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Policy solutions in the U.S.

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Abstract The paper focuses on relocation, retreat, zoning, insurance, and subsidy as major dimensions of coastal hazard mitigation measures that have resurfaced as potent forces for combating coastal inundation and climate change. It reviews the issues surrounding the practice of these measures and discusses compatibilities of policies, engineering measures, and natural defense. Property rights, development interest, and distorted financial incentives pose as main barriers to coastal relocation and retreat policies in hazard-prone areas. To understand and propose coastal adaptation solutions, the paper recommends place-based studies of local coastal adaptation strategies. Place-based studies offer an in-depth knowledge of local conditions specifically regarding the level of implementation of hazard mitigation policies, and shed light on important trade-offs and synergies of various hazard policies. In addition, coupling existing hazard mitigation policies with coastal management and community management can better inform long-term and comprehensive planning of coastal adaptation.

1 Introduction

Nonstructural measures in hazard mitigation, coastal management and planning, and climate change adaptation overlap in the shaping of regulatory policies such as relocation, retreat, and financing to protect people and property from harmful coastal hazards. Scholars note the increasing inclusion of nonstructural measures such as land use and insurance in the design of climate change adaptation (Cigler 2009; Glavovic 2008). A number of scholars have also integrated climate change into coastal management examining coastal vulnerabilities (Klein and Nicholls 1999), sea-level rise scenarios (Titus et al 2009; Dawson et al. 2009; Nicholls et al. 2008), human settlement (Small and Nicholls 2003), and integrated coastal management

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(Sales 2009; Wong 2009). The paper builds upon this literature and reviews a range of policy options to protect the coastal population from the new challenges of climate change. The paper specifically focuses on relocation, retreat, zoning, insurance, and subsidy as major dimensions of coastal hazard mitigation measures that have resurfaced as potent forces for combating coastal inundation and climate change. This set of policies deal with people and property addressed as built environment by Nichols and Bruch (2008), and does not include policies regarding hard and soft shoreline protections as well as coastal conservation measures.

The objective of the paper is to understand the issues surrounding the practice of these regulatory policy solutions and to discuss compatibilities of policies, engineering measures, and natural defense. The first part of the paper examines relocation, retreat, hazard zoning, and financial protection measures primarily drawing from U.S. peer-reviewed literature and case studies. The second part of the paper discusses the compatibility of these policies and the findings from the first part of the paper. Climate change adaptation plans are not included in this study as they have just begun to be formulated and it is premature to assess the level of implementation. For reference, this special issue includes Cynthia Rosenzweig et al.'s paper on New York City's climate adaptation planning.

2 Relocation

Relocation refers to the movement of people and properties away from hazard-prone areas to a safer location. It can be forced or voluntary. Forced relocation occurs when extreme events force people out of their lived places temporarily or permanently and when government policies mandate relocation. Relocation programs, financial incentives, and people's awareness of the high risk create motivation for voluntary relocation. Relocation is considered one of the safest options in the face of rising sea levels, and is associated with high economic and social costs (Cutter et al. 2006; Lindell and Prater 2003).

Consultation with the affected community, compensation to property owners who relocate, and the acquisition of at-risk coastal properties are considered key elements of successful relocation policies (Jha et al. 2010). Consultation refers to the participation of the target population in decision-making. It facilitates the transition of people and communities to new locations and decreases the likelihood of people returning to the hazardous environment after relocation. Perry and Lindell (2002), for example, emphasize that communities should organize and participate in decision-making processes and preserve their social networks. International NGOs such as the World Bank and the UN International Strategy for Disaster Reduction (UNISDR 2009) include strategies for relocation and reconstruction in their reports on disaster risk reduction and climate change. They recommend that people and the government form a community relocation committee, consult relocation specialists in the design and implementation of relocation plans, prepare for social conflicts in the host communities, and budget for the prevention of the return of the relocated community (Jha et al. 2010).

Compensation and land acquisition designed as a part of government relocation programs prove expensive as the value of coastal properties continually rises, especially in well-developed regions. For example, the rising cost of waterfront properties and the required 25% match from the local government resulted in few buyouts from

hazardous land acquisition projects in North Carolina (NOAA 2010). The unpopularity of relocation programs is also seen in the case of the National Flood Insurance Program (NFIP). Section 1362 of the NFIP authorized the NFIP to buy substantially damaged properties and transfer the land to a public agency (Kunreuther and Roth 1998). This section of the NFIP was repealed in 1994 and replaced by Section 552, entitled the Mitigation Assistance Program (FEMA 1995). One factor attributed to the repeal is the burdensome purchase of the land by the federal government (Kunreuther and Roth 1998). Communities also resist relocation as they consider rebuilding cheaper, though it tends to be a short-term solution (Bagstad et al. 2007). In addition, moving away from the coast can translate into a loss of livelihoods, since the coastal zone is home to fishing, tourism, and/or port communities (Pomeroy et al. 2006). Local governments in the U.S. also shy away from relocation policies because they fear the absence of their property-tax base (Mills 2009).

Besides the economic cost of relocation, the social cost can run high, especially in the re-creation of communities at a new site. The meaning and significance of a place to residents and the strong sense of community identity often found in rural and island communities are difficult to transfer to a new location (Campbell 2010). In the aftermath of the Indian Ocean Tsunami, for instance, people have resisted government resettlement plans and returned to their original locations (Ingram et al. 2006). The ocean also offers cultural and spiritual amenities that outweigh the cost and safety concerns. Indicative of this are the wealthy residents who can afford to come back to flooded areas because of their propensity for coastal lifestyle (Smith et al. 2006). Government relocation programs in other areas, such as conservation and biodiversity, have failed to sustain communities as communities have become impoverished, have lost their sense of place, and have come to feel incapacitated (Gonzalez-Parra and Simon 2008; Cernea and Schmidt-Soltau 2006; Mutton and Haque 2004). Similar misgivings can occur with relocation efforts to avoid coastal hazards.

3 Retreat

Coastal retreat policies are available to fend off coastal erosion and frequent flooding. With the newer challenges of climate change that can worsen erosion and flooding in the coastal zone, setbacks and rolling easements gain spotlight as renewed and innovative means of lessening people's vulnerability to climate change. By regulating the location of structures on the coast, setbacks and rolling easements indirectly provide incentives for people to move inland.

3.1 Setbacks

Setbacks are designed to mitigate the impacts of beach erosion and storm surges; they complement engineering solutions such as seawalls and beach nourishment, and often create a buffer between the sea and the coastal property. Setbacks serve multiple purposes as they help to prevent the destruction of property, endangerment of life, loss of public access, and environmental degradation (Hwang 1991). Most U.S. coastal states use either construction or erosion-based setbacks (Houlahan 1989; Mangone 2010). Florida used construction setback lines to subject construction seaward of the line to additional regulation of siting and design, and added 30-year

erosion-projection setback lines for areas with an established coastal construction control line to prohibit construction seaward of the line since 1985 (Ruppert 2008).

Shoreline setback distances can be delineated by calculating the annual erosion rate times approximately 30 to 100 years (NOAA 2007b). They are drawn from the high-tide line, the extreme high water mark, the vegetation line, or the crest of the sand dune. Construction is usually not allowed beyond the setback line toward the sea. When there is a lack of erosion data, states can create arbitrary minimal setback requirements. Minnesota's North Shore Management Plan, for example, uses a standard 125-ft setback where erosion data is unavailable (Minnesota DNR 2010). Setback regulations tend to be applied to new development. In North Carolina, setback requirements allow existing structures seaward of the setback line to be "grandfathered in" (NOAA 2007b). In South Carolina, repair and rebuilding of more than 50% of the damaged structure must adhere to the current setback line requirements (NOAA 2007b).

Some variations on setbacks include coastal construction control lines in Florida, dune protection lines in Texas, and state erosion plans. They all serve directly or indirectly to protect people and properties from erosion and flooding. Florida's coastal construction control lines incorporate erosion-based setback lines. Local governments designate dune protection lines in Texas and set conditions for construction in and around the dunes including the type of construction and building materials (Tex. nat. res. code ann 63). Sand dune rules bar bulkhead construction and require the removal of new structures in the event that substantial damage or interference with dynamic sand dune systems occur (Higgins 2008). As dunes act as a natural barrier to flooding, dune preservation indirectly serves to protect people and property in the coastal zone (Cooper and Mckenna 2008). Texas erosion response plan is an effort to reduce public expenditure on the repair of public facilities damaged by erosion, and it offers setbacks as an option that local governments may choose (Texas GLO 2010).

One issue with setbacks is the changing rate of erosion over time as erosion can increase at an alarming rate. Because some states established first setbacks many years ago, structures come to sit on the beach after a number of years (Hwang 1991). For instance, setback lines based on a 30-year projection are not effective in protecting buildings designed to last up to 100 years or so (Ruppert 2008). As erosion rates commonly derive from historical measurements, they may not incorporate future changes due to rising sea levels and a possible increase in the intensity and frequency of coastal floods as a result of climate change (IPCC 2007) as well as catastrophic inundations. Setbacks, therefore, need to be reassessed periodically. In the case of South Carolina, setback lines are reevaluated every 8–10 years (NOAA 2007b). Lester (2005) suggested the implementation of rolling setbacks, similar to rolling easements.

Nonetheless, implementing setback regulations can be controversial when it involves "takings" claims. To avoid such claims, state or local governments compromise by issuing variances, temporary provisions, and revised setback policies. The Coastal Resources Commission in North Carolina, for instance, grants variances if the property owner suffers unnecessary hardships, hardships unique to the property in question, and hardships not caused by the applicant (N.C. Gen. Stat. 113A–120.1). In South Carolina, after *Lucas vs. South Carolina Coastal Council*, the setback provisions of South Carolina's Beachfront Management Act acknowledged

the properties built prior to the Act (US Supreme Court 1992). Also, temporary provisions, such as permits for temporary emergency armoring seaward of setback lines oftentimes become permanent measures as the tendency is not to remove armoring once it is in the ground (Ruppert 2008).

Developers and real estate interests can also complicate the implementation of setback policies at the local level. As coastal property carries high value in places such as Florida, wealthy property owners exert political pressure to build along the coast, and their political power can translate into the ability to obtain construction permits (Ruppert 2008). Shorefront property owners and realtors also opposed setback regulations in Maui because they considered the regulation to deter growth (NOAA 2007b). They feared that they would not able to rebuild after hurricane damages. A compromise was reached when a new ordinance allowed rebuilding if damages were due to fire or non-coastal hazards (NOAA 2007b). The local government also allowed the existing structures to extend into the shoreline setback area to avoid takings claims (NOAA 2007b). As such, problems of takings and opposition from developers reflect conflicts between development and public safety (Platt et al. 2002; Hawes 1998).

3.2 Rolling easement

Unlike most setbacks, which prohibit development seaward of the setback line, rolling easements allow development until the shore turns into an intertidal zone and people and structures yield to migrating shores (Titus 1998). Rolling easements recognize the natural progression of the rising sea and the subsequent migration of coastal vegetation, and can include no armoring (Caldwell and Segall 2007). A rolling easement is a legal device derived from law (statutory or common) or regulatory authority to promote public access, and serves indirectly to protect the people and property from flooding with the gradual retreat of structures landward. The U.S. states Maine, Rhode Island, Massachusetts, South Carolina, Oregon, and Texas all practice some variation of rolling easement (Higgins 2008). Rolling easement options include the relocation of structures, the issuing of conditional building permits that require property owners to demolish structures, the payment of rent to the state for the use of public land, or government purchases of easements once properties have come to sit on public tidelands (NOAA 2007a). It is transferred when the original owner sells or donates the property. The new owner is responsible for understanding easement terms and guidelines.

Easements in the U.S. are defined as legal agreements between a landowner and a land trust or government agency to access privately held properties for public use. One question of the practice of rolling easements is whether it constitutes an easement. The rationale underlying the public access of privately-held properties often stems from the historical use of the land by the public. Unlike traditional easements, rolling easements shift over time as the spatial boundary of the easement rolls with the rising sea. The private land on the beach becomes public property once the land is submerged and/or crosses the vegetation line. This puts into motion a debate over whether easements can move and are not fixed to the land.

In the case of Brannan LLC vs. State, the Texas General Land Office declares that “the Open Beaches Act does not create a public beach easement where none

exists," and "once a public easement to the vegetation line exists, the boundaries of the easement shift as the line of mean high tide and the vegetation line shift" (Brannan v. State of Texas 2010). The Texas General Land Office emphasized that the State enforced the Open Beaches Act by respecting the natural movement of the vegetation line and by making the newly formed public beach accessible to the public. The Open Beaches Act allows the public "a right of use or easement to or over an area by prescription, dedication, or has retained a right by virtue of continuous right in the public" from the line of mean low tide to the line of the vegetation line (*Tex. Nat. Res. Code* Ann. *§61)*. Though options exist for voluntary or forced easement, the Texas case demonstrates a mandatory easement using implied dedication because public beach defined as the area between the line of mean low tide to the line of vegetation was historically dedicated for public use.

Another issue is that the movement of property and people as the sea rises is not systematic. The timing and method of the property relocation is determined on an ad-hoc basis that can generate confusion and "takings" lawsuits. For example, several cases are pending in Texas, including the claims by Carol Severance. She filed claims after realizing that three houses that she owned needed to be removed because they fell on the seaward side of the vegetation line after Hurricane Rita in 2005 (Rosenblum 2008). Her houses are within the jurisdiction of the Texas's Open Beaches Act that enabled a rolling easement over the dry beach. The General Land Office offered Ms. Severance $40,000 per home to assist her in removing or relocating the structure; she refused (Severance v. Patterson 2009). She also entered the FEMA buyout program for homes seaward of the vegetation line while she filed claims, and one house has been approved for a buyout, and a second house is pending approval (Peloso 2010). The Severance case is currently under deliberation in the Texas Supreme Court.

4 Hazard area zoning and building standards

Hazard-related zoning and building standards are land use controls intended to protect the coastal population. They are often framed within the state law where zoning exists, and the local government is responsible for the design and implementation of zoning as a part of local comprehensive planning, growth management, or integrated coastal management. New Jersey, for instance, extends full authority to municipal governments to pursue hazard mitigation, and hazard mitigation efforts rely strongly on the willingness of local governments to consider state objectives in their land use (D'Agostino 2008). As such, the role of local government is significant in the design and enforcement of hazard zoning. Local governments use traditional zoning and subdivision ordinances to prevent development in hazardous locations and restrict the type and density of development in high-risk areas (Olshanksy and Kartez 1998).

Hazard area zoning can be independent or overlaid onto existing zones. Restrictions include the type and extent of development, greater setback or buffer standards, and shoreline stabilization methods. The NFIP employs overlay zones. The government designates the Special Flood Hazard Areas and places hazard-protection restrictions onto existing land use. The process by which local governments establish overlay zones involve three steps: defining the intent and purpose of overlaying the district, mapping the district, and developing specific rules that apply to the overlay zones (Gravin 2001). The Special Flood Hazard Area District established as an

overlay district has priority over all other districts in Bellingham, Massachusetts, for example, and requires that all structural and nonstructural activities be in compliance with the state law (Bellingham Townhall 2010).

Hazard zoning is difficult to enforce because land use decisions are made locally and property rights issues may surface. Obstacles present themselves when the implementation of hazard zoning conflicts with existing land use that favors development interests. Deyle et al. (2008) found that existing land use could not be modified to accommodate Special Flood Area Zones as these zones were politically unpopular given development priorities. In addition, land values of designated hazard areas are known to decrease if a community participates in the NFIP (Dehring 2006). Olshanksy and Kartez (1998) recommend that local governments exercise restrictive land uses in hazardous areas before the land is subdivided. If the land is already subdivided, they advocate the acquisition of individual parcels located in highly flood-prone areas.

Various building standards regulate the construction of buildings including building codes, floodproofing requirements, design standards, and retrofit requirements for existing buildings (Olshanksy and Kartez 1998). One of the most serious problems is the implementation at the local level (Spence 2004). Noncompliance with building code regulations, for instance, is a major cause of severe earthquake and flood damages (Burby et al. 2000). Kunreuther (1996) states that one third of the damage from Hurricane Andrew could have been avoided if building codes had been enforced. Since Hurricane Andrew, Florida has enforced stringent building codes that have improved coastal protection. Changed codes and building standards, however, could drive up the cost of compliance (Dehring 2006). There is also a time lag between flooding events and the establishment of new building codes. New building regulations may not be enforced in time to prevent damage from subsequent flooding.

5 Financial protection

A combination of taxation, insurance, and subsidies provides financial protection against coastal hazards and assists with post-disaster recoveries. These elements are interrelated as insurance does not necessarily cover all the damages and requires other forms of disaster assistance from either the national tax base or national and international aid. This section examines the effects of insurance and subsidies in response to coastal disasters and sea level rise.

5.1 Insurance

Two perspectives exist regarding disaster-related insurances. One is negative in the sense that insurance inadvertently encourages people to continue to build in high-risk areas (Mcleman and Smit 2006). Insurance is said to increase the tax burden as the government shifts the cost of high-risk properties to tax payers in the provision of subsidized insurance (Pompe and Rinehart 2008). Some scholars advocate private insurance as one solution that would minimize government spending. Private insurers, however, tend to avoid financing large disasters when the loss exceeds the insurance company's financial capabilities (Botzen et al 2009; Cummins 2006; Crichton 2008).

As for the buyers of insurance, people are generally reluctant to purchase insurance when premiums are high, perceptions of personal vulnerability to hazard are low, and government assistance is available (Blanchard-Boehm et al. 2001; Van Asseldonk et al. 2003).

On the other hand, insurance is necessary to defray the cost of disaster relief. After disasters, it is costly for the government to finance recovery from its regular budget and special government disaster funds. Without insurance, people could self-insure. This not only strains individual welfare but also diverts resources from other investments, leading to unproductive economic growth (Warner et al. 2009). In addition, insurance is often touted as a useful tool for offering incentives for other disaster risk reduction measures (Herweijer et al. 2009). Differential premiums based on the level of risk provide market signals for people to invest in hazard mitigation or relocate (Kunreuther et al. 2009). The U.S. NFIP, for instance, offers lower premiums in exchange for the adoption of flood-sensitive building codes (US Congress 2008).

Actuarially fair insurance is considered an important policy solution for determining the value of adaptation and capturing the uncertainties that Yohe et al. outline in their paper in this issue. Comprehensive catastrophe insurance or insurance-based climate risk financing also reduces the financial burden on households, business, and government (Hoeppe and Gurenko 2006; Smolka 2006; Schwarze and Wagner 2004). Warner et al. (2009) consider a combination of insurance and other adaptation measures that incorporate built-in mitigation incentives to be desirable (Warner et al. 2009). Kunreuther (2008) argues that long-term insurance can be used to encourage preventive measures. Kunreuther et al. (2009) suggest two principles that would help to guide this insurance policy. The first states that premiums reflect risk. This aligns with Yohe et al.'s assessment in this issue that actuarially fair insurance accounts for all uncertainty. The second principle states that the use of public funding in place of insurance subsidizes low-income residents in hazard-prone areas.

5.2 Subsidies

Subsidies include loans, state financial assistance, tax breaks, and international donor aid. A mix of insurance and subsidy is pervasive in the financing of disasters. In hurricane-stricken areas in the U.S., some affected residents receive both disaster aid and insurance—incentives that limit risk and perpetuate America's high regard for coastal living (Allen and Globe Staff 1999). For example, the U.S. NFIP provides financial assistance by guaranteeing loans for the restoration of buildings ruined by flooding in Special Flood Hazard Areas (Bagstad et al. 2007). Major coastal disasters such as hurricanes and tsunamis lead to national as well as international aid partly due to the visibility of the events through media coverage (Olsen et al. 2003).

6 Compatibilities

A combination of highly compatible policies may provide stronger incentives for the public to protect themselves from the newer challenges of coastal hazards and climate change. Identifying complementarities among policies of relocation, retreat, zoning, and insurance is a first step to understanding their compatibilities. Though relocation is safe in that it avoids the hazard area altogether, economic and social costs run high

as a result of people's reluctance to move. Retreat policies implemented as setbacks and rolling easements are designed to have minimal effect on the natural coastal landscape and offer buffer zones that can serve as a barrier to inundation. Hazard zoning can include areas of relocation and retreat to encourage the enforcement of particular measures such as setbacks and rolling easements. Setbacks and rolling easements can complement one another as well, as when governing authorities practice rolling easements in locations where setbacks are difficult to establish for scientific or political reasons. Insurance and subsidies can indirectly influence zoning, setbacks, and rolling easements. For example, the NFIP establishes requirements for building elevation, sanitary systems, and hazard zoning (Bagstad et al. 2007). Insurers may also lower premiums for those who invest in flood defense (Green and Penning-Rowsell 2004). As noted in Section 4, insurance works most effectively if combined with other modes of adaptation. Thus, a mixture of land use controls and insurance can facilitate appropriate rebuilding and retreat measures in the face of an advancing sea.

Some of the policy solutions can be compatible with engineering responses or natural defenses. Table 1 lists different levels of compatibility ranging from high and medium to low. Relocation complements natural defense as it entails complete evacuation of the area and does not necessitate hard shoreline structures. Setbacks may require some shoreline stabilization. Siting structures sufficiently landward allows for the natural migration of the shoreline and helps to create buffer zones between the sea and human structures, and can thereby preserve intertidal habitats from further encroachment. This, in turn, provides some natural barriers to inundation and shows medium compatibility with natural defense. Rolling easement avoids shoreline armoring and thus offers high natural defense. Because hazard area zones limit development, they could encourage the preservation of vegetation and natural defense. At the same time, these zones have properties in place that may require some engineered defense to protect the structures that are located on them. Depending on how financial incentives are established, insurance and subsidies can be highly or moderately compatible with natural defense and engineering responses. Financial support for relocation, for example, can be highly compatible with natural defense because it moves people away from endangered coastal locations. In addition, a lack of financial subsidies in high-risk coastal areas can dissuade people from building in these areas and can provide a space for natural vegetation and contribute to the formation of a natural barrier to inundation. If insurance and subsidies allow for rebuilding and reconstruction, some shoreline structures are necessary to protect people and property.

Table 1 Compatibilities among policies, natural defense, and engineering responses

Policy	Natural defense	Engineering responses
Relocation	High	N/A
Setback	Medium	Medium
Rolling easement	High	Low
Zoning	Medium	Medium
Financial protection	High/Medium	High/Medium

High mainly complementary, *Medium* complementary with some potential for conflicts, *Low* few complementarities and many conflicts

7 Discussion

Policies of relocation, retreat, and zoning are most difficult to implement in highly developed areas. People are reluctant to change the way they live and resist restrictions on development and reduction of their property values. Deyle et al. (2008) find that people continue and even increase development in areas designated as hazard zones. New land use policies have a better chance of success as people's existing land uses are not affected and property owners have time to prepare for the future. For example, new zoning that requires property owners to abandon properties in low-lying areas over the next century could be successful because those affected may not care about the next century or may not believe in climate-induced sea-level rise (Titus 1984).

Financial incentives can also have unintended consequences. Subsidized insurance and government disaster aids inadvertently encourage increased development in high-risk areas and further spread the cost of risk to the rest of the population. High insurance premiums that account for actuarially fair rates serve as disincentives for people to purchase insurance (Blanchard-Boehm et al. 2001). There are also two extreme population groups relatively immune to financial incentives. The rich and poor in the coastal zone tend to return to and rebuild in the same hazardous location after flooding has occurred. The rationale is that the rich can afford insurance and protection, while the poor cannot afford to move away, and so seek low-rent housing in unsafe locations (Smith et al. 2006).

What are the alternatives to the problems of existing policies? One is to investigate how policies are implemented at the local level. Such a micro-study would reveal the way these policies work, and would offer opportunities to examine the process by which locals understand and practice these policies. For example, in South Carolina, Yohe and Neumann (1997) found that state septic system regulations have been more effective in restricting reconstruction after Hurricane Hugo than erosion or zoning regulations. Local investigations generate new knowledge of local conditions and identify gaps in policy design, adoption, and implementation. Findings from local case studies can be circulated to decision-makers at local and national levels, can be incorporated formally into decision-making processes, and can create better policies.

Another option is to examine the trade-offs and synergies of various solutions of policy, natural defense, and engineering. Each solution offers different temporal and spatial aspects of adaptation. Even though seawalls, dykes, sandbags, and beach nourishment offer shorter term relief than do natural defense options, engineered solutions are a very popular response to the threat of coastal inundation (Mangone 2010). Long-term solutions such as vegetation barriers and rolling easements require people to adapt to nature by retreating in the face of rising sea levels. In the coastal zone, different facets of these coastal adaptation solutions coexist. It is difficult to choose one solution over another because a multitude of factors ranging from coastal geomorphology and oceanography to the economics and politics of the place must be taken into account. As such, favoring hard engineering solutions over natural barriers or vice versa is no longer an option; these solutions need to be considered in tandem so as to survive coastal hazards accompanied by rising sea levels and possibly more intense and frequent storms. Identifying complementarities and compromises that lead to sustainable solutions to coastal adaptation is vital. Are there infrastructure and engineering solutions or conservation measures that enable

affected stakeholders to compromise on setback lines or coastal retreat policies? Do flood insurance and disaster aids enhance the implementation of setback and managed retreat policies, or do they hamper it? This type of research requires place-based studies that translate into modeling trade-offs and synergies for comparison and generalization (see this issue's *Editorial*).

8 Conclusion

Coastal adaptation in terms of relocation, retreat, zoning, and financial protection depends largely on the economic and social cost of protection. Even if funds are available to compensate for development and property losses, people are often unwilling to move because of intangible values such as local attachment, cultural and natural amenities, and community identity. This raises questions as to the social cost of relocation and retreat policies. Furthermore, political pressure from landowners and developers to avoid retreat or relocation makes it difficult to implement existing coastal hazard policies let alone climate change adaptation policies. The competing interests of local politicians, developers, state officials, and environmentalists often lead to regulatory gridlocks and stalled coastal programs (Gaul and Wood 2000).

Two dramatic remedies could be conceived of. One calls for a strong state capable of enforcing these policy measures. A strong state could increase the effectiveness of coastal protection and adaptation. The other possibility involves a dramatic restructuring of the governing system following a large-scale disaster. Disasters do function as agents of change, and can bring about positive restructuring of disaster policies (Cheong 2010). However, such extreme measures are unrealistic and unpopular, particularly when they are not supported by the public culture of safety (Spence 2004).

Realistically, what can be done is to understand the process of policy implementation and assess local coastal adaptation strategies. The IPCC (2007), which evaluates past coastal adaptation strategies, lists the transfer of property rights, political will, education at all levels, and socio-economic conditions as major elements of a successful adaptation. These factors need to be considered in the analysis of trade-offs and synergies of engineering responses, natural barriers, and policy options. These can be assessed specifically, for different places, and then generalized so as to produce transferable frameworks. Theoretically, coupling existing hazard mitigation policies with coastal management and community management can better inform long-term and comprehensive understandings of coastal adaptation at different scales (Heinz Center 2000). Theories informed by empirical findings can feed into policy formulation and decision-makings, and, in turn, induce better implementation.

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