

Coastal Zones and Climate Change

David Michel

Amit Pandya

Editors

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The Henry L. Stimson Center.

The Henry L. Stimson Center
1111 19th Street, NW, 12th Floor
Washington, DC 20036
Telephone: 202.223.5956
Fax: 202.238.9604
www.stimson.org

Introduction

Coastal areas figure among the most vulnerable of all environments to global climate change. Projected impacts from global warming include rising sea levels, stronger tropical cyclones, larger storm surges, increasing sea surface temperatures, and—as the oceans absorb more of the carbon dioxide that human activities emit to the atmosphere—growing acidification of surface waters. For coastal ecosystems and communities, the repercussions could be considerable, threatening the livelihoods, health, and welfare of millions of people. More frequent and severe storms can inundate low-lying coastal zones, destroying infrastructure and displacing populations. Higher water levels and larger wave surges can contribute to accelerated shoreline erosion and retreat. Mounting sea levels can also exacerbate saltwater intrusion into the rivers and aquifers that furnish freshwater to coastal settlements. Warmer water temperatures and acidifying oceans can degrade the ecology of coral reefs and threaten the artisanal and commercial fisheries that nourish many seaboard communities.

Climate threats to coastal regions reverberate well beyond the shoreline. Both farmland affected by saltwater incursion and fisheries menaced by higher ocean acidity feed populations distant from the water's edge. Ports, roads, rail lines, and other facilities that could be damaged by cyclones and storm surges serve producers and consumers located far inland. Refugees fleeing coastal flooding may be driven into neighboring countries or even further afield. Countering such risks will present both opportunities for international cooperation and possibilities for international conflict. Many of the coastal countries most vulnerable to global warming have contributed little to world emissions of greenhouse gases, and many possess limited capacity and few resources to counter or cope with prospective climate damages. These nations will require international assistance—technical, financial, and institutional—to enable them to adapt to and rebound from the looming greenhouse impacts that they cannot avoid.

The countries of the Indian Ocean rim, from East Africa and the Arabian Peninsula to South and Southeast Asia, are particularly susceptible to climate change's coastal impacts. One 2007 study assessing the climate threat to low-lying coastal settlements found that 6 of the 10 most vulnerable states worldwide—ranked by total population living in exposed areas—lie on the Indian Ocean.¹ Another analysis, in a 2009 World Bank paper, examined

the dangers to developing nations from potential storm-surge disasters. It concluded that 5 of the 10 countries with the greatest percentage of coastal population at risk, 5 of the 10 countries with the highest percentage of coastal GDP at risk, and 6 of the 10 countries with the highest proportion of coastal urban areas at risk are located around the Indian Ocean basin.² Climate pressures especially endanger small or low-lying islands like Mauritius, the Maldives, and Seychelles. Major infrastructure in these countries—roads, airports, seaports, towns—is situated almost exclusively along the coasts. Moreover, most small islands possess only limited freshwater resources, making them all the more vulnerable to saltwater invasion of their aquifers or diminished rainfall. Human exposure to such hazards will almost certainly increase with ongoing coastal development. Under Intergovernmental Panel on Climate Change (IPCC) scenarios, the world's coastal population could grow from 1.2 billion in 1990 to anywhere from 1.8 to 5.2 billion people by the 2080s.³

Coastal Zones and Climate Change examines the environmental stresses on coastal areas of the Indian Ocean and the resulting dilemmas confronting coastal managers and policy-makers in a warming world. It presents analyses by experts in the region and at Stimson. The work for the volume had its inception in a workshop cohosted by Stimson and the Regional Centre for Strategic Studies (RCSS) in Colombo, Sri Lanka, March 19–20, 2009. The workshop gathered experts from academia, think tanks, government, and NGOs to consider emerging climate risks and potential policy responses.

In the collection's opening paper, Nirmalie Pallewatta surveys the diverse ecology of the Indian Ocean's coasts and details the observed and prospective climate change impacts on the region's ecosystems. Coastal ecosystems count among the most ecologically dynamic and productive on Earth. They provide vital ecosystem goods and services, supplying food, fuel, and materials, and regulating hydrological cycles and nutrient flows. Yet society largely undervalues these roles, leading to the unsustainable exploitation of coastal resources and the degradation of essential ecosystem functions. Global warming threatens to exert additional stresses on coastal areas. Climate impacts such as stronger storms, sea level rise, and increases in the temperature and acidity of ocean waters will interact with and exacerbate the effects of other environmental and human pressures. Beyond certain thresholds, Pallewatta warns, these pressures could trigger dramatic and potentially irreversible damage to coastal fisheries, coral reefs, mangrove forests, and other vulnerable ecosystems.

Climate change exposes coastal populations to several dangers. As cyclones grow more frequent and intense, they will place more coastal communities at risk from inundation and erosion. Mounting sea levels will produce higher storm surges, carrying flooding farther inland. As sea levels rise, saltwater will invade rivers and aquifers, contaminating the freshwater sources on which many settlements depend for drinking and farming. These

threats to the Indian Ocean seaboard are explored in the volume's second paper by Golam Rabbani, A. Atiq Rahman, and Nazria Islam. The authors then take a closer look at coastal management strategies and policy challenges in Bangladesh and Sri Lanka. Bangladesh has formulated a national Climate Change Strategy and Action Plan that includes coastal adaptation. Sri Lanka has created a dedicated Coast Conservation Department. Nevertheless, the authors find that coastal management suffers from institutional weaknesses in both countries, while decision making often remains fragmented among different agencies and across different sectors. Policymakers must improve coordination at all levels, they counsel, and find effective ways to increase the involvement of local stakeholders in policy design and implementation.

Egypt presents in microcosm nearly the full array of coastal risks arising from climate change. Coastal flooding could inundate large swaths of the densely populated Nile Delta, while saline intrusion from sea level rise could taint thousands of square kilometers of prime cropland, imperiling the agricultural sector that employs one-third of Egypt's labor force. At the same time, increasing acidity and warming surface water temperatures harm the coral reefs and marine life that attract tourists to the Red Sea, potentially jeopardizing the economy of a region that provides 90 percent of the country's tourism revenue. In his paper, Mohamed El Raey assesses these and other prospective climate risks and evaluates their implications for the Egyptian economy and society. He concludes that policymakers must elaborate a national integrated coastal management plan to guide climate adaptation strategies, and he calls upon the international community to help Egypt confront these challenges with technical, financial, and capacity-building assistance.

The small island developing states (SIDS) make minimal contributions to the greenhouse gas emissions that cause climate change, yet they are perhaps the most vulnerable of all countries to global warming's impacts. They have also been among the most active of all countries in pressing the international community to combat the greenhouse threat. Alain De Comarmond and Rolph Payet maintain that SIDS can lead the development of green technology as well as green diplomacy. Drawing on case studies of soft-engineering coastal protection measures in Seychelles, safe island relocation centers in the Maldives, and biofuels production in Vanuatu, they argue that SIDS have made significant strides in innovating and adapting sustainable technologies suited to their individual circumstances. Even so, to effectively realize their considerable potential as incubators of green technology, SIDS must supply the enabling policy and institutional frameworks, removing regulatory hurdles, building up their R&D capacities, and providing the necessary infrastructure and market opportunities.

All the countries of the Indian Ocean region will have to take action to adapt to the effects of global warming. Poh Poh Wong describes the various approaches available for reducing the exposure and sensitivity of coastal areas to climate impacts and explains the adaptation

challenges coastal managers must surmount. He finds that although the individual countries of the Indian Ocean region struggle with many of the same issues, they lack a common regional policy framework for addressing their shared problems. Such a framework could fulfill several useful roles. It could facilitate wider data collection, distribution, and evaluation and help establish early warning systems at the regional scale corresponding to environmental risks that transcend national boundaries. It could also foster technology transfer and disseminate best practices. Ultimately, Wong contends that successful adaptation will require both institutional initiatives and conceptual innovations to meet the climate threat to coastal zones.

The papers by the experts from the region furnish close studies of crucial issues and actors. They examine climate impacts on coastal ecosystems, explore adaptation strategies, and illuminate the policy pitfalls and possibilities facing particular countries around the Indian Ocean rim. In the book's concluding paper, David Michel ranges across these analyses and draws out a number of key themes. Coastal managers throughout the region, he notes, confront many of the same environmental threats (e.g., sea level rise, storm surges, saltwater intrusion) and many of the same societal risks (e.g., mass population displacements). At the same time, decision makers must grapple with certain specific policy problems going forward, including inadequate financial resources and enduring institutional obstacles. More broadly, Michel argues, policymakers will need to reconcile the potential tensions between crafting holistic coastal strategies integrating multiple actors, uses, and demands at multiple scales and crafting policies adapted to local circumstances and priorities.

Coastal areas are dynamic regions where terrestrial and marine ecosystems intersect and interact with human socioeconomic systems. The analyses in this volume reflect that complexity. No single paper can encompass the whole of the relations between climate change and coastal zones, but each piece can help illuminate an important set of issues. Taken individually, we think that each paper, like the twist of a kaleidoscope, brings a new constellation of questions into focus. Taken together, we hope the papers provide a fuller picture of the environmental pressures and the policy choices and challenges that coastal managers and national and global decision makers will confront in a warming world.

Notes

1. Gordon McGranahan, Deborah Balk, and Bridget Anderson, "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones," *Environment and Urbanization* 19, no. 1 (2007).
2. Susmita Dasgupta et al., "Sea-Level Rise and Storm Surges: A Comparative Analysis of Impacts in Developing Countries," Policy Research Working Paper 4901 (Washington, DC: World Bank, 2009).
3. R. J. Nicholls et al., "Coastal Systems and Low-Lying Areas," in M. L. Parry et al., eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007).