the IPCC's *Fifth Assessment* but adds further refinement. Importantly, the USGCRP finds "broad agreement" that human activities have had a "measurable impact" on the observed oceanic and atmospheric variability in the North Atlantic and announces "medium confidence" that human activity "has contributed to the observed increase in hurricane activity since the 1970s."[68] It asserts medium to low confidence of a human contribution to extreme precipitation increases in the continental United States.[69] There is evidence supporting a

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[60] U.S. Global Change Research Center, Climate Science Special Report 165 (2017) ("Fifth-Order Draft," with "final clearance" dated June 8, 2017), *available at* http://www.nytimes.com/packages/pdf/climate/2017/climate-report-final-draft-clean.pdf.

[61] *Id.*

[62] *Id.* at 162–63.

[63] IPCC, *supra* note 4, at 869.

[64] *Id.* at 850.

[65] *Id.*at 870.

[66] *Id.* at 871.

[67] Lisa Friedman, *Scientists Fear Trump Will Dismiss Blunt Climate Report*, N.Y. Times (Aug. 7, 2017), *available at* https://www.nytimes.com/2017/08/07/climate/climate-change-drastic-warming-trump.html. The USGCRP's 2017 report was officially released while this book was in production. See Climate Science Special Report: Fourth National Climate Assessment (2017), available at https://science2017.globalchange.gov. The findings, as described above, are the same as those in the official version.

[68] USGCRP, *supra* note 60, at 166.

[69] *Id.*

human contribution to forest fires in Alaska (*medium confidence*) as well as in the western United States (*medium-to-low confidence*).[70] Further, "[h]uman activities have played a role in the observed expansion of the tropics (by 70 to 100 miles since 1979)."[71]

Statements like these inevitably lead to questions about attribution to specific events. Can we say climate change caused *this* heat wave or *that* hurricane? The USGCRP counsels against such inquiry. The better question, it argues, is "whether climate change has altered the odds of occurrence of an extreme event like the one just experienced."[72] The reason is that because many attribution studies use statistical analysis, their answers come in the form of probabilities, not certainties. "To our knowledge," the authors write, "no extreme weather event observed to date has been found to have zero probability of occurrence in a preindustrial climate."[73]

Still, attribution science provides important information on the subject of extreme events. The USGCRP notes that an anthropogenic influence is especially strong for extreme events related to temperature, hydrological drought, and heavy precipitation. There is, for instance, "relatively strong evidence" that human activity contributed to the European heat wave of 2003 and to the dangerous, broiling temperatures Australia experienced in 2013.[74] In contrast, it finds "little or no confidence" in a connection between anthropological influence and "severe convective storms or extratropical storms."[75]

CLIMATE HAZARD AT THE INTERSECTION OF PHYSICAL AND SOCIAL VULNERABILITY

We can think of community hazard as a combination of a "physical vulnerability" and its "social vulnerability."[76] Physical vulnerability includes a community's physical exposure to a place-based risk as well as geophysical characteristics (geology, hydrology, climate, and so on) and built infrastructure. Social vulnerability includes the susceptibility of a community's population groups to the impacts of a hazard. This includes not only demographic characteristics of the population, but also more complex constructs such as health care provision, social capital, and access to emergency response services.[77] We can describe the relationship of hazard and vulnerabilities as shown in Figure I.1. Note that "vulnerability," whether physical or social, suggests a present and future tense: it refers both to a community's ability to *withstand* an immediate assault and its ability to *rebound* from it afterwards.

Physical and social vulnerabilities obviously interact: Sometimes a community's

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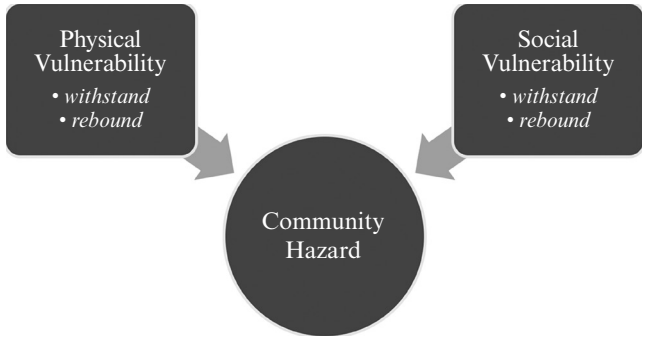
[70] *Id.*
[71] *Id.*
[72] *Id.* at 167.
[73] *Id.* at 169.
[74] *Id.*
[75] *Id.* at 168.
[76] Susan L. Cutter & Christopher T. Emrich, *Moral Hazard, Social Catastrophe: The Changing Face of Vulnerability Along the Hurricane Coasts*, 604 Annals Am. Acad. Pol. & Soc. Sci. 102, 107 (2006).
[77] *Id.* at 103.



Source: This diagram is based on a more comprehensive one provided in Susan L. Cutter & Christopher T. Emrich, *Moral Hazard, Social Catastrophe: The Changing Face of Vulnerability Along the Hurricane Coasts*, 604 Annals Am. Acad. Pol. & Soc. Sci. 102, 107 (2006) at 107 fig.1.

Figure I.1 Components of community hazard

protective physical environment is exploited and destroyed because residents are too powerless to do anything about it. And in some communities poverty is closely linked to a lack of natural resources and impoverished physical surroundings. In this sense, both types of vulnerability have important social dimensions.

The community-hazard framework expands the scope of disaster policy in significant ways. In this view, the factors are not just geophysical; they are also economic, social, and political. They involve a community's natural infrastructure as well as its built infrastructure.

The *Human Development Report 2014: Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience* (the HDR)[78] focuses on those particularly vulnerable to external shocks, especially from persistent or systematic threats to human development such as climate change. The HDR notes that systemic and perennial sources of vulnerability are especially experienced by people such as women, children, adolescents, and the elderly.[79] These aspects of vulnerability all affect a group's, or individual's, capacity to anticipate, cope with, resist, and recover from the adverse effects of physical events, and create multiple sites of vulnerability. As the HDR notes, while globalization has on balance produced major human development gains, especially in many developing countries, the impacts of climate change, among other factors, have created a widespread sense of precariousness. This is because human development achievements can quickly be undermined by a climate disaster or a global economic slump. Real progress in human development not only entails enlarging people's capabilities,[80] but is also a question of how secure these achievements are, and whether conditions are sufficient for sustained human development. Unless vulnerability is explored and assessed, an account of human development progress is incomplete.[81]

The HDR 2014 goes beyond traditional notions of vulnerability, which describe

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[78] Khalid Malik, et al., U.N. Development Programme, Human Development Report 2014 (2014), *available at* http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf.

[79] *Id.* at 1.

[80] For a capabilities approach to Climate Justice and Disaster Law see Lyster, *supra* note 2.

[81] HDR, *supra* note 78, at 1.

exposure to risks and risk management, to emphasize the close links between reducing vulnerability and advancing human development and also refers to life cycle vulnerability on the ground that capabilities accumulate over time and unless nurtured and maintained they can stagnate and decline.[82] The implication is that a sustained enhancement of individuals' and societies' capabilities is needed so that persistent vulnerabilities to climate disasters, which are often structural and tied to life-cycle vulnerabilities, can be reduced.[83] The HDR 2014 states that the more than 2.2 billion people, or 15 percent of the world's population, who are living in extreme poverty and deprivation are the most vulnerable. Three-quarters of the world's poor live in rural areas where rural workers face the highest prevalence of poverty, and are particularly vulnerable to climate change.[84] When disasters strike, the poor quickly exhaust limited resources, further undermining household sustainability. In the long run, this reduces capital and increases hazard exposure or vulnerability, while the poverty and vulnerability trap renders recovery to pre-disaster levels of well-being increasingly difficult. Individual and household vulnerability also arises due to other instances of inequality such as race, caste, religious affiliation, and physical disability, which may intersect with gender and age effects.[85]

In 2016 the World Bank reported[86] specifically on the threats of climate change to the poor. These include: higher agricultural prices that could threaten food security in poorer regions such as Sub-Saharan Africa and South Asia; poor urban households more exposed to floods than the average urban population; and climate change that will magnify many threats to health, as poor people are more susceptible to climate-related diseases such as malaria and diarrhea. As the World Bank states, "[t]he poor live in uncertainty, just one natural disaster away from losing everything they have."[87] Without climate-informed development to reduce the impacts of climate change on the poor, climate change could force more than 100 million people into extreme poverty by 2030. Moreover, over the longer term, there will be limits to what good development and risk management can achieve and "[o]nly immediate emissions-reduction policies can limit the long-term impacts of climate change on the poor."[88] In a follow-up report, *Unbreakable: Building the Resilience of the Poor*, presented to the 22nd COP in Marrakesh, the World Bank found that the impact of extreme weather on poverty is more devastating than previously understood, delivering annual consumption losses of US$520 billion, pushing 26 million people into poverty each year. In addition, by counting only the monetary impact of disasters on buildings, infrastructure, and agricultural production, other impacts are distorted and there is a failure to account for the crushing impact of disasters on the world's poor, who suffer much more in relative terms than wealthier people.[89]

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[82] *Id.* at 3.
[83] *Id.* at 1.
[84] *Id.* at 4.
[85] *Id.* at 456.
[86] S. Hallegatte, et al., World Bank Group, Shock Waves: Managing the Impacts of Climate Change on Poverty (2016), *available at* https://openknowledge.worldbank.org/bitstream/handle/10986/22787/9781464806735.pdf.
[87] *Id.* at xi.
[88] *Id.*
[89] Stephane Hallegatte, Adrien Vogt-Schilb, Mook Bangalore, & Julie Rozenberg,

WHY CLIMATE DISASTER LAW?

The IPCC, in addition to defining climate disasters, also provides what it refers to as the "Solution Space." Here, it demonstrates how various interventions can reduce the risk of disasters by engaging in GHG mitigation strategies to reduce the hazard of climate disasters while also reducing vulnerability and exposure. For our purposes, these actions include engaging in risk assessments, engaging in incremental and transformational adaptation, providing for decision making under uncertainty and coordinating actions across scales. Many of these concepts fit well within the frame of Climate Disaster Law, which works to enhance the resilience of people, and indeed natural systems, exposed to climate disasters through the adoption of laws and policies at all stages of a disaster — prevention; response; recovery and rebuilding; and risk transfer and compensation.[90] The role of insurance as a risk transfer and compensation mechanism is incorporated within the risk transfer and compensation frame. We turn now to a brief discussion of the four stages of Climate Disaster Law.

I. Prevention

We take as a given that the most effective way to avert climate disasters is an immediate and effective reduction of GHG emissions. However, it is also paramount that the resilience of individuals and communities is enhanced so as to prevent, as far as possible, the impacts of climate disasters. The obligation to build the resilience of humans and natural systems to the impacts of climate disasters is paramount and arises at international, national, state, and municipal levels of government. However, it must be acknowledged that when thresholds or tipping points associated with social and/or natural systems are exceeded, limits to resilience will be reached.[91]

Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner. This includes ensuring the preservation, restoration, or improvement of a system's essential basic structures and functions. While older conceptions of resilience refer to "bouncing back," this is an increasingly insufficient goal for climate disaster risk management. This is because of the dynamic and often uncertain consequences of climate change (as well as development trends such as urbanization) for hazard and vulnerability profiles. Recent conceptions of resilience of social-ecological systems focus more on process than outcomes, including the ability to self-organize, learn, and adapt over time.[92] As this book on Climate Disaster Law suggests, resilience at its core involves ensuring the state, community, and global institutions empower and protect people,[93] species, and ecosystems from climate disasters.

Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters (2017), *available at* https://openknowledge.worldbank.org/handle/10986/25335.

90 Monti, *supra* note 5, at 151.

91 *Id.*

92 *Id.* at 34.

93 *Id*. at 4.

Here we claim that climate change adaptation and disaster risk reduction[94] play a significant role in preventing the impacts of climate change and building resilience. Adaptation is defined as:

> the decision-making process and the set of actions undertaken to maintain the capacity to deal with future change or perturbations to a social-ecological system without undergoing significant changes in function, structural identity, or feedbacks of that system while maintaining the option to develop.[95]

The literature suggests that countries ought to integrate their disaster risk reduction (DRR) and climate change adaptation (CCA) strategies[96] or their DRR and development strategies,[97] although we propose that all three should be effectively integrated in a post-2015 world, given that climate disasters can impede and roll back the achievements of Sustainable Development Goals.[98] After all, DRR and CCA share the goal of reducing the impacts of extreme events, and increasing resilience to disasters among vulnerable populations.[99] Indeed, in 2014, the United Nations Development Programme issued a call for action to integrate DRR into development planning. It reinforced the devastating impact of natural disasters on progress towards development goals and the urgency of ensuring a strong DRR focus in post-2015 development planning.[100]

To develop integrated and adaptive governance arrangements for CCA, DRR, and development, it is worthwhile first to restate the fundamental premises of CCA and DRR. CCA accepts that 'normal' understandings of hazards and extreme events may no longer be reliable indicators for assessing current or future climate change risks, but extreme climate events are regarded as shifts within the bounds of current system variability. However, DRR approaches extremes from a different direction by understanding that extremes can interact with existing vulnerabilities and result in disasters.[101] Consequently, the dominant paradigm for DRR has become addressing the root causes of vulnerability to disaster by focusing on risk assessment, multiple stressors, livelihoods and well-being, institutional capacity building, risk mitigation investments, and catastrophe risk financing, as well as emergency preparedness. Meanwhile, the non-linearity

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[94] For a comprehensive discussion see Lyster, *supra* note 2, at chapter 4.

[95] Donald R. Nelson, W. Neil Adger, & Katrina Brown, *Adaptation to Environmental Change: Contributions of a Resilience Framework*, 3 Ann. Rev. of Envt'l Resources 395, 397 (2007).

[96] William Solecki, Robin Leichenko, & Karen O'Brien, *Climate Change Adaptation Strategies and Disaster Risk Reduction in Cities: Connection, Contentions, and Synergies,* 3 Current Opinion in Envt'l Sustainability 135 (2011).

[97] *See* Jerry Velasquez, et al., U.N. ESCAP & UISDR, Reducing Vulnerability and Exposure to Disasters: The Asia-Pacific Disaster Report 2012, at 92 (2012), *available at* http://www.unisdr.org/files/29288_apdr2012finallowres.pdf.

[98] *Id.* at xxiii.

[99] Solecki, et al., *supra* note 96, at 135.

[100] Disaster Risk Reduction Makes Development Sustainable: A Call for Action (2014), available at http://www.undp.org/content/dam/undp/library/crisis%20prevention/UNDP_CPR_CTA_20140901.pdf.

[101] Riyanti Djalante, Cameron Holley, & Frank Thomalla, *Adaptive Governance and Managing Resilience to Natural Hazards*, 2(4) Int'l J. of Disaster Risk Sci. 1 (2011).

of DRR implementation increasingly requires an adaptive governance approach.[102] The need for CCA to internalize more DRR approaches is confirmed by a recent study which reveals the limits of adaptation and the costs of unmitigated climate change in Bangladesh, Bhutan, The Gambia, Kenya, and Micronesia. Affected communities suffered from loss and damage despite undertaking coping and adaptation measures.[103]

Progress in this regard will generally require facilitation through legislation, for, without a binding legal directive which obliges actors and agencies to take action, the inertia of bureaucracies might mean that essential tasks are not undertaken. Law can also be used to provide penalties and incentives by enforcing standards, empowering existing agencies, establishing new bodies, and assigning budgets.[104]

II. Response

How governments, and others, manage climate disasters while they are "on foot" and in the recovery phase, has enormous implications for how individuals and communities recover and rebuild following a disaster. This is true whether the disasters are the result of extreme weather or slow-onset events. The ability of all levels of government — national, state, and local — and of communities to engage in effective response measures during an extreme weather, or slow-onset, event will depend to a large degree on the amount of emergency preparedness which precedes it. Indeed, it is the emergency preparedness and response plans which can prevent a natural hazard from becoming an unnatural disaster.[105] Two instruments in the response phase are particularly crucial: Emergency Action Plans (EAPs) and early warning systems (EWSs).[106]

In an extensive review of EAPs, Binder[107] "explains that emergency plans should be customised, risk-based, user-friendly, integrated documents designed to reduce the risk of loss of life and damages, and minimise any further deterioration of the facility and facilitate recovery efforts."[108] According to Binder, definitions of EAPs may vary[109] but the goal is to have pre-planned EAPs[110] in place and in effect when an extreme weather event occurs. In all jurisdictions, the legal standards for EAPs, if they exist, may be found in statutes, administrative regulations, or the general common law negligence standard of reasonable care under the circumstances.[111] Importantly, their prompt implementation

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[102] Asia-Pacific Disaster Report 2012*, supra* note 97, at xxvi.

[103] Press Release, Institute for Environment & Human Security, U.N. University, Pioneering Study Shows Evidence of Loss & Damage Today from the Front Lines of Climate Change: Vulnerable Communities Beyond Adaptation? (2012), *available at* http://loss-and-damage.net/4818.

[104] *Id*. at 2.

[105] *See generally* Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention (2010), *available at* http://www.gfdrr.org/sites/gfdrr.org/files/nhud/files/NHUD-Report_Full.pdf at 106.

[106] For an extensive discussion of these see Lyster, *supra* note 2, at chapter 5.

[107] Denis Binder, *Emergency Action Plans: A Legal and Practical Blueprint "Failing to Plan Is Planning to Fail,"* 63 Univ. of Pitt. L. Rev. 791 (2002).

[108] Daniel A. Farber & Michael G. Faure, *Introduction*, in Disaster Law, *supra* note 1, at xvii.

[109] Binder, *supra* note 107, at 791.

[110] *Id.* at 792.

[111] *Id.* at 802.

should be one of the first responses in an emergency in order to reduce the resulting injuries and damage, facilitate recovery efforts, and avert a disaster.[112] EAPs must be reviewed periodically in light of changing risks, lessons learned from other disasters, and technological advances.[113]

With regard to EWSs, as the HDR 2014 reports, countries and communities that are underprepared and unaware of the risks, and that have minimal preventive capacity, suffer the impact of disasters far more severely. A point which is made consistently throughout this book is that poor countries tend to suffer disproportionately from climate disasters. The HDR 2014 notes that in the last 20 years at least 1.3 million people have been killed and 4.4 billion affected by all types of disasters, which have cost the global economy at least US$2 trillion. However, in the case of natural disasters, loss of life has declined due to early warning and response systems. For example, in Bangladesh a severe cyclone in 1991 caused nearly 140,000 deaths, while a 2007 cyclone of similar magnitude killed 4,234 people, with the reduction in deaths achieved mainly by improving EWSs, raising awareness at the community level, and developing shelters and evacuation plans

The Sendai Framework for Disaster Risk Reduction reinforces the importance of EWSs by requiring national and local levels:

> (b) To invest in, develop, maintain and strengthen people-centred multi-hazard, multisectoral forecasting and early warning systems, disaster risk and emergency communications mechanisms, social technologies and hazard-monitoring telecommunications systems.[114]

Another crucial issue in the response phase of a disaster is the key question of who is in charge when disaster strikes. As Banks[115] has stated, "Who's in charge?" breaks down into subsidiary questions which are: are civilian or military leaders in charge; and are these decisions made by the federal government or the states? Yet, disasters, whatever their nature, require nimble and adaptable responses to match the nature of the crisis. New plans for governance may even be needed during a crisis and these may not necessarily centralize response authority, or indeed abandon the federal system. Nevertheless, it seems that traditional, vertical chains of command may not be appropriate and that instead what is needed is unified command, meaning the coordinating of decision-makers to ensure that they understand each other's roles and responsibilities. According to Banks, this requires agreement in advance.[116] In this regard, bringing government closer to the people is a central value of federalism so that state and local first responders, including police, fire, and emergency medical staff, in reality assume the lead by virtue of their proximity to the crisis.[117] Their leaders know the emergency response drill and they know

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[112] *Id.* at 793.
[113] *Id.* at 804.
[114] Sendai Framework for Disaster Risk Reduction 2015–2030, U.N. Doc. A./RES./69./283 (June 23, 2015).
[115] William Banks, *Who's in Charge: The Role of the Military in Disaster Response*, 26 Miss. Coll. L. Rev. 75 (2006).
[116] *Id.* at 76.
[117] *Id.* at 81.

who to contact in federal government and how to make contact when needed with support coming from other government agencies.[118]

III. Recovery and Rebuilding

Recovery and rebuilding following a disaster raises many of the same issues that are raised regarding CCA and DRR to build resilience. These implicate law, policy, and governance at all levels of government. In the first place, if national frameworks regarding building in climate-disaster-prone areas were lacking or inadequate before the disaster, so increasing the exposure and vulnerability of the victims, the post-disaster phase would bring to the fore considerations of their utility and desirability. The value of state and local government regulations would also need to be reviewed. Secondly, real questions need to be asked about whether reformed environmental planning and assessment frameworks and building codes are up to the task of preventing similar disasters in the future. Thirdly, should the affected land be quarantined from future developments? It is here that the option of planned relocation, land swaps and retreat from the disaster zone might prove optimal in order to protect individuals and communities in the future.

IV. Compensation and Risk Transfer

As Farber and Faure note, "[a]lmost as soon as the immediate crisis is over, disaster victims begin looking for financial assistance to redress their harms and fund rebuilding,"[119] while state emergency and reconstruction responses are unavoidable.[120] There is no shortage of examples of disaster relief funds[121] and some include: the Australian Natural Disaster Relief and Recovery Arrangements under Appropriation Act (No 2) 2006-07 (Cth),[122] established following the 2010–2011 flood disasters; the revised 2014 EU Solidarity Fund (EUSF)[123] to strengthen the EU's response to natural disasters; the United Kingdom's

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[118] *Id.* at 96.

[119] Daniel A. Farber & Michael G. Faure, *Introduction*, in Disaster Law, *supra* note 1, at xvii.

[120] R. Schwarze, et al., *Natural Hazard Insurance in Europe: Tailored Responses to Climate Change are Needed*, 21 Envt'l Pol'y & Governance 14, 17 (2011).

[121] For a comprehensive analysis of disaster relief funds see Lyster, *supra* note 2, at chapter 5.

[122] *See* Disaster Assist, *Natural Disaster Relief and Recovery Arrangements* (2012), *available at* http://www.disasterassist.gov.au/FactSheets/Documents/NDRRADeterminations/NDRRA%20Determination%202012.doc. Note that a means-tested levy was imposed on Australian taxpayers for the 2011–2012 financial year to assist with the costs of rebuilding infrastructure following the floods set at 0.5 percent of taxable income in excess of AUS$50,000; *see also* Council of Australian Governments, National Disaster Resilience Framework (2011), *available at* http://www.em.gov.au/Publications/Program%20publications/Pages/NationalDisasterResilienceFramework.aspx; Australian Emergency Management Institute, Community Engagement Framework (2013), *available at* http://www.ses.tas.gov.au/assets/files/EM%20Publications/disaster_resilience/National%20Strategy%20for%20Disaster%20Resilience%20Community%20Engagement%20Framework.pdf.

[123] *See* EU Solidarity Fund, European Commission, *available at* http://ec.europa.eu/regional_policy/thefunds/solidarity/index_en.cfm (last visited Sept. 30, 2017).

Bellwin Scheme,[124] and the United States' Robert T. Stafford Disaster Relief and Emergency Assistance Act (the Stafford Act).[125] In some instances, special legislation is passed to take account of the extraordinary losses occasioned by the climate disaster. For example, in January 2013, the US Congress had to approve a further US$50.5 billion under the Disaster Relief Appropriations Act 2013,[126] largely focused on responding to Hurricane Sandy. The Act provided supplemental funding to over 66 different accounts and programs.[127] In January 2013, Congress approved a further US$50.5 billion under the Disaster Relief Appropriations Act 2013.[128] These relief funds usually offer minimum disaster relief, namely shelter, immediate and short-lived compensation for uninsured economic loss, and personal injury and health costs. However, *ex post* disaster relief payment are unlikely to adequately compensate the victims, and, although far more is spent in the *ex post* phase, these payments are seldom adequately budgeted for, and limited to a defined amount.[129]

Another avenue of compensation is public and private insurance,[130] yet a real question is the reliability of the insurance system at a time when the world has witnessed, and is likely to continue witnessing, a series of climate extremes that are at the limits of modern human experience.[131] Clearly, insurance as a social institution for coping with climate disasters currently plays a small role both in developed and developing countries. In the European Union, for example, there is a surprisingly low market penetration rate of disaster risk insurance in certain Member States, indicating that disaster insurance markets are not coping with existing, let alone future, risks. Storm insurance is relatively high, but for other risks, like floods, penetration is only high if the risk is bundled with other risks.[132] In fact, a review of insurance penetration as a proportion of GDP indicates that the uptake of insurance is highest in Liechtenstein, with penetration of 16.5 percent

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[124] *See* U.K. Department of Communities and Local Development, Bellwin Scheme of Emergency Financial Assistance To Local Authorities — Draft Terms of the Scheme (2014) (archived), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/531526/December_-_February_Floods_Bellwin_Scheme_Terms_archived.pdf.

[125] P.L. 93-288 as amended.

[126] P.L. 113-2.

[127] The Fund comprises US$16.0 billion for the Community Development Block Grant program; US$11.5 billion for the Disaster Relief Fund; US$10.9 billion for the Public Transportation Emergency Relief Program; and US$5.4 billion total for disaster-related activities of the U.S. Army Corps of Engineers.

[128] HR 152. For a summary of the Act see H.R. 152 (113th): Disaster Relief Appropriations Act, 2013, GovTrack, *available at* http://www.govtrack.us/congress/bills/113/hr152#summary/libraryofcongress.

[129] R. Schwarze, et al., *Natural Hazard Insurance in Europe: Tailored Responses to Climate Change Are Needed*, 21 Envt'l Pol'y & Governance 14, 17 (2011).

[130] For a comprehensive discussion of insurance and climate disasters, including an extensive bibliography, see Lyster, *supra* note 2, at chapter 6 and H. Kunreuther & R. Lyster, *The Role of Public and Private Insurance in Reducing Losses from Extreme Weather Events and Disasters*, 19 Asia Pacific J. of Envt'l L. 29 (2016). See also Liam Phelan et al., *Ecological Viability or Liability: Insurance System Responses to Climate Risk*, 21 Envt'l Pol'y & Governance 112 (2011).

[131] *See* World Resources Institute in Collaboration with U.N. Development Programme, U.N. Environment Programme, & World Bank, Decision Making in a Changing Climate: Adaptation Challenges and Choices (2011), *available at* http://pdf.wri.org/world_resources_report_2010-2011.pdf.

[132] European Commission, Green Paper on the Insurance of Natural and Man-Made

as a proportion of GDP, with the lowest in Turkey, which is below 2 percent. In the Netherlands (second) and the United Kingdom (third) the uptake is around 13 percent as a proportion of GDP.[133]

Currently, there is also very low insurance penetration in developing countries and, although some innovative products such as microinsurance are emerging, these are only feasible if they are accessible to the poor. This is exacerbated by the fact that in the aftermath of disaster, low-income developing countries face exhausted tax bases, depleted reserves, and declining credit ratings, making external borrowing difficult,[134] albeit that they will attempt to raise post-disaster capital by diverting funds from other budgeted programs, borrowing money domestically, or taking out loans from international financial institutions.[135] The result is that the uninsured and uncompensated climate disaster loss and damage is transferred to individuals, who in developing countries are the poor and the vulnerable. These individuals may secure emergency loans or remittances from family, micro-credit agencies, or money-lenders. They may sell or mortgage assets and land or rely on limited public post-disaster assistance and international aid.[136] However, these informal finance mechanisms are often unreliable and inadequate for catastrophic events.

In our view, insurance is unlikely ever to fully compensate the victims of climate disasters in both developed and developing economies, albeit that it can play an important role. Indeed, insurers have already withdrawn disaster insurance from areas which are not financially viable, while governments inevitably cap the disaster payments and/or struggle to maintain publicly funded insurance schemes. At best, insurance works in concert with government-sponsored disaster relief payments to alleviate some of the financial losses suffered by victims of climate disasters. However, neither government nor private insurance ever make good all of the losses.

CLIMATE DISASTER LAW AND THE PARIS AGREEMENT

The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC)[137] is to achieve stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable sustainable economic development (Art. 2).

Disasters 6–7 (2013), *available at* http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0213&from=EN.

133 *See* European Environment Agency, Urban Adaptation to climate change in Europe 69–70 (2013), *available at* http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change.

134 Joanne Linnerooth-Bayer, *Insurance, Developing Countries and Climate Change*, 34 Geneva Papers 381, 385 (2009).

135 *Id.*

136 *Id*. at 384.

137 *See* First Steps to a Safer Future: Introducing The United Nations Framework Convention on Climate Change, U.N. Framework Convention on Climate Change, *available at* http://unfccc.int/essential_background/convention/items/6036.php. For an extensive discussion of the UNFCCC and the negotiations and decisions of the COP see Lyster, *supra* note 2, at chapter 2.

I. The Paris Agreement

A. Convergence of climate change, sustainable development, and disaster risk reduction

The COP, in the Preamble to the Agreement, welcomes the United Nations General Assembly resolution on 'Transforming our world: the 2030 Agenda for Sustainable Development' and the adoption of the Sendai Framework for Disaster Risk Reduction. The COP recognized that climate change represents an urgent and potentially irreversible threat to human societies and the planet and requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of GHG emissions.

B. The long-term temperature goal and human rights

On October 31, 2015, the UNFCCC Secretariat published a Synthesis Report on the aggregate effect of the communicated Intended Nationally Determined Contributions submitted by the Parties in the lead up to COP 21.[138] This indicated that the INDCs are currently inadequate and place the world on track for a 2.7°C rise.

Consequently, the COP recognized that deep reductions in global emissions will be required in order to achieve the ultimate objective of the UNFCCC and emphasized the need for urgency in addressing climate change. The Parties are reminded that when taking action to address climate change, they should respect, promote, and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations, and the right to development, as well as gender equality, empowerment of women, and intergenerational equity.

The Agreement aims to:

- hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
- increase the ability to adapt to the adverse impacts of climate change and foster climate resilience and low GHG emissions development, in a manner that does not threaten food production;
- make finance flows consistent with a pathway towards low GHG emissions and climate-resilient development.

The Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.[139]

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[138] *See* Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions FCCC/CP/2015/7 (2015), *available at* http://unfccc.int/resource/docs/2015/cop21/eng/07.pdf.

[139] *Id.* at Art. 2.

C. Mitigation

In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of GHG emissions as soon as possible, recognizing that this will take longer for developing country Parties. Parties must undertake rapid reductions thereafter in accordance with best available science so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.

Each Party must prepare, communicate, and maintain successive nationally determined contributions (NDCs) that it intends to achieve, and pursue domestic mitigation measures to achieve its NDC. Each Party's successive NDC will represent a progression beyond its previous NDC and will reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances. Developed country Parties should continue taking the lead by setting economy-wide absolute emission reduction targets. Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances. The least developed countries (LDCs) and SIDSs may prepare and communicate strategies, plans, and actions for low-GHG emissions development, reflecting their special circumstances. It is recognized that mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification plans can contribute to mitigation outcomes under this Article.

Efforts to achieve this must be communicated by all countries. Every five years, each country must establish a new target, under a pledge and review process. NDCs will be recorded in a public registry maintained by the UNFCCC Secretariat.[140]

D. Adaptation

All countries will establish the global goal of not only adapting to climate change, but also strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development. Each Party should, as appropriate, submit and update periodically an adaptation communication, which may include its priorities, implementation and support needs, plans, and actions, without creating any additional burden for developing country Parties. This communication will be submitted and updated periodically, as a component of or in conjunction with other communications or documents, including a national adaptation plan, a nationally determined contribution, and/or a national communication. The adaptation communications will be recorded in a public registry maintained by the UNFCCC Secretariat. The Global Stocktake, provided for in Article 10, discussed below, will review the adequacy and effectiveness of adaptation and the support provided for adaptation. It will also review the overall progress made in achieving the global goal on adaptation set out in Article 2.[141]

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[140] *Id.* at Art. 4.
[141] *Id.* at Art. 7.

E. The Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts

The COP recognized the importance of averting, minimizing, and addressing the loss and damage associated with the adverse effects of climate change, including extreme weather events and slow-onset events, and the role of sustainable development in reducing the risk of loss and damage. The Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts continues to provide authority and guidance to the COP, serving as the meeting of the Parties to the Paris Agreement. The Mechanism may be enhanced and strengthened including for:

- early warning systems;
- emergency preparedness;
- slow onset events;
- events that may involve irreversible and permanent loss and damage;
- comprehensive risk assessment and management;
- risk insurance facilities, climate risk pooling, and other insurance solutions;
- non-economic losses;
- resilience of communities, livelihoods, and ecosystems.

The Mechanism will collaborate with existing bodies and expert groups under the Agreement, as well as relevant organizations and expert bodies outside the Agreement.[142]

It is interesting that under the Draft Paris Agreement it was proposed that, under the Adaptation Framework and the Warsaw International Mechanism, a climate change displacement coordination facility be established to help coordinate efforts to address climate change-induced displacement, migration, and planned relocation. This did not survive the final round of negotiations.

F. Finance

Developed countries have already agreed to provide US$100 billion per year by 2020 to assist developing countries to mitigate and adapt. Under the Paris Agreement, developed countries will be required to scale up these financial resources. Other Parties may on a voluntary, complementary basis provide resources to developing countries, including through South–South cooperation initiatives. For example, at COP 21 China agreed to provide ¥20 billion (about US$300 billion) for such cooperation. In addition, developed countries are required to integrate climate considerations, including resilience, into international development assistance. Financial resources must be balanced between both adaptation and mitigation, while adequate support must be provided to the Warsaw International Mechanism. Developed countries must report on the level of support which they provide to developing countries in accordance with new guidelines that will be adopted.

Developed country Parties must biennially communicate indicative quantitative and qualitative information on their projected levels of public financial resources to be provided to developing country Parties. The Global Stocktake must take into account the information provided by developed country Parties.

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[142] *Id.* at Art. 8.

The COP decided that the Green Climate Fund and the Global Environment Facility, the entities entrusted with the operation of the Financial Mechanism of the Convention, as well as the Least Developed Countries Fund and the Special Climate Change Fund, administered by the Global Environment Facility, shall serve the Agreement.[143]

G. A global stocktake

This is a new measure which will periodically take stock of the implementation of the Paris Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals. It will be done in a comprehensive and facilitative manner, considering mitigation, adaptation, and the means and financial support, and in light of the best available science. The Global Stocktake will be done first in 2023 and every five years thereafter. The outcome of the Stocktake will guide and inform Parties in updating and enhancing their actions and support, in a nationally determined manner, in accordance with the relevant provisions of this Agreement, as well as in enhancing international cooperation for climate action.[144]

H. Transparency framework

The Transparency Framework is a key part of the Paris Agreement and builds on existing reporting and review requirements under the 2010 Cancun Agreements. Its purpose is to:

- provide a clear understanding of the anthropogenic emissions by sources and removals by sinks of individual Parties;
- facilitate an understanding of global aggregate emissions and removals to inform the Global Stocktake;
- ensure clarity and tracking of progress made towards achieving individual countries' respective mitigation and adaptation actions;
- achieve, to the extent possible, a full overview of aggregate financial support provided.

The information provided by each Party will be subject to a technical expert review, in accordance with guidelines and procedures adopted by the Parties. It will identify any areas for improvement in reporting and possible capacity building, in consultation with the Party concerned. The technical expert review will be carried out by an expert review team that will produce a report, in consultation with the Party concerned, for publication by the Secretariat and consideration by all of the Parties to the Agreement. It will identify any issues related to compliance with the Agreement. A multilateral and facilitative examination will also consider the expert review's report.[145]

I. Implementation and compliance

An implementation mechanism will be established under the Agreement. It will consist of a committee that will be expert based and facilitative in nature and function in a manner

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143 *Id.* at Art. 9.
144 *Id.* at Art. 14.
145 *Id.*

that is transparent, non-adversarial, and non-punitive. The committee will pay particular attention to the respective national capabilities of the countries in meeting their commitments under the Agreement, and any associated failures. From a legal point of view, this is a weak implementation mechanism as no penalties for non-compliance are mentioned.[146] Rather it is a political and diplomatic mechanism for "naming and shaming" Parties that do not comply with their NDC, adaptation, and other commitments.

CULTIVATING THE "SOLUTION SPACE"

Amid this tumbling landscape, our book hopes to launch a bigger conversation about the ways law can meet the specific challenge of disaster risk influenced by anthropogenic climate change. As lawyers drawn to solving problems, we want to thrust our spade into the "solution space" (recalling, again, the IPCC's hopeful term) and prepare the soil for wider and more fruitful cultivation. To do this, we divided our field into quarters — representing international law, public law, environmental law, and private law — and asked leading experts from several countries to examine some aspect of the climate disaster challenge that they found particularly fascinating and important. Some contributors have spent their entire careers studying battered shorelines or chewing on A2 and B2 scenarios. Others have taken a topic not always associated with climate disaster (occupational safety is one example) and shown how climate change might change the field dramatically. The result is a well-crafted discussion that is creative, astute, compassionate, and compelling.

Part I, which is devoted to international law, opens with Tim Stephens' forceful call for a place in international climate law specifically devoted to environmental disaster. The policies addressing the reduction of disaster risk in its generic form, he argues, are no substitute for the urgent task of reducing GHG emissions. Instruments such as the Sendai Framework for Disaster Risk Reduction, as important as they are, can offer only wishful thinking when it comes to the governance of environmental disasters in the Anthropocene. But for the international climate regime to confront disaster risk in a meaningful way, Lavanya Rajamani argues that the global community must first clarify and operationalize one of the regime's foundational pillars: the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC). Rajamani examines the principle of CBDR-RC, including its core content, its legal status, and its role in the Paris Agreement, to see where things stand and what the future options are. Christine Bakker then extends the discussion of global climate policy to the notion of sovereignty itself. Looking at recent developments, from Brexit to recent withdrawals from the International Criminal Court, she discerns a renewed reliance on state sovereignty to justify unilateral action, which she thinks could dampen efforts to address climate risk. In response, Bakker proposes "hybrid" solutions like the Paris Agreement, which seek to combine ambitious goals with some flexibility for participating states.

Jacqueline Peel next examines efforts to adapt international environmental rules largely developed to respond to "manmade" disasters to hybrid climate disasters that involve both natural and human-sourced elements. She explores challenges presented by efforts to

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[146] *Id.* at Art.15.

forge better linkages between disaster management and environmental communities and institutions, with the aim of fostering more integrated approaches for dealing with climate disaster. To conclude the discussion of international law, Rosemary Lyster and Maxine Burkett take on the tragic issue of climate-induced displacement. They focus on DRR and CCA; relocation and resettlement in the event of displacement; and financing, compensation, and risk transfer. The chapter also highlights possible opportunities arising from: the new synergies between the Paris Agreement, the Sendai Framework for Disaster Risk Reduction 2015–2030, and the 2015 Sustainable Development Goals; the 2016 Task Force on Displacement under Warsaw International Mechanism for Loss and Damage; and the proposed 2018 UN global compact for safe and orderly and regular migration.

Part II, which is devoted to public law, considers the developing role of administrative law in pursuing climate resilience. Daniel A. Farber investigates the constitutional and administrative challenges of climate change at a general level that might apply to many countries. He identifies problems that cut across legal systems — concerning risk management, federalism, and individual rights — and suggests some effective approaches to solving them. Lisa Grow Sun looks at climate disaster through the lens of public security and law enforcement. Concerned about the traditional narrative of disaster situations as involving human violence and crime, Sun worries that the public response to disasters leans towards solutions based on law enforcement, rather than on humanitarian impulses. While security concerns should not be ignored, she argues, decision makers should be cognizant that such concerns may be overblown and should guard against overemphasizing security at the expense of prompt, effective, and humane disaster response. Sidney Shapiro and Katherine Tracy shine their spotlight on the health, safety, and economic risks that workers are likely to bear as climate impacts increase in intensity and scope. Using the United States as a case study, they show how labor policies already fail to protect many workers from extreme weather events and suggest this problem will only get worse. They argue for stronger standards and better risk management tools to protect workers from illness, injury, and economic dislocation as climate policies usher in a transition to a green economy.

Part III takes up the role of environmental law in addressing climate disasters. Craig Anthony (Tony) Arnold begins the discussion by describing the structural roles that law plays in helping communities prepare for climate disasters. Such disasters, he shows, highlight the need for legal systems to help human communities and environmental systems to adapt. That means legal systems must themselves become more adaptable. Arnold recommends four changes that would make legal systems more adaptive: greater flexibility; use of law for transformation; a revolutionary evolution in the law; and an intentional focus on justice. Robert R.M. Verchick extends Arnold's discussion, drawing lessons about climate adaptation policies from examples in the United States and around the world. He proposes a set of guiding principles and a decision-making framework for adaptation and shows how two very different cities — New York City and Surat, India — have used similar ideas to their advantage. Verchick then considers how law can "prompt" planning efforts through international frameworks and traditional environmental reviews.

In the context of planning, Teresa Parejo-Navajas and Michael B. Gerrard then draw our attention to building codes and consider how buildings should be modified to cope with climate-related extreme events. Importantly, they pay particular attention to slums and to provisional and post-disaster housing. Of course, even with the best planning and

building standards, there will always be some developments that are in areas too exposed to danger to make sense. Thus Susan S. Kuo confronts "the uneasy case for disaster buyouts." While voluntary buyouts are often seen as appealing mechanisms for removing households from harm's way, the tactic in some circumstances can be highly coercive. Kuo shows why and argues that disaster buyouts should be regulated to protect owners' individual and communal interests.

Robin Kundis Craig carries the discussion from land to water, examining the roles of water law in addressing three different forms of water-related climate disasters: drought, flooding, and coastal inundation. The key to effective policies on all counts, she argues, is a commitment to flexibility in allocation and use of water resources. Rosemary Lyster and Robert R.M. Verchick look for the same opportunities for resilience and flexibility in electricity infrastructure. As extreme-weather events threaten power grids throughout the world, they call for innovations in law and policy that would encourage utilities to harden infrastructure, integrate resilient digital technology, and favor renewable sources that are more adaptable. John Copeland Nagle continues the discussion of environmental law by going narrow. He presents the fascinating account of the U.S. government's attempt to protect the polar bear from climate-related habitat loss through the federal Endangered Species Act. In this compelling example, Nagle finds lessons for preparing for climate impacts and for protecting species of all kinds. Finally, Jonathan Verschuuren focuses on one of the most important issues in CCA: global food security. At both the international and domestic levels, Verschuuren argues that policies should address three aspects of the problem: reducing loss at the front end through adaptive practices and technologies, strengthening emergency response capabilities, and developing compensation and rebuilding strategies aimed at realizing a more resilient agricultural sector.

Part IV looks at climate disaster through the lens of private law. Here, R. Henry Weaver and Douglas A. Kysar begin with the fundamental question, asking whether courts applying common law tort principles have any business addressing a problem like global climate change, a challenge of such "massive scale and complexity." Focusing on courts' role in articulating norms and enforcing rights, Weaver and Kysar argue that courts must accept the challenge. "[J]udges redeem the very possibility of law when they forthrightly confront the merits of climate lawsuits," they write. In contrast, ducking the issue through weak procedural maneuvers will only reinforce "a sense of law's disappearance into the maw of normative rupture." John D. Echeverria follows with an examination of how private property law is likely to fare in a warming planet. While some property law regimes could actually facilitate adaptation in the face of modest changes in climate, Echeverria argues that more dramatic impacts could lead to major changes in coastal boundary law, water allocation, and the regulatory takings doctrine. Michael Faure and Qihao He focus their chapter on insurance, which has received increased attention due to its emphasis on risk management. The authors argue that private insurance can act not only as a form of post-disaster compensation, but also as a form of private regulation — a contractual device controlling and motivating behavior to avoid the occurrence of climate change losses. Closing out this discussion, M. Scott Donald considers the state of pension funds in a world where long-term environmental conditions are fraught with uncertainty. In this final chapter, Donald offers a nuanced and contextualized account of the legal and regulatory framework for pension funds in Australia, finding insights relevant to other countries as well.