Chapter 1

Introduction and Overview

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Introduction

Since the emergence of climate change as a public policy concern in the late 1980s, most attention has focused on mitigation—reducing humanity's impact on the climate, principally by controlling the emissions of greenhouse gases (GHGs). Unfortunately, due to the global and cumulative nature of GHG emissions, mitigation measures will not yield tangible climate benefits for many years, and those benefits will not be especially local, though mitigation often yields collateral benefits, such as reducing fossil fuel use and conventional air pollution.

More importantly and tragically, mitigation alone will not be sufficient. Even with the most aggressive plausible mitigation efforts, GHG emissions will continue to increase globally for decades before they peak and decline, and the effects of climate change will continue to worsen.[1] Thus, while mitigation is essential, so is adaptation.

"Adaptation" is the term used to describe efforts to moderate, cope with, and prepare for the current and anticipated impacts of climate change on human and natural systems. A closely related concept is "resilience"—the capability to anticipate, prepare for, respond to, and recover from climate impacts. Also related are both "sensitivity" (the degree to which a system is affected by climate-related stimuli)[2] and "vulnerability" (the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change).[3]

Unlike mitigation, the direct benefits of many adaptation measures are short-term and local. Most anthropogenic GHG emissions come from economic activity, and the burden of mitigation falls largely (though not exclusively) on those who are wealthy enough to consume the most goods and services. In contrast, the worst effects of climate change, and therefore the greatest need to adapt, tend to fall on the poorest areas of the world, which also have the least capacity to adapt.

At least until a few years ago, adaptation received far less attention than mitigation. There are several reasons:

- There was fear that working on adaptation would divert attention from mitigation.
- Adaptation was seen as a sign of defeat.

- Wealthy countries realize that they will have to pay for adaptation measures in poor countries.
- Poor countries fear that adaptation assistance would supplant rather than augment other development aid.
- The uncertainty over the pace and nature of climate change makes it difficult to determine just what needs to be done.
- Difficult choices must be made about preservation versus abandonment of vulnerable places and species.

Nonetheless, there is now a growing realization that both mitigation and adaptation must be pursued vigorously. Society barely has the resources today to cope with the climate change that is already occurring. Without major efforts to control GHG emissions, the suffering will become far worse. The planet is already ailing, and we need both cure (mitigation) and treatment (adaptation).

Many different kinds of law apply to adaptation. They exist at all levels (international, national, state, and local). These laws arise in different forms (constitutions, statutes, agency regulations, judicial decisions, private agreements, and voluntary guidelines). For the most part, they are not coordinated (much less unified), and they embody many contradictions and even more gaps.

This book aims to lay out the law, such as it is, that applies to adaptation. It describes proposals to make the laws that deal with adaptation more rational and comprehensive. There is, as yet, no coherent body of adaptation law. The challenges posed by adaptation intersect with numerous bodies of law that address other problems. Adaptation-related provisions may be grafted onto some existing bodies of law (such as those governing environmental impact assessment, flood insurance, and infrastructure planning); it is much more difficult to do that for some other areas of law (such as property rights, endangered species protection, and water rights). This book addresses how climate impacts intersect with the law and how the law in particular areas is being modified, finessed, and imagined to deal with these impacts. Where there has not been much thought about how the law will or should respond to climate impacts, the book suggests some possibilities.

Law is the major vehicle for decisions of public officials, hopefully utilizing information provided by scientists, engineers, economists, and others, to be translated into requirements, prohibitions, and procedures. A fair amount of information from other disciplines is presented here through a legal lens.

This chapter lays the foundation and sketches the framework for the ensuing chapters. It begins by summarizing current projections of future climatic conditions, and some of the likely impacts of those conditions. It categorizes the various proposed methods to adapt to those conditions, and identifies the related legal structures that are emerging. It touches on such important issues as uncertainty, variability, and equity. It cross-references the other chapters in the book that analyze the legal issues in considerably more detail.

After this introductory chapter and a chapter on the crosscutting topic of adaptive management, the volume is divided into two parts. Part 2 concerns U.S. law. Part 3 discusses international and non-U.S. law.

Projections of Future Climatic Conditions

Many scientists around the world are attempting to project future climatic conditions in view of current and expected GHG emissions and such other relevant variables

as land use changes, population and economic growth, solar activity, volcanoes, and natural climate variability. Several official bodies systematically assemble and review the scientific evidence and attempt to formulate consensus findings, to update them as new information becomes available, and to reflect the levels of uncertainty that are present. The most prominent such body is the Intergovernmental Panel on Climate Change (IPCC), which was established in 1988 by two United Nations organizations, the World Meteorological Association and the United Nations Environment Programme. Every five to seven years, the IPCC publishes a multivolume assessment report that summarizes the then-available information and makes projections. The most recent report, issued in 2007, was the Fourth Assessment Report (FAR), which is relied upon extensively here. The Fifth Assessment Report is due in December 2014.

The U.S. Global Change Research Program (USGCRP) is particularly relevant to U.S. policymakers. It is a joint effort of 13 departments and agencies mandated by Congress in the Global Change Research Act of 1990.[4] It too publishes periodic climate assessments, the most recent of which is *Global Climate Change Impacts in the United States*, issued in 2009. This report, too, is relied upon below. (The next version is due in 2013.)

Some of the most important projections of future climate conditions that will require adaptation actions are temperature, sea level, droughts, extreme precipitation, heat waves, and wildfires.

Temperature

The IPCC FAR projects that for the next two decades, global average temperatures will increase about 0.2°C per decade regardless of GHG emission levels. By midcentury, it is projected that future variations in GHG levels will be increasingly relevant. By 2100, temperatures are expected to be highly influenced by the century's GHG emissions. The IPCC's best estimates of likely temperature increases by the last decade of the century (relative to 1980–1999) range from 1.8°C under the lowest emissions scenario to 4.0°C under the highest. The likely range under the highest emissions scenario is 2.4 to 6.4°C.[5] (Between about 2005 and the onset of the global financial crisis in 2009, global fossil fuel emissions largely tracked the IPCC's highest emissions scenario.)[6]

The USGCRP largely adopts the IPCC projections and reports that "[a] variety of research studies suggest that a further increase (relative to the 1980–1999 period) would lead to severe, widespread, and irreversible impacts."[7]

The National Research Council has found that each degree centigrade of global temperature increase can be expected to produce 5 to 10 percent changes in precipitation across many regions; 3 to 10 percent increases in the amount of rain falling during the heaviest precipitation events; 5 to 10 percent changes in streamflow across many river basins; 5 to 15 percent reductions in yields of crops as currently grown; and 200 to 400 percent increases in the area burned by wildfire in parts of the western United States.[8]

To put these changes in perspective, during the most recent ice age, global temperatures were 3°C to 5°C lower than they are today.[9] The most recent time in Earth's history when mean global temperatures were substantially warmer for a sustained period than today, the mid-Pliocene, had temperatures about 2°C to 3°C above preindustrial temperatures; sea level was at least 50 to 80 feet above modern levels.[10]

Sea Level

After at least 2,000 years of little change, sea level over the past century rose by roughly eight inches.[11] The principal reason for this rise was thermal expansion (water

expands as it warms). The melting of glaciers and ice sheets also contributed. The retreat of the glaciers has been accelerating, and the Antarctic and Greenland ice sheets are experiencing melting and calving—i.e., the breaking off of large chunks of ice. The IPCC projects that, by the end of the century, sea level will rise another seven to 23 inches, depending on the model and emissions scenario.[12] However, these IPCC projections do not reflect calving; when the FAR was released in 2007, the IPCC did not believe that the science allowed future quantitative projections of calving. Subsequent work suggests that by the end of the century, the average sea-level rise is likely to be somewhere between about three and six feet, though there can be considerable regional variations due to land subsidence, ocean dynamics, and other factors.[13]

Droughts

The frequency of droughts (long periods without rainfall) is expected to increase substantially by the end of the century.[14] Several parts of the world—especially southern Africa, southern Europe, Central America, Central Asia, and the islands of the Caribbean and the Mediterranean Basin—are especially likely to experience major droughts.[15] In the United States, the Southwest is particularly vulnerable.[16]

Extreme Precipitation

The IPCC found "an increased chance of intense precipitation and flooding due to the greater water-holding capacity of a warmer atmosphere," and also of more severe tropical cyclones.[17] The USGCRP reported an increase in the frequency and intensity of heavy downpours in the United States and predicted that this trend would continue.[18] It also foresaw a continued increase in the destructive energy of Atlantic hurricanes.[19] The USGCRP also expected an increase in the intensity of snowstorms.[20] A number of more recent scientific studies reinforce the finding that GHG emissions have contributed to the observed intensification of heavy precipitation events in the Northern Hemisphere and consequent flooding, and will do so even more in the future.[21]

Heat Waves and Wildfires

The IPCC and the USGCRP agree that there is an increased risk of more intense, more frequent, and longer-lasting heat waves.[22] Higher temperatures will in turn produce more severe wildfires. The National Academy of Sciences finds that the area burned each year in the western United States from 1°C warming may increase 73 percent to over 600 percent (depending on the ecoprovince—i.e., the ecology of the affected area) compared to recent levels.[23]

Anticipated Impacts of Projected Climatic Conditions

The future changed climates of the world will have major impacts on many human and natural systems, with considerable variations across the globe. Below are a few examples. The individual chapters of the book explore these impacts in more depth.

Water Supplies

Climate change impacts on water supplies will vary widely in different parts of the world. According to the IPCC, in the high latitudes of North America and Eurasia, in

2050 water runoff will increase 10 to 40 percent, while in the Mediterranean, southern Africa, and western United States/northern Mexico (areas that are already experiencing water stress), runoff will decrease 10 to 30 percent.[24] In areas that depend heavily on glacier melt (notably in the Hindu Kush-Himalaya and South American Andes), river flows will increase over the next several decades as the glaciers melt and then will significantly decline.[25]

The United States will experience similar great variations. The USGCRP found that "climate change has already altered, and will continue to alter, the water cycle, affecting where, when, and how much water is available for all uses."[26] It predicted that precipitation and runoff are likely to increase in the Northeast and Midwest in spring and summer, and decrease in the West, especially the Southwest, in spring and summer.[27] Higher water temperatures will lead to lower levels of dissolved oxygen in lakes, reservoirs, and rivers, with negative effects on coldwater fish and the insects and crustaceans on which they feed.[28]

Chapter 3 of this book details the negative effects that too little or too much water will have in the United States, and chapter 22 describes the negative effects on the rest of the world. Both chapters show that human settlement patterns are heavily influenced by the availability of water, and that major changes in the supply and quality of water can create massive disruptions.

Food Supply

As with water supply, the effects of climate change on food supply will vary considerably in different parts of the world. The IPCC projects that in low-latitude regions, even moderate temperature increases (1 to 2°C) are likely to reduce yields of major cereal crops. In mid- to high-latitude regions, temperature increases of 1 to 3°C may have small beneficial effects on crop yields, but with greater increases the effects turn negative.[29] Increased heat stress, droughts, and flooding will further reduce crop yields and livestock productivity.[30]

The worst effects on food will be felt by smallholder and subsistence farmers, pastoralists, and fishers, many of whom already barely get by.[31] Chapter 23 establishes that reduced water supply and higher food prices can have severely negative effects on the poorest populations.[32]

The USGCRP found that many crops respond positively to elevated carbon dioxide and low levels of warming, but that higher levels of warming often negatively affect growth and yields. It concluded that crop yields will also be reduced by extreme events such as heavy downpours and droughts; that weeds, diseases, and insect pests benefit from warming, and weeds also benefit from higher carbon dioxide concentration; and that forage quality in pastures and rangelands generally declines with increasing carbon dioxide levels.[33]

Human Health

The IPCC found that climate change is likely to affect the health of millions of people through increases in malnutrition; more deaths, disease, and injury due to heat waves, floods, storms, fires, and droughts; the greater burden of diarrheal disease; the higher frequency of cardiorespiratory diseases due to higher concentrations of ground-level ozone related to climate change; and the altered spatial distribution of some insects and other infectious disease vectors.[34]

The United States has less vulnerability than many other parts of the world to malnutrition, and there will be some reduction in the risk of death related to extreme cold. However, the USGCRP predicted increases in the risk of illness and death in the United States related to extreme heat and heat waves, and an increase in some diseases transmitted by food, water, and insects.[35]

Coastal Conditions

The IPCC projected that coasts will be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise, with many millions more people being flooded every year due to sea-level rise by the 2080s. Especially at risk are those densely populated and low-lying areas where adaptive capacity is relatively low, and that already face other challenges such as tropical storms or local coastal subsidence.[36]

In the United States, 20 municipalities with populations greater than 300,000, and 160 municipalities with populations between 50,000 and 300,000, have land area at or below elevations where proximity to the sea and expected rise in sea levels make them especially vulnerable to coastal flooding.[37]

Infrastructure

Climate change poses difficulties for all kinds of infrastructure—transportation, electric power, water and wastewater utilities, drainage, etc. The impact varies considerably with location.[38] The USGCRP found that sea-level rise and storm surge increase the risk of both temporary and permanent flooding of airports, roads, rail lines, and tunnels. Flooding from increasingly intense downpours will heighten the risk of disruptions and delays in air, rail, and road transport.[39]

Ecosystems

Many ecosystems and individual species will be affected by changes in temperature, water availability, wildfires, insects, ocean acidification, and other conditions. The IPCC concluded that though there are some positive impacts, the effects on biodiversity and on ecosystem goods and services such as water and food supply will be predominantly negative.[40] The USGCRP found that large-scale shifts already have occurred in the geographic ranges of species and the timing of the seasons and animal migration; that fires, insect pests, disease pathogens, and invasive weed species have increased; that coastal and near-shore ecosystems are already under multiple stresses; and that all these impacts are likely to continue. Deserts and drylands are likely to become hotter and drier, feeding a self-reinforcing cycle of invasive plants, fire, and erosion.[41]

Economic Losses

Examining the United States alone and adopting IPCC climate change projections, Sandia National Laboratories estimated that total loss to the gross domestic product due to climate change may be approximately $1.2 trillion through 2050 at a 0 percent discount rate, with a total annual job loss by 2050 of nearly 320,000 full-time jobs. Economic and job losses would increase rapidly after 2050.[42] A global estimate would require an even larger number of assumptions, but one study found that climate change–induced tropical cyclones alone could cause losses in the range of $28 billion to $68 billion per year.[43]

Ways to Respond to Anticipated Climate Conditions

Typologies of Responses

There are as many different ways to adapt to climate change as there are kinds of impacts. Several typologies have been created to help think systematically about these methods.

Professor Ian Burton has developed the following categories of options to address climate impacts:[44]

- Share the loss—for example, purchase insurance.
- Bear the loss—rebuild or abandon sites.
- Modify the events—for example, prevent flooding by constructing levees, sea walls, and stormwater drainage structures.
- Prevent the effects—improve the ability of structures to withstand high winds, intense heat, fire, or flooding events, and implement systems of early warning and emergency management.
- Change use—convert the use of exposed sites from sensitive activities such as development to greenspace.
- Change location—relocate activities that are sensitive to climate impacts to less exposed locations.
- Research.
- Increase education and change behavior.

Professor Alejandro Camacho has proposed three parameters for classifying government adaptation measures:[45]

1. Whether the adaptation primarily anticipates or reacts to effects from climate change
2. Whether the strategy focuses exclusively, partially, or only indirectly on projected climate change effects
3. Whether the strategy is a substantive response to the direct effects of climate change or is an indirect procedural adaptation of a process for deciding among substantive adaptations.

For example, construction of a sea wall or relocation of an island's population because of projected future climate change is anticipatory, is exclusively in response to climate change, and is substantive. Increasing the capacity of a drainage system after it was overwhelmed by a flood can be both anticipatory and reactive; it is partially because of expected future floods; and it is substantive. Changing the methods of environmental impact assessment to reflect future climate conditions is anticipatory, partially due to climate changes (if the revised analysis also helps anticipate current natural variability), and procedural.

Evaluating Possible Responses

In 2008, Congress commissioned the National Academies of Sciences (NAS) to "investigate and study the serious and sweeping issues relating to global climate change and make recommendations regarding what steps must be taken and what strategies must be adopted in response to global climate change, including the science and technology challenges thereof."[46] As part of the resulting *America's Climate Choices* study,

an NAS committee offered this set of criteria by which adaptation plans, policies, and options might be evaluated:[47]

1. Impacts on the current and future generations
2. Impacts on natural and social systems as well as on individuals, firms, government institutions, and infrastructure
3. Effects on the structure and functioning of ecosystems
4. Sustainability so that social, economic, and environmental ramifications of proposed strategies and actions are explicitly recognized
5. Equity and justice implications; consideration of those with a high degree of vulnerability
6. Impacts on all affected parties
7. Use of a portfolio approach to address adaptation issues, including a suite of technology and social-behavioral-economic options
8. Comparison of the risk of actions and inactions
9. International implications of U.S. adaptation and emissions-reduction efforts, as well as the impacts on the United States of decisions made by other countries.

Unique Challenges in Responding to Climate Change

The NAS study has listed the following challenges posed by climate change that must be considered in designing response strategies:[48]

1. Emissions, concentrations, climate changes, and impacts are linked in complex ways
2. There are significant time lags in the climate system, such as between emissions and impacts
3. Human systems take a long time to react
4. Risks, judgments about risk, and adaptation needs vary substantially across different contexts
5. Decisions affecting climate change are made at all levels of society
6. Limiting climate change requires global-scale efforts
7. Climate change is only one of the interconnected challenges facing society
8. The costs and benefits of different courses of action are not easily determined:
   a. Costs and benefits are difficult to quantify
   b. Costs of actions to limit climate change risks are immediate, but many benefits will occur remotely in time and location
   c. Collateral costs and benefits also need to be considered
9. Many factors complicate and impede public understanding of climate change

In many ways the challenges of adaptation to climate change are much more complex than the challenges of mitigating climate change. Climate mitigation is focused discretely on one objective—to reduce emissions of GHGs. Other human activities, such as the emission of black carbon, also contribute to climate change, but GHGs predominate by far. Of carbon dioxide emissions, about 80 percent are from fossil fuel use and most of the rest are from land use change (principally deforestation).[49] A ton of GHGs has the same effect on the global climate wherever in the world it is emitted. Thus the lowest-cost methods of reducing GHGs can be sought and financed. Climate adaptation, on the other hand, involves a very wide range of actions that must be taken all around the world in the places where the impacts will

be felt. Many of these are in regions of extreme poverty, with all the associated challenges that poverty provokes.

There is a sense in which adaptation actions are easier to justify. As noted above, the benefits of mitigation tend to be remote in time and space. A large expenditure to reduce GHG emissions will not yield local climate benefits, if at all, for decades to come. But many adaptation measures have short-term, specific, local benefits in terms of protecting against already occurring climate-related events and natural weather variability. While certain mitigation actions may impede economic development, many adaptation actions promote development by upgrading infrastructure, buildings, or agricultural equipment.

The Legal Response and the Plan of This Book

As discussed above, both mitigation and adaptation are essential. A comprehensive legal approach to mitigation can certainly be envisioned, but formulating a comprehensive approach to adaptation is much more challenging.

Several attempts have been made to create laws that would more or less comprehensively mitigate climate change. In 1992, the United Nations Framework Convention on Climate Change of 1992 (UNFCCC) was negotiated to avoid dangerous anthropogenic interference with the climate. In 1997 the Kyoto Protocol aimed to achieve that objective by requiring developed countries to reduce their own emissions and to pay for the efforts of developing countries to mitigate and adapt.[50] Fifteen years' worth of effort has revealed the severe shortcomings in that system. In 2009, there was great hope that a new global arrangement would be reached at that year's annual UNFCCC conference of the parties in Copenhagen. The same year, the U.S. House of Representatives passed the Waxman-Markey bill to mitigate U.S. emissions, built around an economy-wide cap-and-trade program.

The lawmaking efforts of 2009 failed. The Waxman-Markey bill died in the U.S. Senate, and President Barack Obama, who had supported it, was unable to go to Copenhagen with the congressional backing required to reach a binding new agreement. Instead, President Obama has had few options but to force-fit existing statutes, led by the Clean Air Act, to a global problem that they were not designed to address. Environmental laws that seek to reduce emissions, and those energy laws that attempt to make our economy more energy efficient and less dependent on fossil fuels (at least the dirtiest of them), may together, in an inelegant and fragmented manner, drive down GHG emissions.

The mitigation laws are like a patchwork of scraps that are barely sewn together. The adaptation laws are not even that; there is little cloth, and the existing scraps are hardly linked. In editing a book that attempts to bring together all the U.S. laws and many of the international and non-U.S. laws on climate adaptation, it is striking how little hard law there is that is explicitly aimed at adaptation, at increasing resilience, or at reducing vulnerability to climate change. The United States has taken nonclimate-oriented statutes and is using them as a basis to erect a patchwork regulatory scheme explicitly aimed to mitigate GHGs, with a steady supply of new regulations issuing from EPA, the Department of Energy, and other federal agencies (and a few of the states) that regulate private activity as well as government actions.[51] However, no such phenomenon is occurring for adaptation. As described in chapter 12, several agencies are working to coordinate their adaptation activities and are devoting special attention to adaptation on the federal lands, but there are few requirements applicable to the private sector.

There is no immediate prospect for federal legislation to address climate adaptation. Beginning in 2009, and for reasons that go well beyond the scope of this book, a movement that questioned the very scientific basis for concern about climate change gained considerable political strength. The House of Representatives that was elected in November 2010 is stalwartly opposed to legislation that would advance either mitigation or adaptation, and it has made efforts (so far unsuccessful, as of June 2012) to shut down ongoing federal efforts under existing statutory authority. The results of the November 2012 election, and the ensuing control of the House, the Senate, and the White House, will determine the fate of federal efforts in the years after that. As long as U.S. climate legislation is stalled, it is difficult to envision the other major emitting countries forging an otherwise comprehensive international agreement on climate change, as it would be largely futile without U.S. involvement.

Meanwhile, the preexisting U.S. environmental statutes remain in place. Federal and state environmental law is the foundation for mitigation efforts. However, the law sometimes ironically gets in the way of adaptation efforts.[52] Much of environmental law assumes a baseline environment and seeks to preserve it. Where that environment has been degraded, the law seeks to restore it. But as a result of climate change the environmental baseline is shifting in many ways; attempting to stay in the same place is often futile, and laws that try to tie us down to where we have been can prevent us from moving as gracefully as possible to where we must go. The challenge of adaptive management—altering our rules and practices as we go along so that we can cope with changing conditions—is explored in chapter 2. In the words of Jan McDonald, "Two sets of laws are needed: *adaptation* laws, whose substantive regulatory objectives include adaptation, and *adaptive* laws, the implementation of which can accommodate creeping changes and sudden shocks that climate change might bring."[53]

These changes and occasional shocks will be a hallmark of the world we are leaving to the coming generations. In the words of Robin Kundis Craig, "the new paradigm for environmental and natural resources law in an era of climate change adaptation must be to increase the continuing capacity of the natural world, human society, socioecological systems, and legal institutions to adjust to continual transformation. In other words, the overall goal of climate change adaptation law should be to increase the *adaptive capacity* of humans, other species, society, and the ecosystem."[54]

Nowhere is the need for both adaptation laws and adaptive laws more compelling than in the governance of water. One of the principal direct effects of climate change is to make dry places drier and wet places wetter. Water laws that assume that water availability will remain within a historical range (as most do) have trouble addressing conditions that exceed that range (especially on the dry side). Chapter 3 (which opens part 2 of this book, on U.S. aspects) analyzes U.S. water laws as the country struggles with changing water supplies. Chapter 4 covers U.S. laws that attempt to reduce the demand for water. Chapter 22 considers international laws on water supply and demand.

Trillions of dollars have been invested in creating a built environment that assumes the continuation of recent sea levels, temperature ranges, and other features of the climate that are now moving away from historic conditions. Chapter 5 explores legal aspects of climate change that affect our energy systems, especially fuel extraction and transportation and electric power generation and transmission, and the law's role in helping or hindering adaptation by this sector. Chapter 6 considers those issues with

respect to infrastructure, and chapter 7 examines buildings. These three chapters demonstrate that many of our physical structures are quite vulnerable to entirely plausible future conditions. Precautions against these vulnerabilities have been taken in a few places, showing it can be done, but that is still very much the exception rather than the rule. There are many ways to increase the resilience of the built environment, but few of them are being implemented.

Many of the starkest adaptation choices arise in coastal areas where sea-level rise, erosion, and storm surges can endanger established uses. Society copes with these changes along a spectrum of activities that range from defense to retreat. Defensive strategies involve erecting sea walls and levees, nourishing sand-depleted beaches, paying for reconstruction of damaged or destroyed structures, and other actions designed to allow our newly endangered buildings and infrastructure to stand fast. Retreat strategies may include barring new uses in vulnerable areas, preventing the reconstruction of existing uses that have been damaged, and possibly requiring the abandonment of what is already there. The choice and implementation of these strategies invoke serious questions of property rights and land use law, in addition to the environmental laws that govern work in and near the water. Chapter 8 explores the legal issues in coastal defense, and chapter 9 covers coastal retreat. These chapters show that the United States has no coherent coastal policy. Defense and retreat policies are being pursued simultaneously in different places and at different levels of government.

Animals and plants, and their habitats, are profoundly affected by a changing climate. Some species historically have thrived in areas that are now becoming inhospitable; if they can they are moving (or being moved) to other places—if any such exist—where they can survive. The Endangered Species Act (ESA) is the principal relevant U.S. law. Although it provides a very limited toolbox to deal with climate change, ESA does give us ways to address the nonclimate actions (such as forest clearing and water diversion) that add stress to animals and plants that are imperiled by climate change. ESA and other legal aspects of how species and ecosystems are affected by climate change are the topics of chapter 10. Two great industries, on which many other industries and human activities depend—agriculture and forestry—are based on the creation and management of environments that we use for food, fiber, fuel, and building materials. Chapter 11 covers legal aspects of climate change adaptation of agriculture and forestry.

Cutting across all these impacts are various societal coping mechanisms. Disasters of many sorts have long been with us. The United States has a federal statute (the Robert T. Stafford Disaster Relief and Emergency Assistance Act) and an agency (the Federal Emergency Management Agency) with central roles in managing disaster response. In addition, every state and city has its own program. Chapter 13 discusses how these mechanisms would function in the context of climate disasters. Insurance is the principal instrumentality by which society spreads the risks of disasters and other afflictions. Chapter 14 explores how insurance might deal with climate-related losses.

The National Environmental Policy Act (NEPA) organizes evaluation of the environmental impacts of federal actions. Many states have equivalent laws. Chapter 15 discusses emerging procedures and protocols governing treatment of climate-related impacts under NEPA, its state counterparts, and the securities laws. By and large these

laws do not have substantive bite but they aim to compel analysis, disclosure, and consideration.

Governance of adaptation responses involves every level of government. The principal federal role to date in adaptation to climate change has involved the management of federally owned lands and resources. These are treated in chapter 12. Chapter 16 covers the central roles of states and municipalities, which make decisions on land use, and building and maintaining infrastructure, and provide emergency response.

Part 3 of this book shifts attention from the United States to the international level.

The UNFCCC, while focused on mitigation, does acknowledge the importance of adapting to climate change. For example, one provision requires all parties to "[c]ooperate in preparing for adaptation to the impacts of climate change; [and] develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods."[55] Chapter 17 covers the programs that are emerging from the UNFCCC and associated international mechanisms for adaptation, including the preparation of National Adaptation Programs of Action by the least developed and most vulnerable countries.

The principal adaptation focus of the international community has been financing adaptation efforts. Looking only at developing countries, the World Bank has estimated that the cost between 2010 and 2050 to adapt to an approximately 2°C warmer world would be in the range of $70 billion to $100 billion a year.[56] Of these sums, the largest portion would go to infrastructure, coastal zones, and water supply and flood protection.[57] One of the few tangible outcomes of the UNFCCC conference in Copenhagen in 2009 was a set of nonbinding pledges from developed countries to provide $100 billion per year by 2020 for climate adaptation and mitigation efforts in the developing world. Chapter 18 assesses this program and other international efforts to finance adaptation and to establish institutions to receive and disburse these funds, if they materialize.

Various international organizations and systems have emerged to respond to disasters and associated health crises. These systems will certainly be invoked in the context of climate-related events, and they are the subject of chapter 19.

Perhaps the greatest climate-related peril (and one to which the United States does not seem particularly subject, at least in the coming decades) is mass population displacement and migration. People displaced by climate change do not fit within the internationally accepted definition of "refugee." However, the existing legal regimes for refugees may offer useful lessons for the legal treatment of such persons. Guidelines also exist for dealing with internally displaced peoples. If the displacement becomes so great that all or virtually all of a country's population has fled due to, say, rising waters (a plight that eventually could be faced by some small island nations), the very issues of sovereignty and statehood come into play. These issues are discussed in chapters 20 and 21.

Another matter of great concern to some countries other than the United States is the effect of climate change and shifting coastlines on maritime borders, and the associated jurisdiction over fishing and deep-sea resources. Chapter 21 covers these topics.

International water issues are discussed in chapter 22. Changes in water availability as well as ocean acidification and other climate impacts will have very serious

adverse effects on food supplies, fisheries, and ecosystems in some parts of the world; these are covered in chapter 23.

The book closes with two chapters about subjects that are relevant to the entire world. Chapter 24 concerns the legal rights and remedies of persons and nations that are harmed by climate change. It addresses whether any sort of recourse to the courts or international bodies might be available, and who if anyone might bear liability. Chapter 25 addresses the growing concern that climate change and its associated instability and displacement may threaten national and international security.

Conclusion

This book, viewed as a whole, paints an alarming picture. The changing climate, combined with natural weather variability, is already causing misery in many parts of the world. Even the United States is affected, with extreme droughts in some areas and unprecedented flooding in others. The complex interactions among human and natural systems make it impossible to foresee with confidence a detailed picture of the world of the middle and late 21st century. However, actions taken today will profoundly affect that world, and almost all the current signs and models point to terrible or even grave future conditions in certain regions. Some observers imagine by century's end a world with widespread starvation, mass migration and political chaos, and dystopian visions exceeding utopian ones. Some magic bullets (of the fusion power variety) have been imagined that could theoretically address our mitigation challenges. Few have even imagined, much less predicted, a magic bullet to solve our varied and dispersed adaptation challenges.

Ultimately, scientists and engineers will have to devise the solutions, and politicians will have to provide the legal mechanisms and financial resources to implement them. One bright spot we as lawyers have to offer is that around the world numerous national and subnational governments, often operating in isolation, have developed legal tools to address many of the bewildering array of problems posed. By attempting to bring these tools together in one volume, it is hoped that the most promising ones can be identified, emulated, and ultimately integrated someday to create a coherent body of climate adaptation law.

Notes

1. Intergovernmental Panel on Climate Change, Climate Change 2007: The Physical Science Basis 14 (2007) [hereinafter IPCC, Physical Science Basis].
2. Intergovernmental Panel on Climate Change, Third Assessment Report, Glossary of Terms, *available at* http://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf.
3. *See* National Research Council, Adapting to the Impacts of Climate Change 19 (2010).
4. Pub. L. No. 101-606, 15 U.S.C. §§ 2921 *et seq*.
5. IPCC, Physical Science Basis, *supra* note 1, at 12–13, 749.
6. Global Carbon Project, Carbon Budget 2009 at 12 (Jan. 20, 2011); University of New South Wales Climate Change Research Centre, The Copenhagen Diagnosis, 2009: Updating the World on the Latest Climate Science 9 (2009).
7. U.S. Global Change Research Program, Global Climate Change Impacts in the United States 23 (2009) [hereinafter USGCRP].
8. National Research Council, Warming World: Impacts by Degree 5 (2011). *See also* Mark Lynas, Six Degrees: Our Future on a Hotter Planet (2008).

9. IPCC, Physical Science Basis, *supra* note 1, at § 6.4.1.2.
10. *Id*. § 6.3.3.
11. USGCRP, *supra* note 7, at 18.
12. IPCC, Physical Science Basis, *supra* note 1, at 13.
13. *See* Anny Cazenave & William Llovel, *Contemporary Sea Level Rise*, 2 Ann. Rev. Mar. Sci. 145 (2010); Glenn A. Milne et al., *Identifying the Causes of Sea-Level Change*, 2 Nature Geoscience 471 (July 2009); Martin Vermeer & Stefan Rahmstorf, *Global Sea Level Linked to Global Temperature*, 106 Proc. Nat'l Acad. Sci. 21527 (Dec. 22, 2009); Mary-Elena Carr et al., *Sea Level Rise in a Changing Climate: What Do We Know*? (May 2011) (Columbia Climate Center, Earth Institute, Columbia University); similarly, *see* USGCRP, *supra* note 7, at 25.
14. IPCC, Physical Science Basis, supra note 1, at 782–84.
15. *Id*. at 854–60.
16. USGCRP, *supra* note 7, at 33.
17. IPCC, Physical Science Basis, *supra* note 1, at 783.
18. USGCRP, *supra* note 7, at 32.
19. *Id*. at 34–36.
20. *Id*. at 38.
21. *E.g*., Seung-Ki Min et al., *Human Contribution to More-Intense Precipitation Extremes*, 470 Nature 378 (February 2011); Pardeep Pall et al., *Anthropogenic Greenhouse Gas Contribution to Flood Risk in England and Wales in Autumn 2000*, 470 Nature 382 (February 2011); Quirin Schiermeier, *Increased Flood Risk Linked to Global Warming*, 470 Nature 316 (February 2011). *See generally* Intergovernmental Panel on Climate Change, Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (November 2011).
22. IPCC, Physical Science Basis, *supra* note 1, at 783, 785–87; USGCRP, *supra* note 7, at 24–25. *See also* Kristie L. Ebi & Gerald A. Meehl, *The Heat Is On: Climate Change and Heatwaves in the Midwest, in* Kristie L. Ebi, et al., Pew Center on Global Climate Change, Regional Impacts of Climate Change 8 (2007).
23. National Research Council, Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia 181 (2010).
24. Intergovernmental Panel on Climate Change, Climate Change 2007: Impacts, Adaptation and Vulnerability 183 (2007) [hereinafter IPCC, Impacts].
25. *Id*. at 184.
26. USGCRP, *supra* note 7, at 41.
27. *Id*. at 41.
28. *Id*. at 46.
29. IPCC, Physical Science Basis, *supra* note 24, at 285.
30. *Id*. at 284.
31. *Id*. at 275.
32. *See also* Lester R. Brown, *The New Geopolitics of Food*, Foreign Pol'y, May/June 2011; Justin Gillis, *A Warming Planet Struggles to Feed Itself*, N.Y. Times, June 4, 2011.
33. USGCRP, *supra* note 7, at 71.
34. IPCC, Impacts, *supra* note 24, at 12.
35. USGCRP, *supra* note 7, at 89.
36. IPCC, Impacts, *supra* note 24, at 12.
37. Jeremy L. Weiss, Jonathan T. Overpeck & Ben Strauss, *Implications of Recent Sea Level Rise Science for Low-Elevation Areas in Coastal Cities of the Conterminous U.S.A*., 105 Climatic Change 635 (2011).
38. IPCC, Impacts, supra note 24, at 370–71.
39. USGCRP, *supra* note 7, at 61.
40. IPCC, Impacts, *supra* note 24, at 11.
41. USGCRP, *supra* note 7, at 79.
42. Sandia National Laboratories, Assessing the Near-Term Risk of Climate Uncertainty: Interdependencies among the U.S. States 15–16 (May 2010).

43. United Nations & World Bank, Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention 20 (2010).

44. Ian Burton, *The Growth of Adaptation Capacity: Practice and Policy, in* Adapting to Climate Change: An International Perspective 55 (Joel B. Smith et al. eds., 1996).

45. Alejandro E. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure*, 59 Emory L.J. 1, 17–25 (2009).

46. Consolidated Appropriations Act, Pub. L. No. 110-161 § 114(a), 121 Stat. 1844, 1897 (2007).

47. National Research Council, Adapting to the Impacts of Climate Change 21–22 (2010 prepublication copy).

48. National Research Council, America's Climate Choices 29–37 (2011).

49. IPCC, Physical Science Basis, *supra* note 1, at 2–3.

50. *See* Kyle W. Danish, *The International Regime, in* Global Climate Change and U.S. Law 31 (Michael B. Gerrard ed., 2007).

51. *See* Columbia Center for Climate Change Law, Climate Regulation Tracking Service, http://www.law.columbia.edu/centers/climatechange/resources/epa.

52. Environmental law may also interfere with mitigation efforts, as when it impedes the construction of renewable energy facilities such as wind and solar facilities.

53. Jan McDonald, *Mapping the Legal Landscape of Climate Change Adaptation, in* Tim Bonyhady, Andrew Macintosh & Jan McDonald, Adaptation to Climate Change: Law and Policy 1, 36 (2010) (emphasis in original).

54. Robin Kundis Craig, *"Stationarity Is Dead"—Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 Harv. Envtl. L. Rev. 9, 39 (2010).

55. United Nations Framework Convention on Climate Change art. 4 § 1(e).

56. World Bank, Economics of Adaptation to Climate Change: Synthesis Report (2010), p. xix.

57. *Id*. at xx.