Adapting to Sea Level Rise: the Tension Between Protection and Discontinuous Change**

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Summary
Communities and individuals can spend money and alter their environments to reduce risks they face from sea level rise (SLR) and other climate-driven risks. These actions can be cost-effective in the short-run, but may encourage patterns of development that increase exposure and disruption over longer timeframes. Public policy and expenditure should address the possibility of long-term discontinuous change as part of short-term decision-making. The timing of transition from protection to relocation is a central but unconsidered aspect of adaptation policy.

Current realities
Communities in low-elevation coastal areas are facing a future of escalating risk from flooding and erosion because of SLR and other climate-related phenomena. The current state of scientific knowledge and likely greenhouse gas (GHG) emissions scenarios imply that risks will escalate over a long, but uncertain, period of time and that sometime in the next 75 to 400 years (roughly) many coastal locations are likely to either become extraordinarily risky to live in or altogether uninhabitable. An understandable rational immediate response is how to "climate-proof" communities by protecting key infrastructure and the built environment with improved technology and in-community changes in location. Priority has also been given to preventing new construction in particularly vulnerable areas. For many coastal locations, it is reasonably likely that these strategies will lose relevance on the scale of one century to four centuries if the West Antarctic and/or Greenland ice sheets collapse.

Taking government actions that "climate-proof" key infrastructure and the built environment (e.g., infrastructure elevation, shoreline protection) and those that subsidize investments and activities at risk (e.g., insurance, disaster relief) can also serve to increase exposure to future hazards. The more protected people feel, physically and financially, from the effects of SLR, the more they will build and invest in coastal areas. The greater the amount of physical capital to protect, the higher the incentives to continue to protect that investment — creating a cycle that can increase the number of people and value of property at risk if and when risks become significantly larger.

Two opposite and extreme responses are useful to frame the complex choices facing communities. The first is to stop investing in coastal infrastructure and risk reduction, and to encourage residents to abandon coastal locations as quickly as is feasible. This is both irrational and unlikely to occur. Even the most pessimistic projections about SLR and storms leave many years until the great majority of the Atlantic and Gulf coasts become uninhabitable. It would be economically wasteful and socially disruptive to abandon the high levels of physical and social capital that exist in these coastal areas in the short run.

The opposite response is to commit to protecting communities in their current locations, and to maintain transportation and other key infrastructure regardless of what happens in the future. This is both an unrealistic and a dangerous strategy because it risks using vast resources and encouraging unsafe choices when SLR and storm regimes will eventually destroy the built environment.

How to navigate the continuum between these two choices is the essence of adaptation. The question of "what should be done?" cannot be separated from the equally relevant question of "when?" For example, when should property be protected by public policy and expenditure, and when should it be allowed to sink or swim on its own? When should people and businesses live with and try to mitigate risk, and when should they leave for safer locations?

Adaptive responses can be grouped into three categories: 1) making minimal changes and hoping for the best, 2) investments that “climate proof” communities — reducing risk to make it possible to stay in place longer and more safely, and 3) discontinuous change — relocation or drastic change to the built environment. A key fact is that crucial choices will be made both by autonomous actors (e.g., individuals, businesses, universities) and by multiple levels of government, and it is the interaction of those choices that will determine adaptive actions.

While individual and policy decisions are made in multiple contexts, many key decisions about adaptive response are made following dramatic climate events like hurricanes, floods, or disruptive erosion. That is because these events dramatically alter the benefit/cost calculation for property owners — the costs of the *status quo* become discontinuously larger because of the costs of rebuilding and repair, while the benefits of remaining in place stay the same (or possibly diminish if people reassess their view of hazard risk following these events).

Scientific opportunities and challenges

The wide variety of uncertainties, loci of decision-making, and policies make adaptation to SLR a “wicked problem” — a situation that “defies all-encompassing, definitive, and final solutions; instead, temporary best solutions will have to be sought in the context of an iterative, deliberately learning-oriented risk management framework” (Moser et. al. 2012). At the heart of all this is the fact that fundamental decisions (e.g., whether to stay or go, whether or what housing to build) are made by large numbers of heterogeneous individuals with value systems, scientific assessments, and perceived incentives that are only partially predictable.

There is very significant uncertainty about the relationship between time and risk — rates of SLR are both uncertain and endogenous because they depend on future anthropogenic GHG emissions. In addition, the frequency and magnitude of discrete events that will drive timing of behavioral change (e.g., hurricanes) is also stochastic. What people *believe* about SLR and risk is also highly diverse. There is clearly a payoff to science that reduces uncertainty about the constituent components of this “wickedness” — the rate and consequences of SLR, changes in the storminess regime, resolution of uncertainty about the ability of technology to mitigate risk. There is also value in knowing how specific policies will affect behavior (e.g., insurance products for adverse climate outcomes and disaster assistance policies).

The ability of technology to reduce and manage risk is highly uncertain and significant disagreement exists among experts on its role. For example, many engineers believe that shoreline engineering is effective and efficient at protecting property, while many geologists believe that it is costly, ultimately ineffective, and risks unintended consequences in other locations. Technological advances in protection engineering and “climate-proofing” infrastructure and housing generally increase costs and reduce risk to the existing environment, but may increase risk by encouraging more building. Alternatively, these circumstances may call for technology that reduces risk by adding flexibility and/or reducing financial exposure (e.g., building housing that can be moved at relatively low cost when risks at existing locations become great).

There is also significant value in research that integrates the climatic, physical, policy, and behavioral factors, not because such models can predict what will or should happen, but because they can at least let us explore how complex interactions can produce surprising and even novel results.

A key question in understanding the tradeoffs in short-term protection versus long-term relocation is in specifying how individuals and communities value “place.” If people perceive a relatively low value of living in their current location, then a quicker transition with less additional investment will become relatively attractive. If people have very strong preferences to remain in a particular location, then they will have more tolerance for risk and will tend to spend more on protection and stay longer. If it is the community and not the location that matters, then a relevant issue becomes the ability of large parts of a community to relocate together.

Policy issues

- Amend FEMA programs to make progress on the “age-old” issue of moral hazard in emergency response policy by not providing post-disaster aid that reduces incentives to take *ex ante* precautions.
- Make both pre- and post-disaster assistance more neutral with respect to returning to the *status quo.* The natural tendency to rebuild, and to rebuild stronger and more resiliently, motivates public discourse, and some FEMA programs are focused on rebuilding. However, in many circumstances, the least costly time to consider relocation is after a disaster. Disaster assistance should at least be neutral in terms of whether resources are used to rebuild or to relocate to areas with significantly lower risk.
- Have FEMA (flood insurance) and states (publicly managed wind pools) base insurance rates on the best assessment of prospective risk and update rates regularly to reflect new information.
- Providing compensation to people disproportionately affected by SLR is likely to be a key aspect of future policies as risks escalate. Payments, subsidies, tax breaks, etc. can skew the protection versus relocation decisions (e.g., subsidizing the elevation of low-lying structures). Finding ways to make compensation more neutral with respect to how it helps people adapt (e.g., increasing employment skills, providing cash transfers in place of specific subsidies and expenditures, not tying compensation to subsidizing specific protective measures) can provide clearer and better signals to guide residents’ choices.
- Be mindful of the tension between policy consistency and flexibility in decisions about protecting infrastructure. Setting clear expectations about what public policy will and won’t do in response to climate-driven hazards is, all else being equal, the way to provide efficient incentives and information for individual decisions. However, the countervailing policy dynamic is the need for adaptive management — the ability to change course and alter policy as new scientific information and technologies alter the nature and consequences of available choices. For example, a commitment to shoreline protection could become a very poor policy if climatic drivers of erosion accelerate more rapidly than expected. Such decisions could be tied to an observable variable whose value reflects the outcome of uncertain processes (e.g., a number of inches of sea level rise, a particular observed erosion regime). This is a promising technical solution, which is problematic because there is no political certainty that it will be followed.

These policy recommendations have been unavoidably nonspecific for a fundamental reason — the wickedness of SLR adaptation makes assessing any individual policy problematic. It is the combination of policies across multiple areas, combined with unpredictable climatic, technological, economic, and behavioral developments that will determine how successfully communities adapt to rising seas. The best advice is to learn as much as possible, remain flexible, and always keep one eye on higher ground.

References

Moser, S. C., Jeffress Williams, S., & Boesch, D. F. (2012). Wicked challenges at land's end: Managing coastal vulnerability under climate change. *Annual Review of Environment and Resources*, *37*, 51-78.