Chapter 16 Special Topics: Climate Change Adaptation

This chapter discusses the role of economic analysis and adaptive management (AM) in adaptation to climate change, from the perspective of the Department of the Interior's (DOI) land management responsibilities. The chapter also presents a simple model that illustrates some of the tradeoffs facing Interior's land managers as they consider habitat needs for endangered species in the context of climate change.

Background

Climate change has profound implications for resources managed by the Department of the Interior. Trends in climate-related environmental conditions, such as temperature, precipitation, frequency of extreme weather events, and sea level, directly affect our operations and achievement of our mission. The realities of climate change require the Department to integrate adaptation into our diverse operations, programs, plans, and policies. DOI must structure its management of natural and cultural resources as well as infrastructure to account for changing conditions and threats with respect to human and built assets; work with tribes in their adaptation efforts; and provide scientific information and tools to support the range of activities and programs we oversee in the face of climate change.

These realities require a number of choices in terms of the types of adaptation measures; the scale of implementation (local; regional); the timing of implementation (i.e., does it occur instantaneously as soon as it is first needed, or with some delay); and the specific geographic locations where such measures might be implemented. Choices concerning each of these issues have implications for costs as well as the extent to which adaptation offsets adverse impacts (e.g., how large its net benefits might be). Optimal choices are likely to vary by location and over time, as well as by type of impact and by affected entity. These are issues that are relevant both for on-the-ground projects, as well as in national and global contexts where trade-offs must be considered between the costs of climate policies and the residual damages resulting from climate change. A number of factors complicate any evaluation of adaptation choices:

- Adaptive management and climate adaptation both typically involve multiple entities and decision makers. In the context of the land management decisions facing the Department of the Interior this could imply the involvement of multiple bureaus, stakeholders, and tribal, state and local governments.
- Adaptive management in addition to most adaptation measures must be tailored to local circumstances.
- Institutions – public and private – play an important role in defining the decision making space, in allocating the costs and benefits of any particular adaptation response, and in the pace of decision making.
- The facts of climate change and potential adaptations are not known with certainty, nor are they likely to be agreed upon by all of the parties involved. This fact can influence both the timing and the nature of the actions that occur. The result is that errors in the selecting, timing and scaling of actions are likely. The errors can be in kind (choosing project A rather than project B) or in degree (too hasty or too tardy; too much or too little).

Adaptive management is a form of structured decision making that involves the use of management in the spirit of experimental science to improve management decisions. It calls for explicit identification of objectives and alternative management strategies, and for the involvement of stakeholders in decision making. Evaluating potential adaptation investments also may require identifying a set of climate scenarios. In fact, the choice of adaptation measures may actually depend, to a large extent, on the choice of climate scenarios. Adaptive management acknowledges uncertainties and can be adjusted as outcomes from management become better understood. The feedback between learning and decision making is a defining feature of adaptive management. The feedback between learning and decision making is a defining feature of adaptive management. This type of learning-based approach to natural resource management holds much promise for dealing with the challenges of adaptation to climate change.

Defining the Economic Problem:

The economic problem associated with climate adaptation can be formulated as a cost minimization problem, where society seeks to minimize the sum of adaptation costs and damages occurring as a result of climate change. This problem, which is really a dynamic problem that would seek to minimize the present value of adaptation costs and damages (or avoided damages), could also be defined for different regions or types of habitat (e.g., coastline or other types).

The solution to this problem, at least at a conceptual level, is to equate the marginal adaptation costs to the marginal benefit from avoiding the damage. This is easier said than done because there are a wide variety of alternative adaptation strategies, which could be implemented at different scales and intensities. Damages (or avoided costs) are associated with the loss of land or other resources (either due to sea level rise or other climate related changes that reduce productive capacity). Conceptually, the magnitude of the damages depends on the amount and value of land affected by climate change. The value of land depends on its opportunity cost and would include the value of any foregone ecosystem service flows. It is also possible that, over time, technological change may also result in less costly mitigation or adaptation approaches.

Adaptation, Environmental Markets, and Pricing

Flexible resource allocation is an important component of adaptation. Existing markets can offer a flexible mechanism provided the resources of interest (water, forests, etc.), and their ecosystem services are bought and sold at prices that reflect the full opportunity costs of the resource (full-cost pricing). Active markets exist for some resources, like water, though markets are limited or absent for many environmental goods and services. Government policy is an alternative for these areas, providing incentives for producers and consumers of ecosystem services.

Markets and full-cost pricing internalize the adaptation benefits provided by ecosystems, meaning that trade-offs affecting these resources take account of all the benefits they provide. Robust resource management decisions depend on this full accounting of costs and benefits. Given DOI's wide-ranging resource management responsibilities (including historic and cultural resources), it is in the Department's interest to facilitate the development of these markets and potentially participate as a buyer and seller of ecosystem services in some situations. For example, DOI could lease or purchase water for wetlands or purchase water from water banks to help meet instream flow needs for endangered or threatened species.

Markets for ecosystem services can play an important role in adaptation, providing mechanisms that enhance flexibility and resiliency. However, the success of ecosystem service markets depends on the ability to formalize transactions for services that are largely public goods. Examples of the use of markets include the following:

- Regulation requiring the purchase of environmental offsets for impacts to public resources (the impetus behind wetland mitigation banking)
- Voluntary transactions between a beneficiary of ecosystem services and a supplier (e.g., paying adjacent landowners to maintain trees benefitting pollinators); and
- Government purchases of ecosystem services on behalf of the public (e.g., paying upstream residents to modify land management practices to reduce urban runoff).

Many of these examples require a regulator to establish, enforce, and monitor trading rights. Thus, government rule-making has a strong influence on the market values that emerge. These markets also must be built around measurable and reliable ecosystem service indicators.

Climate change is anticipated to be accompanied by changing patterns and quantities of precipitation in the West (CBO, 2009). Western water markets should be of particular interest to DOI, given the increasing need for institutional flexibility in water management institutions, facilitating efficiency improvements, and in allocating limited supplies among uses and users. In general, markets, or market-like mechanisms (e.g., "water transfers," "water banking," or "voluntary water marketing") introduce flexibility into traditional water rights systems, bringing regional water users together in a collaborative trading setting. DOI has directly participated as a buyer/demander in some water markets (e.g., purchasing water for wetlands and instream flows).

Economic Analysis and the Evaluation of Adaptation Investments

The *DOI Adaptive Management Technical Guide (2009)* and its companion *DOI Adaptive Management Applications Guide* (2012) characterize adaptive management as a systematic approach for improving resource management by learning from management outcomes. Structured decision frameworks, such as adaptive management, can include processes for identifying trade-offs. With sufficient information, these tradeoffs can be valued as part of an economic analysis.[95] These tradeoffs could be identified via a process like structured decision making (discussed below) and integrated into a benefit-cost framework. "Soft" investments such as operational changes to existing facilities (e.g., dam and reservoir operations, harvest restrictions, etc.) are relatively easy to change and adjust in the face of new information. This type of investment may fit with an iterative learning-based approach, assuming that the relevant tradeoffs can be well specified. An example of these types of tradeoffs is a change in the timing of hydropower generation in order to increase instream flows during certain time of the year. "Hard" infrastructure investments require different evaluation with AM because the scale and scope of these investments are set at the outset and may be irreversible or expensive to adjust. A real options approach might be considered for irreversible infrastructure investments. This approach is attractive because it explicitly considers the implications of new knowledge becoming available over time. Otherwise, if incremental changes are possible, they might be evaluated using benefit-cost analysis.

[95] "Success" in the context of AM could be measured by the extent to which a given management change is associated with an increase in net economic benefits. Other criteria/metrics for evaluating the success of AM (e.g., stakeholder involvement, the extent to which progress is made toward achieving management objectives, the

Benefit-Cost Analysis

Decision makers seek to avoid committing public funds to outcomes that result in over-adaptation (overspending) or under-adaptation (and increased exposure to disaster risk).

For Interior the primary issue is identifying which investment decisions should be subject to benefit-cost analysis and then choosing the assumptions and methods used to undertake the analysis. As it is not feasible to evaluate every adaptation decision using benefit-cost analysis, the Department could focus on evaluating those involving "large" expenditures or sensitive resources. Some guiding principles might include:

- Establish a baseline, or "no-project" scenario;
- Value resources at their opportunity cost;
- Match the period of analysis to the life of the adaptation investment;
- Consider the effects of discounting; and
- Evaluate uncertainty and manage risks.

Additional Approaches

The use of additional methods may complement a benefit-cost approach. Some of these approaches could include:

- Real options analysis: Uncertainty in feasibility (environmental or technical) and economic conditions permeate the evaluation of climate change adaptation. Real options analysis provides a quantitative framework where the "option value" is determined as a function of the risk associated with the decision (Farrow 2004).
- Structured Decision Making Approaches – Multi-Criteria Analysis and Scenario Analysis "Multi-criteria analysis" (MCA), which involves comparing alternatives based on a set of pre-defined criteria (de Bruin, 2011) is another possible approach. The analyst examines the rate of return for the decision alternatives under the potential future states, identifying the alternative with the preferred outcome.
- Threshold Analysis: A disproportionate share of the damages from climate change arises from extreme events and occurs when key thresholds are crossed. A broad categorization of thresholds might consider ecological, utility, and decision thresholds.

Adaptation and Interior's Issues

Climate change adaptation in coastal zones

Each adaptation strategy is associated with different costs. Strategies and costs also vary across different coastlines. As a starting point, the tradeoff to be evaluated is between the costs of protection and the values associated with the land threatened by rising sea levels and other climate change-related impacts on coastal areas such as storm surge and sea ice retreat. Protective measures should be put in place as long as the benefits from avoided damages exceed the incremental costs of the protective

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extent to which results from monitoring and assessment actually improve management decisions, and whether implementation is consistent with applicable laws) are less amenable to measurement.

actions. To properly evaluate these tradeoffs, DOI would require an inventory of potentially impacted coastal assets, the extent to which they are vulnerable to climate change, cost estimates for the various strategies, and values associated with the vulnerable areas.[96]

Infrastructure

DOI manages a vast array of infrastructure, including: roads; bridges; buildings; and water treatment, storage, and distribution facilities. Changes to existing infrastructure are part of the adaptation response in many locations. Adaptation costs associated with infrastructure typically have two components (which are not mutually exclusive): costs associated with new infrastructure and costs associated with changes to existing infrastructure. Adapting infrastructure to changing climate conditions can be costly.

Conclusion

A challenge faced by DOI is how to prioritize among a large number of potential climate change adaptation projects, given that resources are limited and that the scope and magnitude of climate change in any particular location is uncertain. Priority-setting needs to account for the severity of potential climate impacts; uncertainty; the values of the systems, species, or populations; and the costs associated with any particular adaption measure or set of measures.

Additional material on this topic will be available in the coming months.

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[96] There is extensive information on adaptation costs for coastal regions worldwide, as well as on a global basis. However such cost estimates are typically only for coastal protection, and have traditionally been estimated only for a 1-meter sea level rise (OECD 2008). These costs are often quite high, with the exception being countries or regions where coastal land values are low (usually because of lower population densities) and where lower protection levels might be optimal. The cost estimates are usually based on models that seek to minimize the costs of protection and the residual (unprotected) damages that will be incurred through loss of land and natural habitats. The benefits in this case are the damages avoided as a result of protection. In regions with extremely valuable assets, “total” protection might indeed be optimal. In other cases, the optimal strategy might well be to invest in partial (or incomplete) protection and accept a certain amount of residual damage.

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