Chapter 3
RESPONDING TO CLIMATE CHANGE: ADAPTATION

SYNOPSIS

I. INTRODUCTION

Adaptation strategies — i.e., those strategies meant to alleviate the impacts of climate change (as opposed to mitigation strategies meant to avoid climate change) — are becoming increasingly important as it becomes clear that at least some major impacts from climate change are inevitable. Examples of adaptation measures run the range from building higher levees, to making evacuation and disaster relief plans, to the relocation of coastal and island communities. Adaptation measures can involve local, national, or international efforts and can include changes in behavior, infrastructure, governance, technology, management, and a wide range of policies. While adaptation is not designed to solve the problem of climate change, it is crucial for reducing the socio-economic damage caused by climate change.

The increasing focus on adaptation is largely a response to the recognition that many climate impacts are virtually certain at this point and that taking proactive adaptive steps can significantly reduce human suffering and economic losses. As the Intergovernmental Panel on Climate Change (IPCC) points out in its 2007 Report, "even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades, making adaptation unavoidable." IPCC, WORKING GROUP II, CLIMATE CHANGE IMPACTS, ADAPTATION AND VULNERABILITY 747 (Fourth Assessment Report, 2007) [hereinafter IPCC 2007: ADAPTATION AND VULNERABILITY]. Indeed, where the need for adaptation was formerly viewed as decades away, recognition of current climate impacts such as melting glaciers and sea ice, more intense storm events, and deeper droughts in many arid regions has brought the timeframe for discussing adaptation forward.

Approaches to adaptation can vary greatly across sectors, across climate impacts, and across geographic scales. Regardless of this variability, adaptation is mostly about integrating projections of climate impacts into the development planning of a specific country, region, or city. Thus, the general approach for developing adaptation policies in most cases requires similar basic steps: (1) identifying significant climate impacts in the specific region (i.e., hurricanes, droughts, etc.), (2) identifying the region's major vulnerabilities to those impacts (e.g., infrastructure, housing, economic base), (3) developing a plan to address those vulnerabilities, and (4) implementing the plan. Such planning puts a premium on information about climate impacts at the particular level of interest. Global climate models are thus less useful than models that can predict the particular impacts in the given country, region or city. Predicting climate impacts at the sub-global level, however, is difficult, expensive, and fraught with uncertainty.

Focusing on adaptation is also not without controversy. Many observers fear that money and attention spent on adaptation will detract from efforts to mitigate (i.e., prevent) climate change in the first place. If priorities have to be set, critics argue, they should be set on preventing the cause of the injury — not on bandages to reduce the impact. Moreover, a focus on adaptation could implicitly signal that we cannot avoid climate change, thus potentially weakening resolve to reduce net greenhouse gas emissions. Internationally, the United States and other industrialized countries are reluctant to embrace adaptation measures in developing countries because they will be expected to pick up the costs. Thus, to some extent the international dialogue over adaptation is really a dialogue over how much financial responsibility industrialized countries are willing to accept for the impacts expected from climate change. Complicating the discussion further is that developing countries do not want funding for adaptation to replace other forms of development assistance.

QUESTIONS AND DISCUSSION

1. The U.S. Government and Natural Research Council have provided the following definitions of adaptation and associated terms of resilience, vulnerability and mitigation:

> **Adaptation:** Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.
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> **Adaptive Capacity:** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
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> **Resilience:** A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.
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> **Risk:** A combination of the magnitude of the potential consequence(s) of climate change impact(s) and the likelihood that the consequence(s) will occur.

> **Vulnerability:** The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.
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> **Mitigation:** An intervention to reduce the causes of changes in climate, such as through reducing emissions of greenhouse gases to the atmosphere.

NATIONAL RESEARCH COUNCIL, ADAPTING TO THE IMPACTS OF CLIMATE CHANGE, AMERICA'S CLIMATE CHOICES: PANEL ON ADAPTING TO THE IMPACTS OF CLIMATE CHANGE, Table 1.1 (2010); *see also* PROGRESS REPORT OF THE INTERAGENCY CLIMATE CHANGE ADAPTATION TASK FORCE: RECOMMENDED ACTIONS IN SUPPORT OF A NATIONAL CLIMATE CHANGE ADAPTATION STRATEGY 15 (2010). Can you see why some adaptation strategies are aimed at increasing resilience and reducing vulnerability? Do you think there will always be a clear distinction between adaptation and mitigation measures?

2. ***Adaptive Capacity.*** Adaptive capacity is the ability or potential of a system to adjust behavior and resources to respond to change. Unfortunately, the capacity to adapt to climate change is unequal across and within societies. Generally speaking, developing countries have fewer resources to respond to immediate threats and adapt for potential future impacts, but adaptive capacity can also vary within developed countries. Consider, for example, the relative capacities of Louisiana and New Jersey to respond to Hurricanes Katrina and Sandy, respectively. As the following excerpt from the IPCC explains, adaptive capacity is influenced by social factors like human capital, community networks, and governance structure, perhaps as much as by the level of economic development or access to technology:

> [A]daptive capacity is influenced not only by economic development and technology, but also by social factors such as human capital and governance structures. Furthermore, recent analysis argues that adaptive capacity is not a concern unique to regions with low levels of economic activity. Although economic development may provide greater access to technology and resources to invest in adaptation, high income per capita is considered neither a necessary nor a sufficient indicator of the capacity to adapt to climate change. Some elements of adaptive capacity are not substitutable: an economy will be as vulnerable as the 'weakest link' in its resources and adaptive capacity. . . . Within both developed and developing countries, some regions, localities, or social groups have a lower adaptive capacity. There are many examples where social capital, social networks, values, perceptions, customs, traditions and levels of cognition affect the capability of communities to adapt to risks related to climate change. Communities in Samoa in the south Pacific, for example, rely on informal non-monetary arrangements and social networks to cope with storm damage, along with livelihood diversification and financial remittances through extended family networks. Similarly, strong local and international support networks enable

> communities in the Cayman Islands to recover from and prepare for tropical storms. Community organization is an important factor in adaptive strategies to build resilience among hillside communities in Bolivia. Recovery from hazards in Cuba is helped by a sense of communal responsibility. Food-sharing expectations and networks in Nunavut, Canada, allow community members access to so-called country food at times when conditions make it unavailable to some. The role of food sharing as a part of a community's capacity to adapt to risks in resource provisioning is also evident among native Alaskans.

IPCC 2007: ADAPTATION AND VULNERABILITY, at 728. What challenges do variations in adaptive capacity present? How should the international community respond to these differences? How should the U.S. federal government respond to differences in adaptive capacity among communities within the United States?

3. Concerns that adaptation would be considered an *alternative* to mitigation are not completely unfounded. Most observers understand adaptation as a second-best response to climate change, necessary to reduce human suffering as much as possible while we find ways to reduce long-term climate change. Some commentators, however, promote adaptation as an alternative to mitigation, arguing that the costs of adaptation are lower than mitigation and that the costs of mitigation would unduly slow the growth in our economy. Better, they say, to allow the economy to create a wealthier world better able to afford adaptation. How would you respond to these arguments, particularly in light of the discussion of cost-benefit analysis in Chapter 2?

4. The National Research Council suggested the following criteria for evaluating proposed adaptation measures:

1. In making adaptation decisions, focus not only on optimizing conditions for the current generation, but also look several generations ahead and consider ways to reduce risk over time.
2. Account for the impacts of adaptation decisions on natural and social systems as well as on individuals, firms, government institutions, and infrastructure.
3. Recognize that ecosystem structure and functioning are particularly vulnerable to climate change and need consideration in adaptation decisions.
4. Evaluate solutions from a perspective of sustainability so that social, economic, and environmental ramifications of proposed strategies and actions are explicitly recognized.
5. Acknowledge equity and justice in adaptation decisions; there is a need to prioritize helping those with a higher degree of vulnerability to become more resilient.
6. There is a need to identify the potential impacts of proposed adaptation options on all affected parties.
7. Develop a portfolio approach for addressing adaptation problems, including a suite of technology and social-behavioral-economic options.
8. Develop methods of evaluation so that the risk of inactions can be compared with the risk of proposed actions.

9. Recognize the 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.

NATIONAL RESEARCH COUNCIL, ADAPTING TO THE IMPACTS FROM CLIMATE CHANGE 23-24 (National Academies Press, 2010). Consider these criteria as you think about the wide range of potential adaptation strategies identified below. Do these criteria apply equally well outside of the U.S. context? Would you recommend other criteria?

II. ADAPTATION STRATEGIES

In many respects, adaptation to climate change is nothing new. Humans have been adapting to weather events and climate variability since the beginning of time. For example, people have historically adapted to weather variations by crop diversification, climate forecasting, famine early warning systems, and increasing water storage capacity. We also frequently take adaptation measures in response to specific catastrophic events, like hurricanes, floods, or heat waves. Evacuations in anticipation of such events or humanitarian relief in their aftermath are familiar forms of adaptive responses.

What is unique about adaptation in the context of climate change is the need to plan for long-term adaptive measures not to address weather variability but in response to a world in which climate generally is more unpredictable — a world in which future rainfall, temperature, sea levels, river flows, growing seasons, and snowfall (to name just a few) may be radically different. In such a context, anticipating possible risks and managing them becomes both more complicated and more urgent.

Virtually every economic sector will need to integrate climate change into longer-term planning to manage potential risk. Agriculturalists, for example, will need to select new crops or planting methods. Construction companies may need to consider stronger building materials to resist more intense storms. Companies using or storing hazardous substances may have to relocate further inland to avoid flood-related contamination like that seen in Hurricanes Katrina and Sandy. Health care professionals may need to prepare for new diseases brought by warmer temperatures. Adaptation strategies thus cover a wide range of possible policies and actions — from individual farming decisions about where or what to plant to collective decisions about whether to build a retaining sea wall. The diversity of potential adaptation measures can be seen in Table 3-1, adapted from the IPCC 2007: ADAPTATION AND VULNERABILITY, at 722.

Table 3-1: Possible Adaptation Practices for Responding to Climate Change Impacts

Country	**Climate-related stress**	**Adaptation Practices**
Egypt	Sea-level rise	Adoption of law regulating setback distances for coastal infrastructure; installation of hard structures in areas vulnerable to coastal erosion.

Sudan	Drought	Expanded use of rainwater harvesting and water conserving techniques; building of wind-breaks to improve resilience of rangelands; monitoring the number of grazing animals and cut trees; establishment of revolving credit funds.
Botswana	Drought	National government programmes to re-create employment options after drought; capacity building of local authorities; assistance to small subsistence farmers to increase crop production.
Bangladesh	Sea-level rise; salt-water intrusion	Consideration of climate change in the National Water Management Plan; building of flow regulators in coastal embankments; use of alternative crops and low-technology water filters.
Philippines	Drought; floods	Shift to drought-resistant crops; rotation method of irrigation during water shortage; construction of water impounding basins; construction of fire lines and controlled burning; adoption of soil and water conservation measures for upland farming.
Philippines	Sea-level rise; storm surges	Capacity building for shoreline defense system design; provision of grants to strengthen coastal resilience and rehabilitation of infrastructures; construction of cyclone-resistant housing; review of building codes; reforestation of mangroves.
Canada	Permafrost melt; change in ice cover	Changes in livelihood practices by the Inuit, including: change of hunt locations; diversification of hunted species; and encouragement of food sharing.
Canada	Extreme temperatures	Implementation of heat health alert plans and a heat-related hotline in Toronto; availability of an emergency medical service vehicle with specially trained staff and medical equipment.
United States	Sea-level rise	Land acquisition programmes taking account of climate change; establishment of a "rolling easement" in Texas, an entitlement to public ownership of property that 'rolls' inland with the coastline as sea-level rises; other coastal policies that encourage coastal landowners to act in ways that anticipate sea-level rise.
Mexico and Argentina	Drought	Adjustment of planting dates and crop variety (e.g., inclusion of drought-resistant plants such as agave and aloe); accumulation of commodity stocks as economic reserve; spatially separated plots for cropping and grazing to diversify exposures; diversification of income by adding livestock operations; provision of crop insurance; creation of local financial pools (as alternative to commercial crop insurance).
The Netherlands	Sea-level rise	Adoption of Flooding Defense Act and Coastal Defense Policy as precautionary approaches to climate change; building of a storm surge barrier assuming a 50 cm sea-level rise; use of sand supplements and reinforcement of dunces in coastal areas; improved management of water levels through dredging, widening river banks, and expanding side channels and wetland areas; conduct regular 5-year reviews of safety of all flood protection infrastructure (dykes, etc.).
Austria, France, Switzerland	Snow line shift; glacier melt	Artificial snow-making; grooming of ski slopes; moving ski areas to higher altitudes and glaciers; use of white plastic sheets as protection against glacier melt.
Switzerland	Perma-frost melt; debit flows	Erection of protection dams in Pontresina (Switzerland) against avalanches and increased magnitude of potential debris flows stemming from permafrost thawing.

United Kingdom	Floods; sea-level rise	Coastal realignment under the Essex Wildlife Trust, converting arable farmland into salt marsh and grassland to provide sustainable sea defenses; maintenance and operation of the Thames Barrier to address flooding.

Several general categories of adaptation strategies are discussed further below.

A. Adaptive Management

In recent years, the concept of adaptive management has become a centerpiece of many new natural resource and land management practices. Adaptive management is based loosely on the idea of "learning by doing," where policymakers are constantly evaluating and presumably improving their management approaches as more information and experience become available. Climate change lends new weight to the approach because managers must learn to make decisions in the face of large amounts of uncertainty and constantly changing circumstances. More flexible approaches can arguably allow for managers to adapt to changing conditions as more information becomes available about, for example, the extent and nature of climate change impacts. *See generally* Robert L. Fischman & Jillian R. Rountree, *Adaptive Management* in MICHAEL GERRARD & KATRINA FISCHER KUH, EDS, THE LAW OF ADAPTATION TO CLIMATE CHANGE (2012); Alejandro Camacho, *Adapting Governance to Climate Change: Managing Uncertainty through a Learning Infrastructure,* 59 EMORY L. J. 1 (2009).

Adaptive management is not without its challenges. Effective implementation of an adaptive approach is difficult, requiring sufficient resources over a long period of time. It is also based on expanding the discretion given to managers. If untethered from clear legal principles or guidelines, "learning by doing" may simply be "trial by error." On the ground results may suffer. Moreover, the information requirements for adaptive management in the face of climate change are daunting and may require laws that emphasize data gathering and organize that data for flexible decisionmaking. For a description of the gap between adaptive management in theory and practice, see J.B. Ruhl & Robert L. Fischman, *Adaptive Management in the Courts,* 95 MINN. L. REV. 424 (2010).

B. Adaptive Infrastructure

Significant climate change impacts may seem to occur only in the long term (e.g., in 25–100 years), but this is well within the expected life of most infrastructure projects. Bridges, dams, dikes, even houses, have a life-expectancy of greater than 100 years. Integrating climate uncertainty into the planning and building of infrastructure is critical for long-term adaptation efforts. Think, for example, about decisions to locate major chemical facilities near a vulnerable coastline, to rebuild a coastal community after a storm, or to design a new bridge or sea wall. To what extent should we take climate change into account in making these decisions today? Consider these questions in light of the examples of adaptive infrastructure designs provided by the IPCC below:

IPCC 2007: ADAPTATION AND VULNERABILITY

at 724

Early examples where climate change scenarios have already been incorporated in infrastructure design include the Confederation Bridge in Canada and the Deer Island sewage treatment plant in Boston harbour in the United States. The Confederation Bridge is a 13 km bridge between Prince Edward Island and the mainland. The bridge provides a navigation channel for ocean-going vessels with vertical clearance of about 50 m. Sea-level rise was recognized as a principal concern during the design process and the bridge was built one metre higher than currently required to accommodate sea-level rise over its hundred-year lifespan. In the case of the Deer Island sewage facility, the design called for raw sewage collected from communities onshore to be pumped under Boston harbour and then up to the treatment plant on Deer Island. After waste treatment, the effluent would be discharged into the harbour through a downhill pipe. Design engineers were concerned that sea-level rise would necessitate the construction of a protective wall around the plant, which would then require installation of expensive pumping equipment to transport the effluent over the wall. To avoid such a future cost the designers decided to keep the treatment plant at a higher elevation, and the facility was completed in 1998. Other examples where ongoing planning is considering scenarios of climate change in project design are the Konkan Railway in western India; a coastal highway in Micronesia; the Copenhagen Metro in Denmark; and the Thames Barrier in the United Kingdom.
* * *

In addition to specific infrastructure projects, there are now also examples where climate change scenarios are being considered in more comprehensive risk management policies and plans. . . . In the Netherlands, for example, the Technical Advisory Committee on Water Defense recommended the design of new engineering works with a long lifetime, such as storm surge barriers and dams, to take a 50 cm sea-level rise into account. Climate change is explicitly taken into consideration in the National Water Management Plan (NWMP) of Bangladesh, which was set up to guide the implementation of the National Water Policy. It recognizes climate change as a determining factor for future water supply and demand, as well as coastal erosion due to sea level rise and increased tidal range.

The challenges for planning and developing adaptive infrastructure, even in a wealthy and technologically advanced country such as the United States can be seen in the following excerpt regarding transportation infrastructure:

NATIONAL RESEARCH COUNCIL, ADAPTING TO IMPACTS FROM CLIMATE CHANGE

71–72 (2012)

Substantial engineering options are already available for strengthening and protecting transportation facilities such as bridges, ports, roads, and railroads from coastal storms and flooding to achieve short-term and long-term adaptation. Infrastructure can be elevated, built

stronger, protected by levees or dikes, and/or moved. For example, several of the major Gulf Coast highway bridges destroyed by storm surges during Hurricane Katrina have been redesigned and replaced by new bridges elevated well above anticipated future storm surges. Because most transportation systems are designed to last for decades, it is important for transportation planners to incorporate climate change in the planning and design cycle for such infrastructure. Indeed, the Federal Highway Administration already encourages and funds the inclusion of climate change in metropolitan planning activities.

The general research approach for adapting to climate change is well established, although effective adaptation will require continued research and application. For example, there is a history of research on developing paving and other materials that are more heat resistant and on construction practices that protect permafrost. Research on climate or weather impacts on various modes of transportation has focused on extreme events (e.g., fog impacts on aviation and ice impacts on highways) and much of this research may be applicable to longer-term climate change issues.

Water-based transportation (e.g., Great Lakes Canal System and Mississippi, Ohio, Colombia, and Yukon rivers) may be constrained in some regions where runoff from the watershed declines and/or water demands for agriculture and cities increase. Adaptation may require redesign of ships and barges, a shortened shipping season, or a shift to alternate modes of transportation. Conversely, more extreme inland storms may well result in greater flood frequencies and levels. Revision of Federal Emergency Management Agency (FEMA) flood maps to reflect the probabilities of greater storm and flood events is critical to the construction of resilient structures along these inland waterways. Retreat of Arctic sea ice will likely open a new transportation corridor between the Atlantic and Pacific oceans. This may require new ship designs to deal with seasonal sea ice, development of new harbors, and development of new technology to handle fuel spills in water with sea ice. * * *

The nation currently has no experience in planning for or deciding when or how to abandon exposed coastal areas or communities that can no longer be adequately protected from rising sea level and greater storm surge. In vulnerable coastal areas, transportation systems and the people they serve will be placed at risk, and the social and political dimensions of relocation will provide a major research and policy challenge in adapting to future climate change.

C. Response to Sea-Level Rise: Defend or Retreat

One of the most vexing and important adaptation questions is how coastal communities should respond to the potential for sea-level rise. In a nutshell, coastal communities have two choices against rising sea levels and higher storm surges: (1) armor the coasts with dikes, concrete, and steel bulworks or (2) retreat strategically over time by moving costly and sensitive infrastructure inland. Choosing between these two strategies is made more difficult because of the wide range of sea-level scenarios that are part of the climate debate. The IPCC's 2007 Fourth Assessment projects a relatively modest sea level rise of less than a meter by the end of the century, which makes a "defense" strategy more defensible. More recent estimates, however, put

sea level rise over 2 meters even without the loss of one or more of the planet's great ice sheets, which makes "retreat" the only plausible scenario. Of course, one strategy will not fit all of the world's coastal areas, but throughout the world, communities are starting to make their decisions.

> Hard engineering — involving the construction of groynes, seawalls, breakwaters, and bulkheads — has long been the traditional response to coastal erosion and flooding in many small island states. Unfortunately, this approach has not always been efficiently implemented and has even helped to increase coastal vulnerability in some cases. In these specific circumstances, the term "maladaptation" (which refers to a response that does not succeed in reducing vulnerability but increases it instead . . . may be applied. Realistically, however, for some islands the application of hard solutions may be the only practical option along well-developed coasts, where vital infrastructure is at immediate risk.
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> There are other potential options available to small island states, including enhancement and preservation of natural protection (e.g., replanting of mangroves and protection of coral reefs), use of softer options such as artificial nourishment, and raising the height of the ground of coastal villages. Raising the height of the ground requires additional aggregate such as sand and stone and a lot of pumping, in which many small islands are seriously deficient. Removal of materials from "unimportant" islands to build up important islands via sand transfer by pipes and barges has been suggested by the IPCC. Some island states may be faced with few practical options. Thus, it might be necessary for them to lose some islands so that the entire nation is not completely inundated.
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> Similarly, beach nourishment may not be a practical or economical option for many island nations because sand often is a scarce resource. Moreover, beach nourishment requires maintenance in the form of periodic sand replenishment, sometimes every 5–10 years or less. Such a requirement could prove to be unsustainable in small economies. In contrast, on some islands such as Singapore, where the technology and resources are more readily available, beach fill projects (used in combination with offshore breakwaters to form artificial headlands) is a feasible option. As a general strategy to respond to sea-level rise, it is likely that Singapore will focus on three main types of responses: coastal protection for developed or heavily populated areas and reclaimed land, anti-salt-intrusion measures for coastal reservoirs, and flood prevention measures (such as tidal gates) for major canals.
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> In some islands, such as those in the Caribbean, more emphasis is being placed on the application of "precautionary" approaches, such as enforcement of building set-backs, land-use regulations, building codes, and insurance coverage. In addition, application of traditional, appropriate responses (e.g., building on stilts and use of expendable, readily available indigenous building materials), which have proven to be effective responses in many islands in the past, ought to be more widely considered. * * *

> Enhancing the resilience of coastal systems has been suggested as an appropriate proactive adaptive response to reduce vulnerability. [T]his could be a more cost-effective way to prepare for uncertain changes such as sea-level rise, rather than relying entirely on building traditional, more costly coastal defenses. . . . One of the ways in which a dynamic and resilient coast can be created is by managed retreat, based on an enforced building set-back that allows the coastline to recede to a new line of defense, thus restoring natural coastal processes and systems. An orderly plan to retreat could be a feasible option on larger islands that cannot commit the resources necessary to prevent coastal land loss in the face of rising sea levels.

IPCC, WORKING GROUP II, IMPACTS, ADAPTATION AND VULNERABILITY, § 17.2.3.1 (Third Assessment Report, 2001). Small island States are not the only ones facing difficult decisions of how to plan for coastal development in the future. All coastal communities around the world are being forced to adapt to eroding beaches and higher sea levels. Consider the challenges facing relatively wealthy resort communities in the United States. The following excerpt was written nearly 30 years ago but it still provides an interesting perspective on the challenges facing coastal communities, such as those in New York and New Jersey devastated by Hurricane Sandy. Should they rebuild, defend, or retreat? Who should pay for adaptation?

JAMES G. TITUS, PLANNING FOR SEA LEVEL RISE BEFORE AND AFTER A COASTAL DISASTER

in MICHAEL G. BARTH & JAMES G. TITUS, GREENHOUSE EFFECT AND SEA LEVEL RISE: A CHALLENGE FOR THIS GENERATION (1984)

The most important issue for resort communities to resolve will be whether to hold back the sea or retreat landward. The previous section assumed that the major impact of sea level rise on a homeowner's post-disaster decisions will be property losses from increased storm damage and erosion. However, public officials must also consider the impact of rebuilding oceanfront houses on the recreational use of the beach. The fact that a property owner might choose to rebuild his house in spite of projected erosion does not necessarily imply that the community's interest would be served by allowing the owner to do so. * * *

Defending the Shoreline

The most commonly used measures to curtail erosion have been groins and beach nourishment. By groins, we mean long, thin structures perpendicular to the shore that collect sand moving downshore, including jetties on the updrift side of inlets. By beach nourishment, we mean dredging sand from a channel or offshore and pumping it onto the beach.

Groins cannot prevent erosion caused by sea level rise, but they can move the problem downshore. A jetty at the south end of Ocean City, Maryland (acting as a long groin) has collected enough sediment to allow the shore to advance hundreds of feet, while to the south,

Assateague Island National Seashore is eroding rapidly. As sea level rises, communities may use increasingly sophisticated methods to trap sand as it moves along the shore, in spite of the problems these measures may cause their neighbors. In contrast, beach nourishment does not adversely affect neighboring areas, although it may be more expensive than groins.

[B]eaches follow characteristic profiles. A 1 ft rise in sea level would eventually require raising the entire beach profile 1 ft. A profile that extended out to sea 0.5 mi would ultimately require 500,000 yd^3 of sand for every mile of beach. Estimates . . . suggest that this would cost $2–5 million. In many resorts, the value of the property that would be protected could justify this level of expenditure. However, sand pumping costs could vary considerably. Profiles extend to sea by very different amounts. For example, the profile of San Francisco may extend out several times farther than most profiles . . . implying that protection costs would be several times greater. The availability of sand also varies considerably. Finally, the costs of beach nourishment may escalate as inexpensive supplies are exhausted. In spite of these uncertainties, such extremely valuable real estate as Miami Beach and Atlantic City could probably justify the costs in any event.

Communities that could not afford to raise their entire beach profiles might still use beach nourishment as a temporary measure until depreciation of oceanfront development or a storm makes retreat economical. * * *

Planning a Retreat

Communities that decide to migrate landward could combine engineering and planning measures. One possible engineering response for barrier islands would be to preserve their total acreage by pumping sand to their bayside, imitating the natural overwash process. This option might require bayfront property owners to be compensated for their loss of access to the water. Furthermore, care would have to be taken to ensure that marine life was not irreparably damaged. But because less sand would be necessary, such a program would be less expensive than pumping sand to the Oceanside. In the long run, it would probably be less environmentally disruptive than any of the alternatives, particularly if mainland marshes are also allowed to migrate landward.

Planning measures will be important. North Carolina already requires most new home construction to be set back from the shore a distance equal to 30 years of erosion. For existing construction, communities could implement strong post-disaster plans. Humphries et al. (1983) recommend that Ocean City, Maryland impose a temporary building moratorium after a major storm to give authorities time to decide which redevelopment is appropriate. However, the need to repair damages quickly may inhibit the careful debate necessary to adequately consider sea-level rise.

Although many post-disaster development decisions cannot be made until local officials assess the damages, the general principles of redevelopment should probably be decided in advance of a storm. An assemblyman once introduced a bill to the New Jersey legislature that would have forbidden people to rebuild oceanfront houses that were more than 50 percent

destroyed by a storm. That bill was extremely unpopular, in part because it made no provision to compensate property owners. Our analysis of individual decisions suggests that if sea level rise is anticipated, many property owners who are offered some compensation will be willing to sell their land and write off their partly damaged houses; some might even do so without compensation.

In some instances, public officials might have to resort to eminent domain to purchase oceanfront property. Partly because of flood mitigation programs that require houses to be built on pilings sunk far into the ground, erosion from sea level rise will not always destroy the oceanfront houses now being built. Instead, some houses will continue to stand on the beach and perhaps even in the water. Although the owners of these houses might not want to move, the obstruction of the beach might be intolerable to the community and hence necessitate purchases under eminent domain.

QUESTIONS AND DISCUSSION

1. From the above, it should be clear that a wide range of options are available to communities for responding to sea level rise, but all of them raise significant challenges. If you were representing a poor, small island State, what options would you recommend to your government? How would the options differ if you represented a wealthy resort community in the United States?

2. Can you see how expectations about government behavior, particularly in the United States, will impact property values? What expectations are reasonable? Should the government be expected to protect property from rising sea levels? Who should pay for this? Could property owners in the United States who lose their property to a storm surge argue that the government's failure to protect them was a "takings" under the Fifth Amendment to the Constitution? How do you think the experience with Hurricanes Katrina and Sandy should change our approach to these questions?

3. The coast is a naturally dynamic place where "the sledgehammer seas and . . . the inscrutable tides of God" (HERMAN MELVILLE, MOBY DICK) constantly erode the coastline in some places and add sand and rock to other places. Rising sea levels will make the coasts an even more dynamic place. How do the processes of erosion and accretion affect a property owner's title to land? Although the rules may vary from state to state, generally speaking a property owner is divested of title to eroded land. She cannot bring a claim to recover land eroded by the ebb and flow of the tides. On the other hand, a property owner is entitled to all accretions. Thus, a waterfront owner may find that her property has been enlarged by dynamic ocean processes. What are the justifications for these traditional property law concepts? What are their implications in light of climate change?

4. The excerpts above describe the three general approaches to protecting beaches from erosion: (1) restoration through beach replenishment, (2) armoring through the construction of groins, seawalls, rip-rap, and other fixed structures intended to stabilize the shoreline, and (3)

retreat, through the establishment of setbacks. All three approaches raise legal questions that climate change and rising sea levels will bring into sharp focus. For example, if the groin built by Joe Beachcomber to protect his seafront property from erosion leads to the erosion of his neighbor's property, what legal remedies does the neighbor have? If Sandy Shore spends considerable resources to replenish her beach, but the sand erodes and drifts to the beach of Lucky George, who owns the sand? If a property owner buys a piece of coastal property, and the state later prevents construction seaward of a setback line, does the state's new setback law constitute a Fifth Amendment takings? Can a state prevent a property owner from armoring her property? *See* JOSEPH J. KALO, ET AL., COASTAL AND OCEAN LAW: CASES AND MATERIALS 275–87 (2d ed. 2002).

5. Adaptation efforts in a coastal area may also reflect broader coastal conservation or planning goals. EPA has identified the following major categories of management goals common to coastal programs:

- Maintain/restore wetlands
- Maintain sediment transport
- Preserve coastal land/development (including infrastructure)
- Maintain shorelines utilizing "soft" measures
- Maintain shorelines utilizing "hard" measures
- Invasive species management
- Preserve habitat for vulnerable species
- Maintain water quality
- Maintain water availability

US ENVTL. PROTECTION AGENCY, CLIMATE READY ESTUARIES PROGRAM, SYNTHESIS OF ADAPTATION OPTIONS FOR COASTAL AREAS, EPA 430-F-08-024, at 10 (Jan. 2009). Can you see how different management goals or priorities can significantly change the adaptation policy mix you may want to pursue? How would you take into account incidental environmental costs or benefits into adaptation planning?

D. Expanding Disaster Relief

Climate change is predicted to make many natural disasters, such as floods, droughts, and hurricanes, more frequent and intense. The result will be more people in need of humanitarian assistance to address shortages in food, water, and housing. Because of the uncertainty, speed, and severity of extreme weather events, relief networks often cannot be set up beforehand and, although resources may be available, the problem will be one of distribution.

Because climate change is expected to make large-scale disasters worse, disaster relief organizations expect that existing resources and distribution networks will be increasingly stressed and less effective. To some extent, the problem will be simply one of funding. More disasters will mean more demands on limited supplies of humanitarian relief. Although some types of disasters may become relatively more common with climate change, no meaningful

differentiation can currently be made about which disasters are caused by anthropogenic climate change and which would have occurred anyways with "natural" climate variability. Moreover, this question is only relevant if special funds are set aside for responding only to climate change-related disasters. What is known is that climate change requires an overall expansion of our humanitarian assistance programs, particularly for those types of events related to extreme weather. At least to some extent, better planning today can ensure more effective relief delivery tomorrow.

QUESTIONS AND DISCUSSION

1. Is there an international legal obligation to provide disaster relief? A moral obligation? How should the responsibility to provide disaster relief for climate impacts be allocated among nations? Would being able to attribute some disasters to man-made causes strengthen the obligation to provide disaster relief?

2. The debate over how to finance disaster relief is not only an international question. Within the United States, debate over the size of the federal government implicates the current and future ability of the Federal Emergency Management Agency (FEMA) and other federal agencies to respond to disasters. Do you think this is an appropriate role for the federal government, or should each state be primarily responsible for responding to disasters that affect it? Would the answer be any different for impacts that can be attributed to anthropogenic climate change?

3. A wide range of international and national organizations currently exists to support disaster relief. The UN Office for the Coordination of Humanitarian Affairs (OCHA) assembles and updates information on current disasters in order to help the international humanitarian community coordinate emergency assistance. *See* ReliefWeb (www.reliefweb.int). The recently launched Central Emergency Response Fund (CERF) provides urgent aid to regions in crisis within 72 hours of the emergency. Generally least-developed countries have been the recipients of these UN-governed funds. The CERF is funded by voluntary contributions from UN member States, private businesses, individuals, and foundations. The private sector organized the Disaster Resource Network (DRN) as part of the World Economic Forum to catalyze and coordinate private sector support for disaster management in developing countries. The DRN believes that the private sector must not only supply funds for relief organizations but must also proactively participate to prevent and mitigate effects of disasters by providing access to resources, knowledge, and assets. In the United States, organizations like the American Red Cross provide shelter, food, and health services to individuals and families affected by the disaster, as well as resources to help them get back to a more normal life after the emergency is over.

4. For discussions of the international legal framework for disaster preparedness in the context of climate change, see Lindsay F. Wiley, *Global Health and Disaster Preparedness*, in MICHAEL GERRARD & KATRINA FISCHER KUH, EDS, THE LAW OF ADAPTATION TO CLIMATE CHANGE (2012).

E. Adaptive Agriculture

All sectors that are dependent on the land or natural resources will be particularly affected by climate change. Not surprisingly, this means that agriculture will be faced with significant challenges in adapting to a more uncertain climate future. Consider that most agricultural expertise in most countries is the product of centuries, if not longer, of cumulative trial and error passed down from generation to generation. This traditional and localized knowledge has been based on a certain set assumptions about the climate of particular regions based on past experience — yet those very assumptions now may be changing.

As suggested by the following excerpt, many adaptive techniques exist for agriculture, including planting earlier in the year, adopting a different crop rotation, and selecting different varieties of crops. For example, different rice varieties have different abilities to tolerate high temperature, salinity, drought, and floods.

INTERDEPARTMENTAL WORKING GROUP ON CLIMATE CHANGE, FOOD & AGRIC. ORG. OF THE U.N., ADAPTATION TO CLIMATE CHANGE IN AGRICULTURE, FORESTRY AND FISHERIES: PERSPECTIVE, FRAMEWORK AND PRIORITIES

6–7 (2007) [Hereinafter FAO Adaptation Report]

Two main types of adaptation are autonomous and planned adaptation. Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that s/he changes crops or uses different harvest and planting/sowing dates. Planned adaptation measures are conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, deliberate crops selection and distribution strategies across different agri-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity.

Farm level analyses have shown that large reductions in adverse impacts from climate change are possible when adaptation is fully implemented. Short-term adjustments are seen as autonomous in the sense that no other sectors (e.g., policy, research etc.) are needed in their development and implementation.

Long-term adaptations are major structural changes to overcome adversity such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques. … [T]he following "major classes of adaptation" [have been defined]:

- seasonal changes and sowing dates;
- different variety or species;
- water supply and irrigation system;
- other inputs (fertilizer, tillage methods, grain drying, other field operations);

- new crop varieties;
- forest fire management, promotion of agroforestry, adaptive management with suitable species and silvicultural practices.

Accordingly, types of responses include:

- reduction of food security risk;
- identifying present vulnerabilities;
- adjusting agricultural research priorities;
- protecting genetic resources and intellectual property rights;
- strengthening agricultural extension and communication systems;
- adjustment in commodity and trade policy;
- increased training and education;
- identification and promotion of (micro-) climatic benefits and environmental services of trees and forests.

With changes in precipitation and hydrology, temperature, length of growing season and frequency of extreme weather events, considerable efforts would be required to prepare developing countries to deal with climate-related impacts in agriculture. Among the key challenges will be to assist countries that are constrained by limited economic resources and infrastructure, low levels of technology, poor access to information and knowledge, inefficient institutions, and limited empowerment and access to resources. * * *

Climate change and variability are among the most important challenges facing Least Developed Countries because of their strong economic reliance on natural resources and rain-fed agriculture. People living in marginal areas such as drylands or mountains face additional challenges with limited management options to reduce impacts. Climate adaptation strategies should reflect such circumstances in terms of the speed of the response and the choice of options.

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As the above excerpt suggests, the problem is not that adaptive technologies do not exist. The challenge is recognizing the need for adaptive steps before we have suffered through significant years of declining harvests. Long-term changes in agricultural practices may also be beyond the reach of those countries most in need of them, requiring resources and governance structures that are simply not in place in many developing countries.

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F. Adaptive Water Management

Closely related to agricultural management will be challenges to managing water resources. As with many impacts, climate change is a threat intensifier with respect to water availability. Generally speaking, climate change is expected to make flooding and droughts worse. This also suggests that general approaches to water management in an era of climate change may become more urgent, but may not be qualitatively that different from what is generally the case for areas prone to flood or drought.

In general, water management approaches are divided into "demand-side" and "supply-side" approaches. Supply-side approaches are those that find ways to make more water available at the times and locations where it is needed. Dams are an obvious example as are increased use of groundwater, expanded desalinization of seawater, water transfers, rain water collection, and improved riparian zone management. On the demand-side, examples include enhancing water conservation through improved water use efficiency, metering and higher user fees, and reducing demand by improving agricultural or industrial practices. Climate change will build economic and political pressure for more intensive water management efforts, which will likely increase calls for more water storage and flood control (e.g., through dams) and greater supply through desalination and groundwater mining. The environmental costs of these options are often significant.

As is obvious from reviewing these adaptation options, conflicts over water uses are likely to increase over time. Increased dams, reservoirs, irrigation works, or desalination plants will all come with an environmental price, and over-allocated rivers in current dry areas will face greater stress. In-stream uses for ecological purposes are likely to suffer. Climate-related stress on water systems will also make it more difficult to realize the newly recognized right to water in UN General Assembly Resolution 64/292, to ensure that all humans have access to sanitation and fresh drinking water.

QUESTIONS AND DISCUSSION

1. The links between climate, water shortage and agricultural production are clear. As the FAO put it,

> The inter-annual storage of excess rainfall and the use of resource efficient irrigation remain the only guaranteed means of maintaining cropping intensities. Beyond the direct agricultural interventions, water resource management responses for river basins and aquifers, which are often transboundary, will be forced to become more agile and adaptive (including near real-time management), as variability in river flows and aquifer recharge becomes apparent. Competing sectoral demands for water will place more pressure on allocations to agriculture to account for its dominant use of raw water. Additionally there may be increased water demand for irrigated systems.

FAO ADAPTATION REPORT, at 12.

2. Professor Robin Kundis Craig suggests that climate change will so stress water scarcity in parts of the United States that the federal role in water quantity issues should be expanded. Water use and management is largely a matter of state law, reflecting the generally local conditions that affect the availability of water. Federal law currently intervenes primarily when federal dollars have paid for dams or other infrastructure. With the national or global nature of climate change, there could be a greater role for federal law in the future. See Robin Kundis Craig, *Adapting*

Water Federalism to Climate Change Impacts: Energy Policy, Food Security, and the Allocation of Water Resources, 5 ENVTL & ENERGY L. & POL'Y J.183 (2010). As part of this expanded federal role, adaptation in the water supply context could be treated as a matter of emergency planning, which according to Professor Craig could, among other things, allow planners to invoke the public necessity doctrine and restructure private water rights to allow for more integrated and effective water management. See Robin Kundis Craig, *Adapting Water Law to Public Necessity: Reframing Climate Change Adaptation as Emergency Response and Preparedness,* 11 VERMONT J. ENVTL L. 709 (2010). Do you think a greater federal role in water management is warranted? What arguments would you anticipate emerging against Professor Craig's proposal?

G. Relocation of Climate Refugees

As noted in Chapter 1, sea-level rise and other impacts may force a growing number of people permanently from their homes. Some put the estimates as high as 150 million "environmental" refugees by 2050, most of which would be displaced by conditions exacerbated or caused by climate change. In 2005, the 100 people in the village of Lateu on Vanuatu became some of the first people forced to evacuate because of climate change. Although storm surges had occasionally swept over the village in the past, such storm surges became more frequent and intense, presumably because of global warming. The villagers of Lateu moved inland to higher ground on Vanuatu, with financial and technical support from the United Nations Environmental Programme (UNEP) and the Canadian Government. Such international cooperation is likely to become increasingly necessary in the future. Nor are climate refugees just an issue for distant small island States; several Alaskan villages have already begun significant efforts to relocate.

Relocating a community is a difficult and complex task. Besides the enormous costs of moving the population, critical "social capital" is also lost through the loss of traditional care-giving networks, access to employment or consumers, or other social and economic relationships. In fact, it is not certain whether communities can be successfully relocated, even when more resources are made available. Consider the following discussion about relocating Alaskan Eskimo villages.

> Alaskan coastal and river communities have always experienced erosion and flooding, but climate change and infrastructure development have exacerbated these risks. Climate-induced changes already observed include (1) increased storm activity; (2) reduced sea ice extent, which increases the intensity of storm surges; (3) increased windiness; and (4) thawing of permafrost, which increases coastal susceptibility to erosion. Because of these increased risks, six Alaskan communities are in various stages of planning some type of relocation. * * * The U.S. Army Corps of Engineers has identified 160 additional villages in rural Alaska that are threatened by climate-related erosion, with relocation costs estimated at $30 to $50 million per village.
>
> In September 2007, the Governor of Alaska established an Alaska Climate

Change Sub-Cabinet to prepare and implement an Alaska Climate Change Strategy to address issues of adaptation and risk. The Immediate Action Workgroup (IAW) sketched out an emergency suite of projects that could be completed within 12 to 18 months to protect life and safety in the six communities requiring immediate relocation. The IAW also identified the governance issues that needed to be resolved in order to fully implement a relocation strategy for communities at risk. The Alaska legislature appropriated $8.3 million and leveraged $31 million in federal funds in fiscal year 2009 to protect current infrastructure with revetments, but no funds had yet been appropriated to begin the relocation process.

Barriers to relocation include disagreement within some villages about desirable solutions and lack of clear authority and process among existing institutions and agencies to implement relocation once a relocation plan has been agreed to. For example, the Yup'ik Eskimo village of Newtok began working toward relocation in 1994 and obtained authorization from the U.S. Congress in 2003 for its preferred relocation site; however, a school, clinic, and airports cannot be built at the new location because the current population (zero) at the proposed site is less than the minimum required by federal and state statutes to authorize the construction of these facilities. In 2009, the Alaska Department of Transportation built the first infrastructure (a barge landing) at the new village site. During this relocation planning effort, funds have *not* been allocated to repair schools, water and sewage facilities, fuel storage facility, barge landings, and other infrastructure damaged by repeated erosion and flooding because of anticipated abandonment of the current village sites. None of the approximately 25 state and federal agencies that have met bimonthly for a year to develop a relocation strategy has a mandate to assist in relocation. The complex regulations that guide the work of these agencies present barriers to their taking effective action in the relocation effort even though the actions required are well defined. Despite these barriers, the community remains unanimous in its determination to relocate rather than disperse to other communities, which would entail loss of cultural integrity of the community.

This experience in Alaska suggests that, even when adaptation is urgently required to protect life and property, the needed action is agreed upon, and initial funding is available, *current institutions may be ill equipped to implement adaption responses*. Instead, current efforts are directed toward continued planning and protection of existing infrastructure until the relocation can be initiated. For people living in high-risk situations, this continual waiting causes substantial frustration and mental stress. Climate-induced human migration in and outside of Alaska will likely become an increasingly central issue, if climate change continues to accelerate. Current estimates put the number of potential climate-induced migrants worldwide at 200 million by the year 2050. Addressing this issue requires substantial institutional innovation and capacity to foster adaptation both in and outside of at-risk communities.

NATIONAL RESEARCH CENTER, ADAPTING TO CLIMATE IMPACTS IN THE UNITED STATES 78–79 (2012).

Because the burden of relocation is so clearly attached to a set of identifiable people, the question of who should bear the costs of relocation is put into particularly sharp focus. The international community's potential responsibility for the situation of climate refugees is discussed further in Chapter 11 on Human Rights. See also in Chapter 17 the discussion of the case filed on behalf of the Alaskan Village of Kivalina seeking damages for relocating their village.

QUESTIONS AND DISCUSSION

1. Relocating communities of climate refugees raises interesting international law questions. International humanitarian institutions differ in their definitions of refugees, and many definitions do not easily cover environmental refugees. The Global Governance Project, a European research program aimed at improving global governance, has proposed creation of a Climate Refugee Protection and Resettlement Fund. Money could be raised through a levy on air travel or similar mechanism. Funds could be provided as grants, completely separate from other adaptation and sustainable development funds. The legal framework would be established in a separate protocol to the UNFCCC on the Recognition, Protection, and Resettlement of Climate Refugees. *See generally* Frank Biermann & Ingrid Boas, *Preparing for a Warmer World; Towards a Global Governance System to Protect Climate Refugees* 17–18, 29–30 (Global Governance Working Paper No. 33, 2007). What value is there to a separate protocol focused specifically on climate refugees? Are there any arguments for treating climate refugees differently from refugees displaced by other environmental causes? By non-environmental causes? These questions are discussed further in Chapter 10 in the section on human rights and climate change.

H. Enhancing Natural Resilience and Ecosystem Services

Climate change will have significant impacts on natural systems and, at the same time, natural systems can be important for the adaptive capacity of different regions. The resilience of natural systems and their ability to absorb the stresses brought about by climate change have been weakened in the past century by other man-made impacts, such as pollution or habitat fragmentation. The resilience of these systems can be proactively restored, and in many instances these natural systems can provide effective defenses against climate change. In particular, the protection of natural coastal buffer zones can reduce the impacts from storm surges or general sea-level rise. The disastrous flooding of Hurricane Katrina was in part due to the widespread loss of coastal dunes and wetlands in the Gulf Coast over the past decades. Similarly, some areas in New Jersey fared better in Hurricane Sandy because of an effort in the state, called the Blue

Acres Program, which acquired coastal lands vulnerable to storms and returned them to recreational and conservation uses as a buffer zone. The State of Georgia has also expanded protection of its coastal salt marshes to better withstand the expanded storm surges expected as sea levels rise. *See also* the discussion of recovery plans for endangered species threatened by climate change in Chapter 14.

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I. Insurance as Adaptation

In wealthier countries, insurance has been used for years to spread the risks of extreme weather events such as floods, hurricanes, or droughts. The purchaser of insurance pays a premium to be protected against catastrophic or substantial loss. Because climate change increases the frequency and intensity of storm events, private insurance is getting more difficult to find in some coastal areas in the United States. A survey of industry officials by Ernst & Young found that climate change is currently viewed as the top insurance risk worldwide. Insurance companies are beginning to not only raise rates for homeowners in threatened coastal areas, but are also cutting them off from renewing their policies. The *New York Times* described the availability of insurance in the northeast, even before Hurricane Sandy hit:

> In the last three years, more than three million homeowners have received letters from their insurers as insurance companies, determined to avoid another $40 billion Katrina bill, have essentially begun to redraw the outline of the eastern United States somewhere west of the Appalachian Trail. * * *
>
> Companies including Allstate, State Farm and Liberty Mutual have "nonrenewed" policies not only in hurricane-battered places like Florida and Louisiana, but in New York and other Northern states that have not seen hurricanes in years. Since last year, Allstate has turned down all new homeowners' insurance business in New Jersey, Connecticut, Rhode Island, Maryland, Massachusetts and the eight downstate counties of New York. * * *
>
> The companies say they are obliged to avoid undue risks where they see them, and to remain solvent. "Considering what happened between 2003 and 2005," said Robert P. Hartwig, president of the Insurance Information Institute, an industry lobbying group, "and considering that the best meteorological minds are telling us that for the next 15 to 20 years hurricane activity will be heavier than normal, if we didn't do something to reduce our exposure, we'd be out of business."

Paul Vitello, *Home Insurers Canceling in the East*, N.Y. TIMES, Oct. 16, 2007. Particularly given the devestation of Hurricane Sandy, the insurance companies' approach to risk seems well justified.

In response, however, states and the federal government have had to pick up where insurance companies leave off, finding creative ways to offer publicly supported insurance. At the national

level, the National Flood Insurance Program provides federally backed flood insurance in more than 20,000 communities to homeowners, renters, and business owners in communities that adopt and enforce floodplain management ordinances to reduce flood damage. This program, which was recently reauthorized to 2017, is viewed as necessary because private flood insurance is largely unavailable at reasonable costs. The state of Florida, as another example, created the Citizen's Property Insurance Corporation to make affordable homeowner insurance more widely available. These measures are controversial. Some insurance companies argue that they keep insurance rates artificially low. Environmentalists and taxpayer groups argue that they subsidize risky developments and encourage unsustainable land-use patterns.

Insurance may also have a role in international adaptation policy. Both the Kyoto Protocol and UNFCCC recognize the role of insurance as a possible adaptation response. The following excerpt from the Pew Center explains international insurance strategies:

> The insurance sector is growing rapidly in emerging economies, which, at current growth rates, will represent half the world market by 2050. But this growth is unlikely to reach many among the populations most vulnerable to climate change. Donor governments, possibly in partnership with the private sector, could support insurance-type approaches in vulnerable countries by subsidizing premiums or by pledging backup capital to reduce risks to public or private providers. A variety of risk-transfer instruments could be supported for different sectors and types of risk. * * *
>
> The insurance industry and developing country governments are exploring or testing a number of [other] insurance-type approaches to cover climate-related risks. Examples include:
>
> Pooling Cash Reserves. As a form of collective self-insurance, the Eastern Caribbean Central Bank is accumulating cash reserves through mandatory contributions by member governments, which can then draw loans if struck by natural disasters.
>
> Indemnifying Debts. The Commonwealth and Smaller States Disaster Management Scheme provides insurance to risk-prone governments so they can continue to service outstanding debt following natural disasters. Countries pay a flat-rate premium of 1 percent of the sum insured.
>
> Catastrophe Bonds. The World Bank is exploring whether catastrophe bonds, now in use in developed countries, might be extended to developing country markets. "Cat" bonds insure against a predefined event. Investors who purchase them realize a return if the event does not occur but may lose their entire investment if it does.
>
> Indexed Insurance for Agriculture. These contracts, also known as weather derivatives, provide payments to farmers under predetermined conditions (such as

> number of days with temperatures above a set threshold) without requiring proof of loss. The World Bank is studying their feasibility in Ethiopia, Morocco, Nicaragua, and Tunisia.
>
> The World Bank is developing a proposal for a Global Index Insurance Facility, with $100 million in public and private capital, to reinsure governments and primary insurers providing index-based coverage against weather and other risks. Reinsurance — or "backstopping" — also could be provided for acute losses from extreme events such as hurricanes or typhoons. One potential model is the Turkish Catastrophe Insurance Pool, a national earthquake insurance program backed by a standby line of credit from the World Bank, the first instance of an international financial institution absorbing developing country risk. Backstopping also could take the form of catastrophe bonds, in which investors funding a reinsurance pool receive above-market returns if no losses occur but risk their full investment should there be a major disaster. Mexico plans to issue catastrophe bonds on the private market to reinsure its national catastrophe relief fund. Donor governments, alone or with private investors, could use the same mechanism to back climate relief in vulnerable countries.

See IAN BURTON, ELLIOT DIRINGER & JOEL SMITH, ADAPTATION TO CLIMATE CHANGE: INTERNATIONAL POLICY OPTIONS 19–21 (Pew Center on Global Climate Change, 2006) [hereinafter *Pew Center, Adaptation Policy Options* (2006)].

QUESTIONS AND DISCUSSION

1. Indeed, some homes in flood-prone areas have been rebuilt multiple times with the assistance of federally supported insurance. According to one study, almost 30% of all claims to the National Flood Insurance Program (NFIP), totaling over 200 million per year, were from properties that had filed at least one claim previously. Kenneth J. Bagstad, et al, Taxes, *Subsidies and Insurance as Drivers of United States Coastal Development,* 63 ECOLOGICAL ECON. 285 (2007). NFIP does not currently have the capacity to condemn houses or require they be moved, but in reauthorizing NFIP in 2012 Congress phased out premium discounts for repetitive loss properties. Should NFIP have the authority to decline coverage for a repetitive loss property? Who should bear the risk of rebuilding property in flood zones?

2. In the 2010 Cancun Agreements, the small island countries successfully pressed the other Parties to consider a collective insurance-like program to spread the risks of climate impact across countries. Decision 1/CP.16, paras. 117, 123; *see also* Decision -/CP.18 (outlining the issues for the Parties to consider for an international insurance scheme, which is known in the climate change regime as "loss and damage"). Some observers believe such an insurance approach could avoid or at least reduce tensions over whether adaptation costs should be paid based on liability. Consider the insurance-type instruments described above. How could they reduce tension over legal claims of liability? Does it help if insurance-type instruments address all impacts whether due to climate variability or long-term climate change? How would you

shape an international insurance fund for risk-sharing? What elements do you think the island States would demand? What would be the main obstacles to gaining the support of industrialized countries?

III. INTERNATIONAL CHALLENGES OF ADAPTATION

Until recently, adaptation has mostly taken a backseat to mitigation in the international negotiations. The UNFCCC acknowledged adaptation in general terms, but its primary focus, as well as that of the Kyoto Protocol, was clearly on mitigation. The relative lack of emphasis on adaptation has begun to change, however, particularly as developing countries have placed increasing demands on the industrialized countries to provide funding for adaptation. From the developing country perspective, substantial financial support for adaptation from industrialized countries is warranted, both because industrialized countries are the primary contributors to climate change and because they have greater resources generally. Funding for adaptation is at least implicitly understood as part of the political price that industrialized countries must pay for developing country participation in the international climate regime. Developed countries, on the other hand, do not want the discussion over adaptation funding to reflect questions of legal responsibility; adaptation funding has to be about voluntary development assistance in the political context of the climate negotiations and not about responsibility or obligation linked to emissions.

Adaptation presents other significant challenges on the global level. Although adaptation is seen as an integral part of the international political bargain reached under the climate regime — i.e., that developing countries' participation in mitigating climate change may be conditioned on financial support for adaptation — the UNFCCC is not necessarily the most appropriate institution for directing or managing many adaptation efforts. Adaptation ultimately requires local activities that differ not only among countries but among localities. Adaptation in the international context also relates to disaster relief, typically carried out by well-established humanitarian organizations. Proactive adaptation strategies may require civil engineering, long-term agricultural or ecological planning, or other areas of expertise that are not necessarily found in the climate regime. Nor is there an obvious reason why those activities should be brought under the UNFCCC. Consider the following analysis by the Pew Global Center for Climate Change:

PEW CENTER, ADAPTATION POLICY OPTIONS

at 15–17[*]

From a political standpoint, it may be most plausible to pursue future adaptation efforts within the Framework Convention. To the degree that additional adaptation support is bound with the question of future commitments on climate mitigation, the UNFCCC negotiating process is the most obvious venue for structuring agreements that speak to both. Further, it

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makes sense to build on, or where appropriate redirect, the adaptation apparatus already established under the Convention. There may be constraints, however, on what can be achieved within a regime created specifically to address climate change. First, the climate regime has not traditionally engaged many of the agencies and actors whose participation in adaptation is essential. Even if the regime assigned a higher priority to adaptation, it still might not be the best channel for engaging relevant policymakers and stakeholders. Second, the regime's inherent focus on climate change may not easily lend itself to a comprehensive effort addressing both climate change and natural climate variability.

Still, a proactive approach under the regime could help to address urgent climate change-specific impacts while also facilitating comprehensive long-term climate risk management at the national level. Specific elements of a Convention-based approach could include:

- Support to vulnerable countries for the development of comprehensive national adaptation strategies;

- Reliable funding to assist countries with approved national strategies to implement high-priority measures, with priority given to those addressing impacts reasonably attributable to climate change; and

- Establishment or designation of an international body to provide technical support, judge the adequacy of national strategies, and select high-priority projects for funding.

Convention support for developing national adaptation strategies would help establish frameworks for action and strengthen capacity in vulnerable countries. The strategies could build on the [National Adaptation Programmes of Action (NAPAs)], which target urgent priorities, to map out comprehensive long-term plans identifying: climate risks (from both climate change and climate variability); existing and needed adaptation capacities; risk reduction objectives; high priority adaptation measures; and national policies and measures to integrate climate risk management fully into development decision-making. In addition to organizing national-level adaptation efforts, the strategies could serve as a basis for targeting implementation assistance through the regime or other channels. Such assistance could be made conditional on a country's completion of an adequate national strategy.

If assistance is provided for specific adaptation measures, parties would need to establish parameters for qualifying projects. Given that assistance through the Convention would likely be limited, and that the Convention concerns itself specifically with climate change, such funds presumably would be targeted to urgent needs arising directly from climate change impacts. This determination may be possible only in a narrow range of circumstances — such as sea-level rise or glacial melting — which could be agreed as classes of impact eligible for funding. Beyond such readily identifiable priorities, Convention funds could be packaged with other assistance through development channels to support broader climate risk management efforts in vulnerable countries.

Institutionally, such an approach would require means to support development of national

plans and capacity, assess the adequacy of national plans, and allocate any implementation assistance made available under the Convention. These functions could be performed by a new or existing body, which, in coordination with other expert and implementing agencies, could serve as a clearinghouse for information, expertise, and funding. This institution would need political legitimacy with both donor and recipient countries, and sufficient independence to credibly pass judgment on national plans and to choose among competing projects. Some form of political oversight, perhaps by the Conference of the Parties, also would be needed.

* * * In the long term, a Convention-based strategy would be effective only insofar as it succeeded in institutionalizing adaptation in vulnerable countries. To the degree possible, assistance provided for planning or implementation should serve simultaneously to build or strengthen national capacities so that, over time, countries are better able to adapt on their own. Also critical to long-term success would be adequate, predictable, and sustained funding.

Under the UNFCCC, the Parties have agreed to prepare for adaptation, assist developing countries in creating appropriate adaptation plans, and promote sustainable economic growth to facilitate coping with climate change. At the first UNFCCC meeting in 1995, the Parties established a three-stage framework for addressing adaptation. Stage I was to identify vulnerable countries, Stage II was to start building capacity to prepare for adaptation, and Stage III was to implement measures to facilitate adaptation. Most of the focus has been on Stages I and II, assessing countries' vulnerabilities and setting up NAPAs for these countries. *See* Pew Center, *Adaptation Policy Options*, *supra*, at 13. Under the Kyoto Protocol, Parties are to implement adaptation programs and provide funding for vulnerable developing countries and high-risk areas.

Adaptation became a more central element of the international climate regime during and after the 2009 Copenhagen Summit. The Copenhagen Accord and subsequent Cancun Agreements saw significant advances in the international regime's approach to adaptation. The developed countries collectively committed to provide new and additional resources of $30 billion for the period 2010–2012, with a "balanced allocation" between adaptation and mitigation. Although the developed countries may not have met the $30 billion pledge, they did significantly increase the amount of new financing for adaptation in the period up to 2012. The Parties also established the Cancun Adaptation Framework to enhance all Parties' efforts to plan and implement adaptation actions, with a particular focus on assisting least developed countries (LDCs) to develop and implement national adaptation plans. Moreover, the Parties created an Adaptation Committee to provide technical support to the Parties, facilitate sharing of information and adaptation good practices, and make recommendations to the Parties on finance, technology and capacity-building. Decision 1/CP.16, paras. 11–24.

As adaptation has become more central to the international negotiations, the divisions have been clarified as well. Adaptation planning and preparation to reduce future losses is politically easier to support because a prospective approach is slightly removed from discussions over who should pay for actual damage. As the losses from climate-related impacts mount, particularly for island States and other vulnerable countries, the focus of the negotiations has been on who

should pay for damages. In 2012, in what some observers saw as the most important development in the Doha climate negotiations, the United States and other donors agreed that future negotiations could include a discussion over a mechanism to compensate for "loss and damages" from climate change. This agreement to negotiate ensures that adaptation financing will be a central and controversial part of climate diplomacy moving forward.

QUESTIONS AND DISCUSSION

1. One of the biggest constraints on adaptation is financing. A UNFCCC estimate puts the cost to developing countries between $28 to $67 billion per year by 2030, which is generally consistent with a 2007 estimate from Oxfam ($50 billion dollars per year) and the World Bank (up to $41 billion per year for developing countries). Charlotte Sterrett, *Financing Adaptation: Why the UN's Bali Climate Conference Must Mandate the Search for New Funds*, OXFAM BRIEFING NOTE, Dec. 4, 2007; UNFCCC, INVESTMENT AND FINANCIAL FLOWS RELEVANT TO THE DEVELOPMENT OF AN EFFECTIVE AND APPROPRIATE INTERNATIONAL RESPONSE TO CLIMATE CHANGE (2007). Under the Cancun Agreements, the industrialized countries pledged to provide $100 billion per year by 2020 to address both mitigation and adaptation. Great uncertainty exists around whether the industrialized countries will indeed be able to provide that much funding. What is certain is that finding the money is not going to be easy, and serious questions arise about how to manage both global revenues and expenditures.

2. Assessing the costs and benefits of adaptation measures is difficult because of uncertainty in climate change projections. Some studies have been done on various sectors to try to estimate costs and benefits of adaptation, but any benefits from adaptation measures will only be successful if the local community can adapt and implement these measures. *See generally* NICHOLAS STERN, THE STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE 410–12 (2006). The agriculture sector has been studied extensively for costs and benefits of adaptation. At first, the focus was on benefits such as increased crop yields, but gradually studies have recognized that changing planting dates and crop diversification have costs as well. Additionally, many of these studies assume that farmers can adapt immediately to changing climate conditions. Even if farmers and agricultural regions could adapt perfectly, costs of adapting to a different climate would still be significant. *See generally* IPCC 2007: ADAPTATION AND VULNERABILITY, at 725–26 (2007).

3. Given that adaptive capacity is so dependent on the level of development, many adaptation strategies are indistinguishable from development generally. Building capacity for a country to address climate risk necessarily means that it will be better off in addressing other risks as well. The IPCC and other observers thus argue that adaptation must be "mainstreamed" into the planning of all development institutions. Existing infrastructure lending from the World Bank, for example, should now take into account changing priorities due to climate change. Disaster relief efforts, too, should mainstream planning based on future climate scenarios. Such efforts that already have community-based delivery mechanisms in place may provide the core capacity for responding to climate change-related disasters. Viewed in this light, is it easier to see why we may understate the benefits of adaptation? Is there good reason to separate those adaptation

measures that are simply development efforts relabeled from those adaptation measures specifically tailored to respond to climate risk?

4. Moreover, the issue is not only about the amount of money. Under the UNFCCC's general financing approach, donor countries agree to provide financial support to pay only the incremental costs incurred by developing countries in responding to global environmental issues. Thus, for example, assistance is available to cover the additional costs of installing new pollution control equipment to reduce greenhouse gas emissions for purposes of addressing climate change. This criterion to address the incremental costs has a different twist when applied to adaptation. In adaptation, the question of what costs are incremental would require scientists to be able to differentiate between disaster impacts caused by anthropogenic climate change and disasters caused by natural causes. Why should donor countries be more concerned about providing disaster relief from climate-induced changes than from, for example, victims of earthquakes or the tsunami that struck Thailand and Indonesia in 2006? Does this argue that adaptation be addressed generally through expanded disaster assistance? Why establish a special Adaptation Fund at all? Is this related to the question of responsibility and liability?

5. Adaptation raises important issues of fairness in the international context. Developing countries are generally more vulnerable to climate change impacts because they have fewer resources for adaptation. Countries that have more resources or better adaptive capacity can anticipate climate change and begin to address projected impacts faster. Developing countries have also not contributed as much to climate change historically as the industrialized countries. Is there a way to link responsibility and adaptive capacity? In an article exploring the social justice implications of adaptation, Paul Baer briefly considers various theories on how to assess and distribute the costs of climate change:

> Given the disproportionate share of emissions from the industrialized countries of the North and that the developing countries of the South are more vulnerable to climate impacts, plausible interpretations of "common but differentiated responsibilities" imply that the North should shoulder the major part of the costs of adaptation. . . . [A]ll the donors to the [existing adaptation funds] are wealthy countries with significant responsibility. However, the funds' voluntary nature allows other countries with equal or greater wealth or responsibility to avoid paying for adaptation. . . . It seems likely that Northern governments are resistant to explicit claims for "polluter pays" liability for adaptation investments because there is a clear link between current responsibility for adaptation and eventual liability for compensation for actual climate damages. Northern governments might reasonably fear that acknowledging such claims would obligate northern countries to the largest share of a potentially enormous financial liability. Direct "polluter pays" liability has been avoided so far by emphasizing ability to pay rather than responsibility for climate change, while continuing to give rhetorical support to the importance of the responsibility. The strong correlation between responsibility and capacity has allowed this compromise to justify an initial round of adaptation-related funding. However, reliance on capacity as the basis for sharing burdens implies that the magnitude of

> funding is determined by capacity limits or, in the end, on the limit on willingness to pay.

Paul Baer, *Adaptation: Who Pays Whom?,* in W. NEIL ADGER, ET AL., FAIRNESS IN ADAPTATION TO CLIMATE CHANGE 131, 132–33 (2006). As suggested by the Baer excerpt, any significant discussion of adaptation immediately leads to discussions of who should pay for adaptation, particularly for responding to events after they have happened. In those situations, the discussion over adaptation is closely linked to one of liability or responsibility. In your view, who should bear the costs of adapting to climate change? On what basis should these costs be allocated across countries? Does it matter how wealthy a country is? Should the countries with the highest current emissions pay? The highest past emissions? Why do you think industrialized countries have thus far only supported voluntary contributions to adaptation funds?

6. Oxfam has created an Adaptation Financing Index to assess responsibility and how much a country should contribute to the assistance funds to address climate change adaptation:

> The index is constructed on the basis of four principles: responsibility, equity, capability, and simplicity. . . . Ideally it would be calculated for all greenhouse-gas emissions, but those data are currently available only up to 2000, so we use CO_2 emissions instead, because they provide a reliable proxy for this purpose.
>
> **Responsibility**: greenhouse-gas emissions have been contributing to global warming for over a century and so strict responsibility stretches back more than 100 years. The damaging impact of emissions has been widely known since 1990, and in 1992 — under the UNFCCC — all countries acknowledged the importance of cutting global emissions to stop climate change. Hence here we assess responsibility on a very conservative basis, starting from 1992, counting each nation's excessive CO_2 emissions since then to 2003 (the most recent data available).
>
> **Equity**: each person on the planet has the right to an equal share of the atmosphere's resources, and so has an equal claim to producing greenhouse gases within the earth's capacity to avoid dangerous global warming. In order to keep global warming below 2 degrees relative to pre-industrial levels, greenhouse-gas emissions must be reduced to 50 per cent of 1990 levels by 2050. Fifty per cent of 1990's global CO_2 emissions was 10.7bn tonnes, and so each person is assumed to have an equal right to produce annual emissions within that 'permissible' global total. Given the average size of the global population between 1992 and 2003, this approximates to a CO_2 allowance of 2 tonnes per person per year.
>
> **Capability**: countries are considered capable of assisting if they have already achieved a high level of human development at home. UNDP's Human Development Index (HDI) combines average income, life expectancy, adult literacy, and school enrolments, scoring countries on a scale of 0 to 1. The HDI provides a measure of financial wealth but also excludes countries with high

levels of poverty at home, which they have an immediate obligation to address. Only countries that have achieved the highest levels of human development — an HDI score of 0.9 or above, on a scale of 0 to 1 — are considered capable of providing international assistance. Using the HDI also gives some implicit weight to historic CO_2 emissions because countries that have achieved high levels of development have typically done so through fossil-fuel based industrialisation.

Only countries which are *both responsible and capable* are included in the index.

Simplicity: the value of an index lies in its ability to combine clear principles with relevant data in a systematic way, while ensuring that the complexity of the methodology is not greater than the quality of the data. We aim to make this index reflect the fundamental principles in as clear and simple a way as possible.

The Adaptation Financing Index gives equal weight to a country's responsibility and capability (50 per cent of the score each), and produces a broad indication of the share that each country should contribute to financing adaptation in developing countries. . . . Taking Japan as an illustration: annual CO_2 emissions per person from 1992 to 2003 were on average 9.6 tonnes (7.6 tonnes over the 2-tonne threshold), across a population of 126 million. Compared to other countries, this gives Japan responsibility for 9.9 per cent of excess global emissions up to 2003. Japan's HDI score is high at 0.949: given population size, this implies that Japan has 15.9 per cent of international capability to assist. Taking the average of the two gives Japan a share of 12.9 per cent of the Adaptation Financing Index. This implies that Japan should be contributing approximately 13 per cent of the finance needed for adaptation.

China, by comparison, had average per capita emissions of 2.7 tonnes from 1992 to 2003. That's 0.7 tonnes per person above the 2-tonne allowance, but across a very large population of 1.2 billion people. But China's HDI is low at 0.768, due to 600 million people still living on less than two dollars a day, so China is considered not to have the capability to assist, due to critical development needs at home. Since the index requires both responsibility and capability, China does not qualify for inclusion. Though China and other newly industrialising countries are, according to this index, not responsible for financing adaptation, they will have to play important roles in global mitigation strategies because of their size and rapidly rising emissions.

What does the index reveal? Of course the methodology used is just one way of approaching the issue, but this approach implies that:

- 28 countries are both responsible for and capable of financing adaptation in developing countries;

- the USA and the EU should contribute over 75 per cent of the finance needed, with over 40 per cent from the USA, and over 30 per cent from the EU;

- Japan, Canada, Australia, and the Republic of Korea should contribute a further 20 per cent of the finance, with Japan providing over half of that;

- 17 of the EU's 27 member states are included in the index (the other ten have HDI scores below 0.9 and so do not qualify). The top five European contributors should be (in order): Germany, the UK, Italy, France, and Spain: together they account for over three-quarters of Europe's share . . .

See Adapting to Climate Change: What's Needed in Poor Countries, and Who Should Pay, Oxfam Briefing Paper 104, at 23–26 (2007). Do you agree with Oxfam's approach? If not, what other criteria would you use? Can you see how the question of financing for adaptation may depend on historical emissions more than the question of how to address mitigation of current emissions?

IV. ADAPTATION IN THE UNITED STATES

In some ways, adaptation policy in the United States mirrors that of mitigation. The unfortunate politicization of the debate over climate science that has made federal mitigation efforts difficult has also slowed the national preparation for adapting to climate change. No clear legislative framework for adaptation exists at the federal level, and no Administration prior to the Obama Administration had made adaptation a significant focus of federal policy. The following excerpt from a 2009 National Research Council report highlights some of the challenges facing U.S. adaptation policy.

NATIONAL RESEARCH COUNCIL, ADAPTING TO IMPACTS FROM CLIMATE CHANGE

121–24 (2012)

Despite the nation's substantial economic assets, at present its adaptive capacity to respond to new stresses associated with climate change is limited. As a starting point, it can be argued that our societies are not even well adapted to the *existing* climate, especially to well-understood natural hazards (hurricanes, floods, and drought) that continue to result in human disasters. Numerous reports and academic research papers describe long-standing impediments to natural hazards mitigation, and these challenges will continue to limit our capacity to adapt to climate change — especially when it involves the intensification of natural hazards.

Adaptation requires both actions to address chronic, gradual, long-term changes such as ecosystem shifts and sea level rise, and actions to address natural hazards that may become more intense or frequent. Addressing gradual changes is challenging because the eventual extent of such changes is difficult to recognize and measure, plans beyond 20 years are usually met with

skepticism, and costs for initial investments may be unaffordable even when cost-effective in the long term. The experience of New Orleans with Hurricane Katrina — and in fact, continued development throughout the nation in hazardous areas that increase exposure to coastal storms, flooding, and wildfires — indicates a need for fundamental changes in the management of climate sensitive resources such as coastal areas regardless of the intensification of hazards due to climate change. The continued development of vulnerable areas such as those prone to flooding increases climate risks. Climate changes such as sea level rise and increased storm intensity further exacerbate climate risks, bringing new urgency to these issues. Existing recommendations for improvements in natural hazards management should be considered very seriously since many of these actions would address the most immediate needs for climate adaptation as well.

Political Impediments

For several decades, climate change adaptation has been neglected in the United States, perhaps because it was perceived as secondary in importance to mitigation of greenhouse gas (GHG) emissions, or perhaps more importantly because it would actually take attention away from mitigation by implying that the country can simply adapt to future changes. In addition, the topic of climate change and the discussion of options for responding have become much more highly politicized in the United States than in some other parts of the world. Arguments in the media over whether climate change is "real" and to what degree it is a problem generated by human activity have confused people about whether action is needed and whether their actions can make any difference. Furthermore, there are frequent suggestions in the media that responding to climate change is "too expensive" or that the options available to limit emissions and adapt to impacts will have a negative impact on the U.S. economy.

Adaptations to long-term problems involve long-term investments and bring considerations of intergenerational equity and other social and economic factors into play that significantly affect the calculation of costs and benefits. The influences of climate change extend well beyond the election cycle of the typical public official in the United States. Long-term adaptations must, therefore, hold some promise of short-term reward if they are to be attractive to elected decision makers.

Institutional and Resource Limitations

Several reports have found that current U.S. institutions at virtually every scale lack the mandate, the information, and/or the professional capacity to select and implement climate change adaptations that will reduce risk sufficiently, even when these adaptation actions are urgently needed. New institutions and bridging organizations will be needed to facilitate the communication and integrated planning required to address complex intersectoral problems that cross geographic scales. Moreover, the availability of funding for climate change adaptation at most levels of government has been highly constrained, and there are few public-sector entities that have identified resources for adaptation.

Identifying new financial resources that can be directed toward adaptation might be difficult in any case, but it is particularly challenging as the world's major economies struggle to recover from the worst recession in decades. The vagaries of economic cycles and the associated political volatility make it clear that adaptation efforts need consistent sources of funding over time because "stop-and-go" efforts are far more expensive and far less effective. Mainstreaming adaptation considerations and outcomes into decisions with climate-sensitive consequences (such as reauthorization of laws affecting land and water use, the National Flood Insurance Program, or the Coastal Zone Management Act) is one way to reduce cost, provide incentives to adaptation, and perhaps smooth the intensity of adaptation efforts. . . .

Notwithstanding efforts to reduce costs, the total expenditures on adaptation will most likely have to be substantial and grow over time. There is very little reliable source material, however, on the total financial costs of adaptation, particularly for the United States. To be sure, some studies apply uniform and, in many cases, simple rules to estimate how societies will adapt and the cost of such adaptations. Such a "topdown" approach often does not sufficiently account for geographic variation in vulnerabilities, adaptations, and costs, and it usually fails to distinguish between voluntary and policy-driven adaptation. * * *

The literature does not contain comprehensive estimates of adaptation costs in the United States, but early estimates for some sectors have been published. For example, it has been estimated that the *cumulative* infrastructure costs of protecting low-lying coastal areas in the United States from up to a 3-foot sea level rise could reach more than $100 billion, which avoids even larger losses to property and land values. The cumulative costs of adapting water resource infrastructure to climate change in 2050 are estimated to be half a trillion dollars. These studies suggest that the annual financial costs of worthwhile adaptation in the United States could be tens of billions of dollars by midcentury.

Although the lack of funding is a much more serious concern in developing countries, it is clear that the United States has failed to properly maintain existing water, wastewater, transportation, and energy infrastructure even for the climate that it faces now. . . . As a result, there is already an "adaptation deficit." The need to cope with a dynamic climate that will pose new threats over time only adds to the challenge and will most likely increase the costs of investing in infrastructure.

Soon after taking office in 2009, the Obama Administration took the first significant steps to develop a federal adaptation policy by establishing an interagency Climate Change Adaptation Task Force and ordering all federal agencies to evaluate the climate change risks and vulnerabilities to their respective missions, programs, and operations. In addition, all federal agencies were instructed to integrate climate change adaptation into their planning, operations, policies, and programs. *See* Federal Leadership in Environmental, Energy, and Economic Performance, Executive Order 13514, Sec. 16 (Oct. 5, 2009); *see also* Federal Agency Climate Change Adaptation Planning: Implementing Instructions (Mar. 4, 2011). The Task Force is charged with developing a national climate change adaptation strategy and has issued periodic progress reports in 2010 and 2011, identifying recommendations for agency actions in support of

a national strategy. Its 2010 Progress Report set forth a short list of policy goals "to reinforce existing adaptation efforts, harness a range of capabilities and resources across the Federal Government, and build strong partnerships with local, state, regional, Tribal, and international stakeholders to advance a common adaptation agenda."

PROGRESS REPORT OF THE INTERAGENCY CLIMATE CHANGE ADAPTATION TASK FORCE: RECOMMENDED ACTIONS IN SUPPORT OF A NATIONAL CLIMATE CHANGE ADAPTATION STRATEGY

11–12 (2010)

Summary of Policy Goals and Recommended Actions for the Federal Government

1. Encourage and Mainstream Adaptation Planning across the Federal Government — *Climate change will challenge the mission, operations, and programs of nearly every Federal agency. Ensuring that the Federal Government has the capacity to execute its missions and maintain important services in the face of climate change is essential.*

- Implement adaptation planning within Federal agencies
- Employ a flexible framework for agency adaptation planning
- Use a phased and coordinated approach to implement agency adaptation

2. Improve Integration of Science into Decision Making — *Access to integrated, interdisciplinary science is critical to understanding potential climate change impacts, and informing the development, implementation and evaluation of response strategies.*

- Create a "roadmap" of existing Federal science efforts that inform and support adaptation
- Prioritize activities that address science gaps important to adaptation decisions and policies
- Build science translation capacity to improve the communication and application of science to meet the needs of decision makers
- Explore approaches to develop an online data and information clearinghouse for adaptation

3. Address Key Cross-Cutting Issues — *The breadth of certain climate change impacts creates challenges that cut across the jurisdictions and missions of individual Federal agencies. Addressing these issues will require a collaborative approach along with coordination and partnerships at the local, state, Tribal, and regional levels. The Task Force focused on an initial set of cross-cutting issues and recommends the following actions:*

Improve water resource management in a changing climate

- Strengthen data and information systems for understanding climate change impacts on water
- Improve water-use efficiency to reduce climate change impacts

- Develop a national action plan to strengthen climate change adaptation for freshwater resources

Protect human health by addressing climate change in public health activities

- Enhance the ability of Federal decision makers to incorporate health considerations into adaptation planning
- Build integrated public health surveillance and early warning systems to improve detection of climate change health risks
- Promote resilience of individuals and communities to climate-related health risks

Build resilience to climate change in communities

- Ensure relevant Federal regulations, policies, and guidance demonstrate leadership on community adaptation
- Integrate adaptation considerations into Federal programs that affect communities

Facilitate the incorporation of climate change risks into insurance mechanisms

- Explore a public/private partnership to produce an open-source risk assessment model

Address additional cross-cutting issues

- Develop a strategic action plan focused on strengthening the resilience of coastal, ocean, and Great Lakes communities and ecosystems to climate change
- Develop a strategy for reducing the impacts of climate change on the Nation's fish, wildlife, and plant resources and their habitats

4. Enhance Efforts to Lead and Support International Adaptation — *Climate change poses risks and opportunities that are important to many of the U.S. Government's international development, security, and diplomatic priorities. Climate change adaptation should be a core consideration in the design and implementation of U.S. foreign assistance activities. Agencies should enhance collaboration to support international adaptation objectives.*

- Develop a Government-wide strategy to support multilateral and bilateral adaptation activities and integrate adaptation into relevant U.S. foreign assistance programs
- Enhance collaboration on adaptation among international development, national security, and technical support agencies
- Engage global development partners and the private sector to promote knowledge sharing and coordinate investments

5. Coordinate Capabilities of the Federal Government to Support Adaptation — *The Federal Government should improve coordination of its science, services, and assessments to better support stakeholders.*

- Build and maintain strong partnerships to increase responsiveness of Federal Government activities to support local, state, and Tribal needs
- Develop regional climate change adaptation consortia among Federal agencies
- Establish performance metrics for evaluating Federal adaptation efforts

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Although support and cooperation from the federal level is important, ultimately the most important activities have to take place at the state and local level. As of 2012, seventeen states had either developed or were developing statewide adaptation plans, and another seven states had adopted a climate action plan calling for statewide adaption planning. *See* the interactive map provide by Pew Center for Climate and Energy Solutions, online at http://www.c2es.org/us-states-regions/policy-maps/adaptation. Some states have also adopted sectoral adaptation plans for particularly sensitive sectors, even in the absence of statewide adaptation planning. Thus, for example: Minnesota has developed a Water Sustainability Framework to plan for water uses over the next twenty-five years in light of climate change among other predicted changes; Michigan has released an adaptation plan focused on public health; many states have issued plans to safeguard wildlife and endangered species in light of climate change; and South Carolina has issued a plan focused on protecting its shorelines.

Local communities have also issued an increasing number of adaptation plans. A 2011 survey of 396 mayors from all 50 states found that over 30 percent are already taking climate impacts into account in planning future infrastructure improvements. US Conference of Mayors, Clean Energy Solutions for America's Cities: (2011), available at http://www.usmayors.org/cleanenergy/report.pdf. Several cities and localities have been recognized as taking a leadership role in climate adaptation. As you read these examples, note how adaptation planning necessarily responds to the particular vulnerabilities (be they drought, heat, flooding or hurricanes) that the locality anticipates. This diversity of priorities is one reason why local and statewide action is so critical for adaptation.

> **King County, Washington,** for example has funded a district-wide study of the implications of climate change for water quality and quantity in the region. Working with the Climate Impacts Group at the University of Washington, it conducted an infrastructure assessment that included a GIS tool for mapping the potential for the County's wastewater treatment facilities to flood. Based on the infrastructure assessment, the County has begun to shape its infrastructure investments in wastewater treatment, flood control levees, and transportation according to future projections of climate change. Additionally, the County has begun to acquire properties that flood repeatedly and to allow the local river to reclaim its natural flood plain.
>
> The **City of Los Angeles** has recognized the importance of climate adaptation as a stand-alone issue and established a Climate Adaptation Division within the Environmental Affairs Department. The Director of the Climate Adaptation Division has the lead responsibility for adaptation planning in the city. In cooperation with the University of California at Los Angeles, the City is planning to develop a climate change model that can be used to predict mid- and long-term impacts on the City. As initial steps,

Los Angeles has identified the heat island effect as a major vulnerability and has responded with a massive tree planting effort to increase shading.

Miami-Dade County has identified its major vulnerabilities to be from sea level rise and associated storm-surges. Indeed, Miami is one of the most vulnerable cities to sea level rise in the world. The County developed a Climate Change Advisory Task Force with the participation of 250 stakeholders from multiple backgrounds and sectors, which is an ongoing source of recommendations for both mitigation and adaptation efforts. The County has also used federal funding to strengthen buildings and develop hurricane shelters.

Phoenix, Arizona has explicitly incorporated climate change adaptation actions into the city's sustainability program. This program focuses on land use, pollution prevention, and water-use measures that increase climate change resilience. The Phoenix Water Resources Plan incorporates assumptions about climate-driven changes in water availability in their long-term development plans. To counter the increasingly intense urban heat island effect, Phoenix has also established a task force to promote sustainable designs for the city's urban core, the use of cooler building and pavement materials, and increased planting of trees.

These examples were adopted from case studies highlighted in Center for Clean Air Policy, *Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions* (June 2009). A comprehensive database of state and local climate adaptation plans and reports is maintained by the Georgetown Climate Center at http://www.georgetownclimate.org/node/3324?page=1.

QUESTIONS AND DISCUSSION

1. The National Research Council identified three general approaches that the United States could take towards adaptation in the future:

1. A strong federal government adaptation program, nested in a body of federal government laws, regulations, and institutions. With this approach, the federal government would take the lead in identifying adaptation actions in the national interest, mandate appropriate responses while providing resources to support them, set goals for improvements in the nation's adaptive capacities, and ensure coordination with other national programs and parties nationwide.

2. A grassroots-based, bottom-up approach that is very largely self-driven. Adaptation planning and actions would be decentralized. Decisions would be made without significant federal encouragement or coordination, except for programs of the federal agencies themselves. Current adaptation efforts are largely occurring in this manner.

> 3. An intermediate approach, where planning and actions are decentralized but the federal government plays a significant role as a catalyst and coordinator at the outset, providing information and technical resources and continually evaluating needs for additional risk management at a national level.

NATURAL RESEARCH COUNCIL, ADAPTING TO THE IMPACTS OF CLIMATE CHANGE 11 (2010). Which approach do you favor? What are the advantages and disadvantages of each approach?

2. Adaptation planning can be highly politicized at the state and local levels, and it too can mirror broader debates over climate science. For example, North Carolina adopted a bill in 2012 that would prohibit state officials from considering future sea level rise when developing regulations for housing and infrastructure projects. The legislation would require state planners to rely only on historical measurements of sea level rise. This initiative was a political response to a report developed by an expert panel convened by North Carolina's Coastal Resources Commission, which found that sea levels in North Carolina could rise from between 15 and 55 inches by 2100 and recommended that state planners use 39 inches as a best estimate.

3. The private sector is also taking action to adapt to climate change. In 2011, nearly nine out of ten firms reported that they suffered climate impacts in the last three years. Investors are also increasing pressure on firms, as evidenced by a record 101 shareholder resolutions in 2010 calling on North American companies to manage climate change risks. Businesses are starting to take preventive action to protect their assets, employees, and operations from climate change risks. Approximately one quarter of North American firms reported actively making changes within their business to minimize climate risks and damages.

Only in the past five years has adaptation received significant attention from U.S. environmental lawyers. At first glance, adaptation does not seem to raise significant legal questions, but, as climate change impacts are better understood, the law, too, may have to adapt. Many of our laws dealing with property (tidal land ownership), species or habitat conservation, or sovereignty (the extent of the territorial sea), for example, assume that sea levels are essentially constant. *See, e.g.*, Charles DiLeva & Sachiko Morita, *Maritime Rights of Coastal States and Climate Change: Should States Adapt to Submerged Boundaries?*, WORLD BANK LAW & DEV. SER. NO. 5 (2008); David D. Caron, *Climate Change, Sea Level Rise and the Coming Uncertainty in Oceanic Boundaries: A Proposal to Avoid Conflict*, *in* SEOUNG-YONG HONG AND JON M. VAN DYKE EDS., MARITIME BOUNDARY DISPUTES, SETTLEMENT PROCESSES AND THE LAW OF THE SEA (2009). Can you think of other examples where the legal system may be predicated on assumptions that will change as the climate changes? How can we develop laws that are adaptive over time to a changing climate?

Professor J.B. Ruhl surveyed a significant amount of the recent legal literature on climate change and adaptation and identified ten trends he predicts will occur in environmental law as it adapts to climate change:

1. Shift in emphasis from preservationism to transitionalism in natural resources conservation policy;

2. Rapid evolution of property rights and liability rules associated with natural capital adaptation resources;

3. Accelerated merger of water law, land-use law and environmental law;

4. Incorporation of a human rights dimension in climate change adaptation policy;

5. Catastrophe and crisis avoidance and response as an overarching adaptation policy priority;

6. Frequent reconfigurations of transpolicy linkages and trade-offs at all scales and across scales;

7. Shift from "front end" decision methods relying on robust predictive capacity to "back end" decision methods relying on active adaptive management;

8. Greater variety and flexibility in regulatory instruments;

9. Increased reliance on multiscalar governance networks;

10. Conciliation.

J. B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363, 378 (2010). With respect to "conciliation," Professor Ruhl writes:

> If the nation commits to adaptation — and there seems little choice but to do so aggressively — people, businesses, and governments will expect *adaptation.* Climate change adaptation thus presents an opportunity for environmental law to break free from its culture of litigation and contestation and build back what that culture has eroded most — trust. Trust generally does not come about through threats to sue.
>
> I am not suggesting that environmental law roll over to every seawall and water diversion project proposed in the name of adaptation. But environmental law has a choice to make and the luxury of making it early in the formulation of climate change adaptation policy — is it going to be about conflict or conciliation?
>
> The other trends I have predicted suggest that it should be about conciliation. Fighting in court to hold on to preservationism defies the biological reality of climate change, whereas using environmental law to facilitate transitional strategies for species and ecosystems holds much promise "(Trend One).

> Following the path of the common law to secure critical natural capital resources through regulation solidifies property rights rather than challenges them (Trend Two). Working with land-use and water law rather than standing alone will put environmental law at the core of adaptation policy rather than on the sidelines (Trend Three). Acknowledging the need to respond to climate justice and catastrophe risk management concerns, the necessary measures for which may not always be environmentally begin, will provide environmental law the chance to influence how these concerns are satisfied (Trends Four and Five). Participating in, rather than against, the complex policy mix that will form around adaptation keeps environmental concerns within the dialogue, not an afterthought (Trend Six). And recalibrating how environmental law uses instruments and institutions to fulfill its objectives will allow it to keep pace with the demand for an adaptive adaption policy (Trends Seven through Nine). Conflict may be called for at times along the way to fulfilling these trends, but conciliation — the essence of which is overcoming distrust and hostility — must be environmental law's core norm for participating in climate change adaptation policy.

Id. at 432–33.

QUESTIONS AND DISCUSSION

1. Do you agree with Professor Ruhl's conclusions about the direction of environmental law with respect to future adaptation measures? Will environmental law have to be more conciliatory in the face of the urgency required by adaptation?

2. Among the challenges climate change presents for the application of existing environmental laws is the problem of the shifting ecological baseline. The shifting environmental baseline has always presented a problem for laws aimed at protecting "nature" in a time when human activity is constantly impacting nature. As we enter the Anthropocene Era, where humanity's impacts, from climate change particularly, affect everything on the planet, environmental law aimed at preserving nature can seem ill-conceived. How do we measure success for nature conservation, if the natural is no longer a plausible baseline? What is the goal of environmental restoration efforts, once we recognize that it cannot be to restore it to a natural state? How do we protect endangered species if their current habitat cannot be their future habitat? Natural resource managers may have to abandon an emphasis on preserving existing wildlife in their current habitat and seek to maximize ecological function through more aggressive interventions, such assisting the migration of species to new habitats that may be more suitable in a shifting climate. *See, e.g.*, Alejandro Camacho, *Assisted Migration: Redefining Nature and Natural Resource Law under Climate Change*, 27 YALE J. ON REG. 171 (2010). More generally, see BILL MCKIBBEN, THE END OF NATURE (1989); PAUL WAPNER, LIVING THROUGH THE END OF NATURE; THE FUTURE OF AMERICAN ENVIRONMENTALISM (2010).

V. PRIORITIZING ADAPTATION EFFORTS

The impacts from climate change are going to be profound and enormous. They will affect everyone, but some countries and some people more than others. Wealthy coastal landowners may lose their second homes, but millions of poor may be permanently displaced. Agriculture will take enormous financial hits and so will transportation and energy infrastructure. Food security may be threatened, as will water supplies. When one considers the breadth and complexity of climate impacts, several key questions arise about adaptation, including the following:

- What role should government play and at what level (international, national or local)?

- Given that we will not have sufficient financial resources to address all adaptation challenges, how do we prioritize our adaptation efforts?

Professor Dan Farber proposes that countries adopt two requirements for adaptation planning:

> First, adaptation plans should be required to consider multiple scenarios, including at least one based on high climate sensitivity and emission levels [(i.e. a worst case scenario)]. The approach should be precautionary in the sense that plans should be robust in the pessimistic scenario as well as more favorable circumstances. Second, adaptation plans should guarantee protection of the most vulnerable individuals and communities, although that protection could take alternative forms. Governments should assume an obligation to ensure that individuals do not lose their lives or become homeless as a result of climate change, and that displaced individuals be treated appropriately. Adaptation must at a minimum protect core human rights.

Daniel Farber, *The Challenge of Climate Change Adaptation: Learning from National Planning Efforts in Britain, China and the USA*, 23 J. ENVTL L. (UK) 359 (2011). The U.S. Interagency Climate Change Task Force on Adaptation Policy identified a more elaborate set of guiding principles and policy goals for the federal government to advance national adaptation.

Guiding Principles for Adaptation

> **Adopt Integrated Approaches:** Adaptation should be incorporated into core policies, planning, practices, and programs whenever possible.
>
> **Prioritize the Most Vulnerable:** Adaptation plans should prioritize helping people, places and infrastructure that are most vulnerable to climate impacts and be designed and implemented with meaningful involvement from all parts of society.

Use Best-Available Science: Adaptation should be grounded in the best-available scientific understanding of climate change risks, impacts, and vulnerabilities.

Build Strong Partnerships: Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders.

Apply Risk-Management Methods and Tools: Adaptation planning should incorporate risk management methods and tools to help identify, assess, and prioritize options to reduce vulnerability to potential environmental, social, and economic implications of climate change.

Apply Ecosystem-based Approaches: Adaptation should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services on which humans depend to reduce vulnerability of human and natural systems to climate change.

Maximize Mutual Benefits: Adaptation should, where possible, use strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce greenhouse gas emissions including the development of cost-effective technologies.

Continuously Evaluate Performance: Adaptation plans should include measureable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes.

The White House Council on Environmental Quality, Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy (Oct. 5, 2010).

QUESTIONS AND DISCUSSION

1. What do you think of Professor Farber's emphasis on scenario planning, precaution and human rights as core elements of priority setting? Are they reflected as well in the Adaptation Task Force recommendations? What criteria or components would you add to guide policymakers in priority setting?

2. Given that adaptive capacity is at least partly dependent on social and economic factors, effective adaptation will require sensitivity to gender disparities in both climate vulnerability and capacity. Consider the following discussion from the IPCC:

Empirical research has shown that entitlements to elements of adaptive

capacity are socially differentiated along the lines of age, ethnicity, class, religion and gender. Climate change therefore has gender-specific implications in terms of both vulnerability and adaptive capacity. There are structural differences between men and women through, for example, gender-specific roles in society, work and domestic life. These differences affect the vulnerability and capacity of women and men to adapt to climate change. In the developing world in particular, women are disproportionately involved in natural resource-dependent activities, such as agriculture, compared to salaried occupations. As resource-dependent activities are directly dependent on climatic conditions, changes in climate variability projected for future climates are likely to affect women through a variety of mechanisms: directly through water availability, vegetation and fuel wood availability and through health issues relating to vulnerable populations (especially dependent children and elderly). Most fundamentally, the vulnerability of women in agricultural economies is affected by their relative insecurity of access and rights over resources and sources of wealth such as agricultural land. It is well established that women are disadvantaged in terms of property rights and security of tenure, though the mechanisms and exact form of the insecurity are contested. This insecurity can have implications both for their vulnerability in a changing climate, and also their capacity to adapt productive livelihoods to a changing climate.

A body of research argues that women are more vulnerable than men to weather-related disasters. The impacts of past weather-related hazards have been disaggregated to determine the differential effects on women and men. Such studies have been done, for example, for Hurricane Mitch in 1998 and for natural disasters more generally. These differential impacts include numbers of deaths, and well-being in the post-event recovery period. The disproportionate amount of the burden endured by women during rehabilitation has been related to their roles in the reproductive sphere. Children and elderly persons tend to be based in and around the home and so are often more likely to be affected by flooding events with speedy onset. Women are usually responsible for the additional care burden during the period of rehabilitation, whilst men generally return to their pre-disaster productive roles outside the home. Fordham (2003) has argued that the key factors that contribute to the differential vulnerability of women in the context of natural hazards in South Asia include: high levels of illiteracy, minimum mobility and work opportunities outside the home, and issues around ownership of resources such as land.

The role of gender in influencing adaptive capacity and adaptation is thus an important consideration for the development of interventions to enhance adaptive capacity and to facilitate adaptation. Gender differences in vulnerability and adaptive capacity reflect wider patterns of structural gender inequality. One lesson that can be drawn from the gender and development literature is that climate interventions that ignore gender concerns reinforce the differential gender dimensions of vulnerability. It has also become clear that a shift in policy focus

> away from reactive disaster management to more proactive capacity building can reduce gender inequality.

IPCC 2007: ADAPTATION AND VULNERABILITY, at 730, Box 17.5. What types of policies could address these gender imbalances in the context of climate change? More generally, does the above excerpt allow you to see the importance of planning and preparation for assisting vulnerable groups in adapting to climate change?

3. Another complexity in considering future adaptation measures is how such measures may create positive feedback loops to further exacerbate climate change. If adaptation plans include increased use of air conditioners in the summers, for example, the expanded use of energy could in turn lead to greater greenhouse gas emissions. Similarly, as agriculture adapts to warming climates by requiring more irrigation, energy demand for pumping water will increase. What other potential feedback loops can you identify where adaptation measures could make achieving our mitigation goals that much harder? What procedural or other steps should be taken in developing adaptation plans to ensure they are not contributing further to climate change? *See generally* IPCC 2007: ADAPTATION AND VULNERABILITY, at 759–62.

4. *Problem Exercise.* Climate change impacts affect every economic sector of society, and every sector will need to adapt to climate change. The class may be divided into groups corresponding to different sectors of the economy, including, for example: fisheries, forestry, agriculture, urban planning, homeowners, health care providers, or insurance. The exercise can be tailored as well to the country, region or community where the class is being held. Each group should discuss an adaptation plan for their assigned sector by considering the following questions:

(1) what criteria will you use to evaluate and prioritize potential adaptation policies;

(2) what are the major climate change impacts that are expected in your sector;

(3) what specific measures should be adopted at the international, national, state and local levels to promote adaptation in the sector?