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Guest editorial on coastal adaptation

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Coastal adaptation has become an increasingly important area of study as the significance of climate change rises and coastal hazards continue to damage coastal space and communities. Coastal adaptation solely for climate change is not possible given the financial, infrastructural, and political constraints. A more realistic approach is to use existing methods and strategies of coastal adaptation that inform and meet new challenges of climate-change-induced vulnerabilities. The IPCC has, since 1990, incorporated adaptation methods and strategies on coastal erosion and inundation in its assessments and has identified three generic adaptation options: retreat, accommodate, or protect.

This special issue divides these options into engineering, vegetation, and policy solutions based on their respective disciplinary and science background. It draws from five papers presented at a symposium entitled "Coastal Adaptation," held at the 2010 Annual Meeting of the American Association for the Advancement of Science (AAAS). This issue is timely since increased attention is now being paid to managing the risks of extreme events by combining traditional disaster management strategies with climate change adaptation. Indicative of this is the forthcoming IPCC Special Report on managing climate extremes. The objective of the special issue is to discuss the roles of these three major solutions and offer a preliminary assessment of trade-offs and synergies. They are applied to a study of the economics of adaptation, with insurance policy operating as a major underlying factor in assessing and managing risk , and New York City serving as a case study for coastal adaptation planning with sea-level rise considerations.

Coastal adaptation to hazards has been relatively well developed building on coastal engineering and management practices (Nicholls et al. 2007a, b). A historical

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reliance on engineered shoreline protection has been gradually supplemented by soft protection measures such as beach nourishment as well as flood insurance policies and land use regulations (Platt 1994). Furthermore, ecosystem protection and restoration are increasingly recognized as legitimate coastal protection services that provide vegetation barriers to coastal inundation. Recently, policy solutions such as coastal setback lines, rolling easements, building codes, and zoning have also resurfaced as potent forces to combat coastal hazards coupled with climate change.

Traditionally engineering approach and ecosystem conservation often have stood in opposition as hard shoreline structures destroy coastal habitats, worsen coastal erosion, divert ocean currents, and prevent the natural migration of shores. A natural migration of shores without structure translates into the abandonment of properties in the coastal zone, and is at odds with property rights and development. As such, engineering, natural defense, and policy can be more conflictual than complementary. Nonetheless, all these responses are used in combination in many locations. For instance, all of these adaptation strategies will likely be employed to protect New York City from inundation as illustrated in the final paper of the issue by Rosenzweig et al. (2011). Because of mixed responses and short- and long-term interests and values, trade-offs are an important aspect of coastal adaptation solutions. General principles that guide trade-offs are slow to develop (Nicholls et al. 2007a, b). Prior to the development of principles, however, complementarities and compatibilities must be assessed when considering the necessity of engineering responses, natural defense capabilities, and policy options that this issue has begun to investigate.

An additional theme shared by these papers is the need to be specific about local contexts. To be useful, trade-offs and synergies of coastal adaptation should be particular to the ecosystems and coastal geomorphology, existing hard and soft structures, and the social systems. Gedan et al. signal the importance of context-specific measurements of wetlands protection as wetlands can be affected by hydrological and geomorphological forces. Francis et al. state that location size matters as a larger test bed may enhance the synergistic value of wetland restoration and infrastructure protection. One of the most important elements of a policy solution is property rights, and they differ from place to place (Nicholls et al. 2007a, b). Most notably, the enforcement of property rights vastly differ because of cultural disparities. One system may opt for litigation where another will abide by government regulations, while another system may prefer communal negotiation. In this context, place-based research is necessary to identify trade-offs and synergies, and understand the mechanisms of the way they function in specific locations.

The papers presented here address three key aspects of coastal adaptation—vegetation, engineering, and policy solutions. A common goal of these efforts is the search for sustainable adaptation for the coast. The first paper by Gedan et al. (2011) examines the role of wetlands and mangroves in protecting the coast from inundation. Wetland plants dampen waves, slow water velocity, and prevent erosion. The authors argue that protection levels are context-dependent as nonlinear variation in attenuation exists because of different biological and geomorphological characteristics of the coast. Storm heterogeneity can also produce different wave attenuation rates. An important advance is that wetlands are likely to offer the greatest protection for smaller storms that occur more frequently. This becomes highly relevant in the event that the frequency distributions of disruptive climatic events escalate along with the rise of sea-levels.

The second paper by Francis et al. (2011) tests three scenarios of electric power networks with and without wetland restoration and with and without underground infrastructure hardening in a hypothetical town of 5,000 located between Category 3 and 5 hurricane storm surge zones on the North Carolina coast. As an important theme of the issue, the paper investigates the synergistic effects of wetland restoration and infrastructural protection. Contrary to popular belief, the authors conclude that a 'do nothing' option of keeping all power lines overhead without wetland protection is preferred. The synergistic effects of wetland restoration and infrastructure hardening, they find, is also very limited. This conclusion is critical as it reveals the level of practicalities of the proposed solutions, as well as the difficulties of combining engineering and natural defense in a mutually beneficial way. It also highlights the need for the higher valuation of ecosystem services.

The third paper by Cheong (2011) discusses policy solutions to coastal inundation in the U.S. focusing on new and old land use and insurance policies in defense against coastal erosion and inundation. Some important examples of the property rights and financing are included, providing insights into the benefits and challenges of coastal hazard policy implementation as well as the potential for applications with sea-level rise. One innovative approach of the paper is a preliminary assessment of compatibilities of different policies as well as complementaries with engineering responses and natural defense. They provide a guidance to evaluating trade-offs and synergies of different adaptation responses. In addition, the emphasis is on a realistic assessment of current hazard management practices specific to local contexts, and the necessity of combining hazard mitigation policies with coastal management and community management to inform policy formulation and decision-making.

The fourth paper by Yohe et al. (2011) assesses the role of actuarially fair insurance as a policy response to sea-level rise and as a defining factor in specifying the baseline against which the benefits of adaptation should be valued. It illustrates two sea-level rise scenarios with green adaptation, and case studies of two locations in Boston with and without insurance: one urban location with infrastructure protection and one suburban location with environmentally benign design. A significant development of the paper is that actuarially fair insurance is a primary determinant of the value of adaptation. Without actuarially fair insurance, the value of adaptation rises as risk aversion increases, and this accelerates other adaptations that require significant upfront investment such as engineered structures. This finding illustrates the effects of insurance policies (i.e., risk-spreading mechanisms that make risk neutrality a workable assumption) on other adaptation measures.

The fifth paper by Rosenzweig et al. (2011) illustrates the procedures, tools, and strategies prepared by the New York City Panel on Climate Change. The paper reflects the central themes of the special issue as it examines the current status of high risk infrastructure and generates adaptation planning utilizing regulatory policies, engineering responses, and natural defense. Another significant contribution is the innovative discussion of climate protection levels derived from current practices and regulatory codes that incorporate both the science of climate change and social/technical responses on a local scale. As a case study, the paper provides cities with transferable guidelines on the various aspects of coastal adaptation to climate change.

The five papers in the special issue have substantially increased our understanding of the role of coastal adaptation solutions and allowed us to define the next stages of adaptation research and initiatives. The special issue offers a unique approach that pursues interdisciplinary research to integrate marine ecology, geomorphology, coastal engineering, probabilistic risk analysis, policy analysis, economics of adaptation, and adaptation planning. This begins to fill the gap in coastal adaptation analysis focusing either on institutions and policy using integrated coastal management with a secondary component of natural sciences and engineering, or marine sciences that often omit the perspectives of engineering and risk analysis. What this special issue has accomplished is to start the inclusive and integrative process of these areas to solve the new challenges of coastal hazards accompanied by rising sea levels and possibly more frequent and intense storms. Discussants at the AAAS session indicate that these papers represent a first step. Stephen Schneider warned authors and practitioners to include uncertainty in their analyses and to think carefully about discount rates. Barry Smit expressed concern that some of the papers, particularly the one by Yohe et al. (2011), did not translate their conclusions into language that would be useful to decision-makers.

On behalf of the conference participants, I wish to thank the AAAS for providing the venue to discuss and present the themes of coastal adaptation. I also gratefully acknowledge the constructive comments and encouragement from the discussants, Steve Schneider and Barry Smit and appreciate the contribution of the moderator, Barbara Ransom at the AAAS session. Special thanks to Katarina Kivel, Assistant Editor of Climatic Change, for her constant assistance. Finally, I wish to thank all contributing authors to this special issue and the reviewers of their manuscripts for timely responses and excellent work.

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