Troubled Waters

Climate Change, Hydropolitics, and Transboundary Resources

David Michel
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Editors

STIMSON
PRAGMATIC STEPS FOR GLOBAL SECURITY

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Contents

The Energy and Resources Institute (TERI) was formally established in 1974 in New Delhi with the purpose of tackling the acute problems that mankind is likely to face in the years ahead resulting from the depletion of the Earth's energy resources and the pollution their unsustainable use causes. The Institute works to provide environment-friendly solutions to rural energy problems, tackle global climate change issues across continents, advance solutions to the growing urban transport and air pollution, and promote energy efficiency in Indian industry. TERI is the largest developing country institution devoted to finding innovative solutions toward a sustainable future. TERI has established affiliate institutes abroad: TERI-NA (North America) in Washington, DC; TERI-Europe in London, UK; and has a presence in Japan and Malaysia.

The Henry L. Stimson Center, located in Washington, DC, is a nonprofit, nonpartisan institution devoted to offering practical solutions to problems of national and international security. Since its establishment in 1989, Stimson has been committed to meaningful impact, a thorough integration of analysis and outreach, and a creative and innovative approach to global security challenges. Stimson has three basic program areas: reducing the threat of weapons of mass destruction, building regional security, and strengthening institutions of international peace and security. These program areas encompass work on a wide range of issues, from nonproliferation to transnational challenges in Asia, from UN peacekeeping operations to analyzing the resources needed for 21st century statecraft.

Preface

Stimson's *Regional Voices: Transnational Challenges* project is devoted to enhancing the information and analysis available to US policymakers about emerging transnational security challenges in the Middle East, South Asia, Southeast Asia, and East Africa. The project draws on analysis by technical and subject experts, as well as by political and strategic thinkers.

The knowledge and analysis are developed by means of dialogue among experts from various disciplines and occupational backgrounds. Our work includes the organization of workshops in the regions, partnerships with regional institutions and individuals, interviews in the field, and research. We have sought the input of experts and practitioners who constitute new voices in the conversation with the US government. We have not shied away from perspectives that dissent from conventional wisdom, as long as they represent significant bodies of opinion in the countries of the regions.

In 2007, we organized our work by region and sought to arrive at an understanding of perspectives specific to each. This was reflected in our 2008 publication *Transnational Trends: Middle Eastern and Asian Views.* During 2008, we have engaged in dialogue and collaboration across all the regions and organized our work topically on themes as varied as the political economy of natural resources, climate change and river systems, maritime resources and security in the Indian Ocean, and the relationship between Islam and politics.

We have tried to integrate these varied inquiries by asking the following overarching questions:

- What are the key relationships among social, economic, environmental, technological, and political trends? How do these trends relate to traditional security concerns? What new sources of instability, crisis, or conflict are found in these, and with what consequences?
- How does the current public policy debate address the technical, governance, and cultural challenges of these specialized subject areas?

- How do political structures and cultural traditions constrain or facilitate effective responses?
- What are the current examples and future opportunities for transnational cooperation?
- What are the social, political, and security consequences of rapid change?

We have sought throughout to maintain a transnational perspective, to look at trends or threats that transcend national borders or are national in scope but recur in many societies in a region. In all our conversations, conferences, meetings, roundtables, and focus groups, we have sought to elicit the most candid possible discussion, and we have done so by explicitly placing all conversations off the record and not for attribution.

Each volume in the present series consists of essays on some of these questions by experts and thinkers from the regions covered, accompanied by one or more essays by Stimson scholars designed to synthesize and analyze our findings and describe the key trends that we have noted.

Amit Pandya
Director, *Regional Voices: Transnational Challenges*

Acknowledgments

This volume would not have been possible without the generous contributions of time, energy, and intellectual analysis of numerous experts abroad and in the United States; at our partner institution, The Energy and Resources Institute (TERI); and at Stimson. In addition, many people worked tirelessly behind the scenes to shepherd it through all stages of design, editing, formatting, and publication.

Our partner TERI deserves special thanks for helping the *Regional Voices* project develop and carry out the workshop in Delhi September 5–6, 2008, which formed the basis for this volume. TERI experts Ligia Noronha, Ashok Jaitly, and Jayashree Vivekanandan were incredibly gracious, accommodating, and effective co-hosts of the workshop. Syed Iqbal Hasnain's expertise on glaciers added a very important dimension to the discussions over the two days.

I also wish to express deep appreciation to the meeting participants and interviewees who provided valuable cross-regional and multidisciplinary insights into the complex issues surrounding transboundary water resources and climate change. These include a group of knowledgeable experts in Washington who generously helped shape the conceptual and intellectual side of the workshop and indirectly this volume. Experts consulted in preparation for the Delhi workshop and in the research for this volume are listed in appendix 2. I am also grateful to many others not named here who provided sound advice, information, and assistance.

I am indebted to chapter authors Ashok Jaitly, Mohamed Abdel Raouf Abdel Hamid, Khairulmaini Osman Salleh, Jayashree Vivekanandan, and Sreeja Nair for their valuable analytical contributions and patience with the process of publication. In addition to writing a chapter for this collection, Kendra Patterson, Research Associate on the *Regional Voices* project, performed essential roles in both the organization of the Delhi workshop and the coordination, research, and editorial work for the volume.

This book owes its existence to the energy and efforts of the *Regional Voices* team and others who worked many minor miracles. Director Amit Pandya, who coedited this volume, provided vision and intellectual leadership. Stimson's Director for External Relations,

Nancy Langer, played a major part in bringing this volume to completion, as did Laura Kim, who is largely responsible for the production values. I am grateful to Kendra Patterson and Elizabeth Benedict for their extensive editorial work, and to the project's indispensable Contract Analyst Nicole Zdrojewski, who manages operations for the entire project. Project interns David King and Max Mealy provided essential research assistance.

Finally, I owe my sincere apologies and thanks to anyone I have inadvertently failed to properly acknowledge.

David Michel
Research Fellow, *Regional Voices: Transnational Challenges*
January 2009

Introduction

Global climate change presents the most significant of all the world's environmental challenges. Every country contributes to growing greenhouse gas emissions, and every country will bear the ecologic and socioeconomic consequences of worsening greenhouse warming. Climate is an elemental component of the natural environment within and against whose bounds human civilization has developed and prospered. Left unchecked, continuing global warming could cause worldwide social and environmental disruptions.

Climate change will particularly affect the world's shared freshwater resources. Shifting precipitation patterns and increased melting of mountain glaciers will disrupt the upstream sources that nourish river waters, upsetting the timing and quantity of downstream flows. Rising sea levels will exacerbate saltwater intrusion into many rivers' lower reaches. Stronger storm surges may inundate low-lying coastal deltas. Should climate change alter the amount or distribution of river resources, riparian states may suffer both chronic pressures, such as decreased freshwater availability, and acute crises, such as flooding or drought. Both types of threats can impair food production, endanger public health, stress established settlement patterns, and jeopardize livelihoods and social well-being.

Troubled Waters: Climate Change, Hydropolitics, and Transboundary Resources examines the environmental dangers and policy dilemmas confronting the sustainable management of shared water resources in a warming world. It presents analyses by regional experts as well as by Stimson staff. The content of this volume draws substantially on a two-day cross-regional workshop co-hosted by Stimson and The Energy and Resources Institute (TERI) in Delhi September 5–6, 2008. The workshop focused on the impacts of climate change on major transnational river basins and gathered experts from academia, think tanks, NGOs, public service, and the private sector. The basis of our analysis also includes interviews and literature from the field, as well as consultations with US experts.

In the collection's opening paper, Jayashree Vivekanandan and Sreeja Nair first set out the array of threats that greenhouse warming poses through shared water supplies and systems to human well-being, from compromising food security, to undermining development goals, to endangering public health, etc. They then sketch an analytical framework for understanding the complex web of resulting policy puzzles. Both global climate governance

and sustainable water management must grapple with pervasive mismatches between the national political level at which key decisions are made; the individual, societal, and economic levels where the actions generating environmental change occur; and the ecosystemic levels at which the environmental consequences unfold. Effectively addressing these challenges, they show, will require policymaking structures and processes that can successfully encompass multiple scales from the local to the global, while also navigating the disparate perspectives of diverse stakeholders situated at levels extending from households and communities to the national, regional, and international.

The volume is divided into two sections. In "Perspectives from the Regions," experts from South Asia, Southeast Asia, and the Middle East provide an introduction to the array of complex interlinkages characterizing climate change and water and explore some of the key issues in their respective regions.

South Asia presents a microcosm comprising nearly the entire range of environmental risks and policy problems arising at the intersection of global warming and water management. In his contribution, "South Asian Perspectives on Climate Change and Water Policy," Ashok Jaitly assesses the subcontinent's vulnerability to climate-induced strains on common freshwater supplies already stretched thin from the increasing demands imposed by population growth, expanding industrialization, and intensifying agriculture. On many fronts, he concludes, the region faces an incipient water crisis, posing challenges that its existing management systems—too often burdened by ineffective regulatory mechanisms and fragmented institutions—appear ill-prepared to surmount. Surveying the prospects for tensions over the region's transboundary waters to aggravate international conflicts, he urges the countries of South Asia to devote renewed efforts to dialogue, negotiation, and cooperative management of their shared resources.

Global warming will affect every country on Earth, but its risks will prove especially damaging to developing countries. Farming, fisheries, forestry, and other environmentally sensitive sectors represent significant portions of the economies of most developing nations, making them particularly vulnerable to climate impacts. In "Climate Insecurity in Southeast Asia: Designing Policies to Reduce Vulnerabilities," Khairulmaini Osman Salleh asks how the countries of the Association of Southeast Asian Nations can craft greenhouse policies to increase the resilience and reduce the exposure of the poor and marginalized among their populations. He calls on the nations of the region to incorporate climate change into the poverty line indexes that inform their development policies. Then, looking more closely at livelihood structures in three low-income groups—the urban poor, the highland communities of major river basins, and certain coastal areas—he maps a "geography of vulnerability" and discusses how current and potential climate change adaptation and capacity-building programs at these community levels should be integrated into national, regional, and international development policies.

In the section's final paper, Mohamed Abdel Raouf Abdel Hamid takes up the particular challenges that global warming poses to the Arab nations, focusing on the oil-rich but water-poor countries of the Persian Gulf. These states figure as the world's heaviest per capita emitters of greenhouse gases. At the same time, these desert states count among the most vulnerable countries to the effects of climate change. Indeed, so scarce already are freshwater supplies in the region that the six nations of the Gulf Cooperation Council depend on desalination plants for some two-thirds of their needs on average. Even so, each of these fossil fuel–producing countries remains acutely conscious that global efforts to curb carbon emissions strike at the historic engine of their economic prosperity. Raouf concludes that Arab awareness of the climate threat is growing among policymakers and publics alike. Yet governments have been slow to craft national action plans, and their international policy engagement is low. While the Arab nations have begun many promising initiatives, he argues, they must further develop measures and incentives to reduce their carbon profiles, promote clean energy technologies, and combat the adverse impacts of climate change.

In the volume's second section, "Interpreting the Trends," Stimson analysts pick up and expand on two cross-cutting issues—integrated water management and climate risks to environmental security—that run as recurring threads through the four regional contributions.

First, Kendra Patterson makes "A Case for Integrating Groundwater and Surface Water Management." These two sources of fresh water are typically treated as distinct supplies, studied and managed separately, often by separate authorities. Rivers, lakes, and other surface waters are considered renewable flows, part of dynamic hydrological cycles. Most groundwater represents finite stocks, confined in nonrenewable fossil reservoirs. Yet both surface and groundwater can straddle boundaries and, for shared rivers as for shared aquifers, withdrawals made by one user affect the water supply available to the others. Patterson takes lessons from the Ganges-Brahmaputra river system between India and Bangladesh, on the one hand, and the Nubian Sandstone Aquifer in North Africa, on the other, to argue that shared groundwater and shared surface water alike must be managed holistically if they are to be managed sustainably. In both cases, water managers must strive to incorporate and reconcile the demands of multiple users. By the same token, where demands can be met by drawing on both surface and groundwater, policymakers must integrate their handling of the two. Together, the resources comprise the total water available to their riparians. Where climate change or other pressures increase the stresses on one source of supply, so users will tend increasingly to exploit the other. If policymakers govern either resource in isolation, they risk mismanaging both.

In the concluding paper, David Michel evaluates whether climate change impacts on shared freshwater supplies could produce conflicts that might threaten global security. He

judges the outbreak of full-scale water wars unlikely. Historically, riparian states in transnational basins have deployed their diplomats and drawn up cooperative agreements to manage shared waters far more often than they have deployed armies and drawn their swords to settle disputes. But he cautions that open warfare between nations is not the only risk to peace and prosperity posed by greenhouse pressures on transboundary water resources. Droughts, floods, and frictions over shared rivers, he finds, are already fueling violent instability within states as well as between them. Rising climatic stresses on common waters will put new and perhaps unprecedented strains on cooperative governance institutions at the local, national, and international levels. He proposes a reexamination of the human security issues surrounding global warming and global water to illuminate where the potential flashpoints lie and guide decision makers in designing policies to head off or defuse the prospective tensions that could ignite future conflicts.

No one volume can supply a comprehensive view of such a complex and continually evolving subject. We have not attempted to produce such a book. Instead, adopting diverse, intersecting angles of approach, each author charts the regional and international terrain from a distinct vantage. Individually, their contributions insightfully explore salient aspects and suggest possible paths through the thickets of global climate governance and transboundary water policy. Together, their complementary and contrasting viewpoints vividly illuminate the contours of this difficult realm, providing the added depth and dimension afforded by the interplay of multiple perspectives.

Climate Change and Water: Examining the Interlinkages

Jayashree Vivekanandan and Sreeja Nair

Governance at all levels, from international to local, is facing challenges that are transnational and global in nature. States are coming to terms with issues that do not fall wholly under their sovereign control, and find themselves having to cope with problems that may originate beyond their territorial borders. Climate change is such an issue. In attempting to address it, states are compelled to share their policymaking and implementation with a host of other actors at the international and subnational levels.

This paper seeks to engage with these policy dilemmas in the context of the pressures climate change is adding to existing water crises around the world. The transboundary and transnational forces exerted by climate change are fracturing the singular statist frame within which water as a resource was conventionally understood, appropriated, and governed. The paper is divided into three broad sections. The first examines the characteristics intrinsic to climate change and water resource management that make their interface problematic. In the second section, the paper outlines the pathways through which climate change affects water, in terms of both the quality of the resource itself and its larger relationship with natural and human systems. Lastly, the paper explores the key factors or dimensions that mediate this multifaceted interface. It acknowledges the efficacy of existing governance institutions, and the simultaneity of macroprocesses and microbehavior that exert conflicting pressures on the state.

The Complexity of Climate Change and Water

The Politics of Interlinkage

Effective governance of the climate change issue is complicated because of the different scales involved: the level at which action leading to environmental change occurs often differs from the level at which decisions regulating such action are taken. This is further compounded by the fact that water is a transboundary natural resource in its reach, uses, and implications. Rivers, lakes, and oceans traverse multiple states and tie them into common ecosystems. Different water bodies pose diverse challenges to states and communities in

distinct ecosystems. For instance, lakes are more vulnerable to overuse than rivers because of their low regeneration capacity. Rivers are susceptible to sedimentation and the transmission of pollution downstream. Communities living in lower riparian countries depend on water flows from upper riparian states for livelihoods in water-dependent sectors such as agriculture and fishing.

Water has become highly politicized because it is a transboundary resource that is almost always appropriated at a level that does not coincide with its ecosystem limits. This creates management issues and politicization over water rights, distribution, and pricing among the various states through which a river traverses. The manner in which different stakeholders reconcile their interests is key to determining responses to climate change.

There is another crucial way in which the different levels of political control are interconnected, requiring a layered approach to governance: that of the vulnerability of the local level to higher level actions. The resilience and adaptive capacity of local households to cope with the effects of climate change are dependent upon the functioning of systems at the higher levels (national and global), such as information flows, governing and administrative structures, and market and delivery systems that would facilitate the timely passage of information and resources.

Global Causes, Local Theatres of Action

As multidimensional as water may be (given its myriad uses), not all water issues are transnational. Some lakes and rivers traverse national territory without crossing borders. The key issue in this case involves the internal distribution of water rights among multiple users, districts, or provinces, not the competing sovereign claims over the resource. Climate change is a transnational phenomenon in that its cause is geographically removed from the region where its greatest impacts are felt. For instance, climate change resulting from growing greenhouse gas emissions around the world could be the plausible cause for the overflow of a particular glacial lake. The immediate impact of this flooding would be felt at a much lower level than that at which climate change itself occurs. Hence, while causation may be attributed to unbridled industrialization and deforestation occurring at a global level, the communities vulnerable to its fallouts may reside along the torrential course of an affected river basin. The governance of climate change is complicated by the fact that the cause of "national" calamities lies beyond states' sovereign borders.

Livelihoods and life itself depend on the volume and quality of available water, making water scarcity and water securities a concern of every country. All nations seek to maximize their claim over the water traversing their territories. While shared water may be transboundary in its reach and implications, its appropriation as a sovereign resource is not. The transnational nature of water, coupled with the scarcity of the resource itself, has

made the specter of international competition over water a grim possibility. Compounding the conflicting assertions of sovereignty are the different water-related crises brought on by rampant development, such as the impacts of climate change.

What makes water a complex issue? First, a variety of agricultural, industrial, and domestic users compete for it. Different regions such as rural and urban areas may similarly dispute its distribution. Second, surface water supplies such as transnational rivers and lakes are typically considered a common pool resource, that is to say, potential beneficiaries cannot readily be excluded from using it. Such resources are often overexploited because individual consumers cannot easily be made to pay for using the resource or prevented from enjoying it. But variations exist among water types that complicate how the resource is economically defined. Groundwater, for instance, is usually considered to be owned by the person who owns the land from which it is drawn. So while public authorities or user groups may develop mechanisms to manage surface waters collectively, groundwater normally constitutes a private resource vulnerable to unregulated exploitation. Third, the scale of the water resource has implications for the nature and extent of externalities its use may have on other actors and regions. Upstream management of river water affects the quantity and quality available for downstream countries and communities.[1]

In most instances, the water crisis extends beyond the lack of physical availability of water, and can be traced to inequitable access to water resulting from poverty and vulnerability levels across society. Realizing the Millennium Development Goals (MDGs) by 2015 will depend on how humanity tackles the water crisis. The MDG of halving the proportion of the world population that is without sustainable access to safe drinking water and basic sanitation will have implications for the attainment of the other goals and targets regarding education, poverty, malnutrition, health, and sustainable development.[2]

Furthermore, large water management projects have created social, ecological, and economic problems, the repercussions of which cannot be immediately gauged. For instance, China has initiated massive infrastructural projects in Tibet, where many major Asian rivers originate. Industrialization upstream in China has lead to soil erosion, deforestation, and landslides, whose impacts are felt in the lower riparian states of Bangladesh and India. That these countries are part of a common ecosystem was made tragically clear by the flash floods that ravaged northeast India in 2000 caused by a landslide in Tibet.[3]

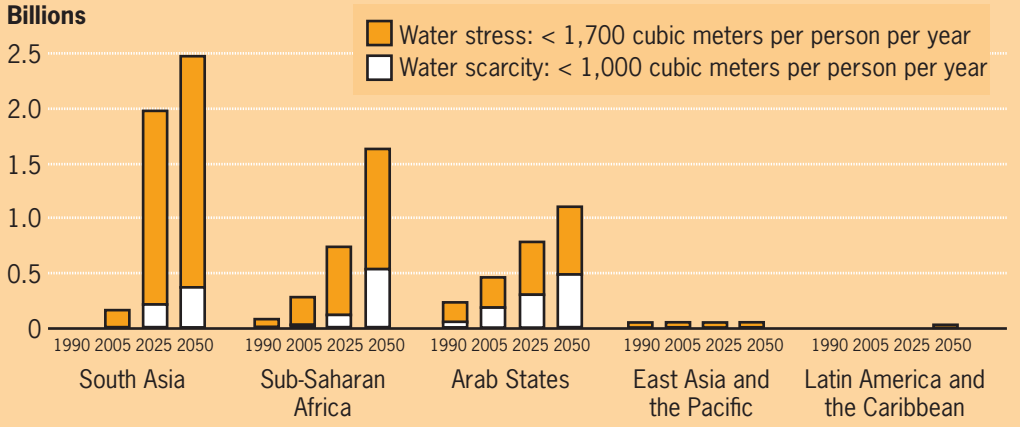
The Impact of Climate Variability on Water Resources

Scientific research suggests that there are strong possibilities of climate variability affecting key spheres essential for human development. The hydrological cycle, like many other natural cycles, functions under a delicate balance across land, ocean, and atmosphere. Hence, any factor that triggers change in these variables would ripple through the sectors

The Looming Water Crisis

About 1.1 billion people in developing countries have inadequate access to water, and 2.6 billion lack access to essential sanitation facilities. Much of this population has access to only about 5 liters a day, as opposed to the minimum daily threshold of about 20 liters. The gender issue embedded in the water crisis cannot be overlooked, since women and girls in underdeveloped and developing countries often bear the brunt of the water crisis—which means more hours of walking to collect water and the associated opportunity cost of missing out on education and personal development. Being denied a fundamental need and human right can trigger unrest in the society. It is essential to underscore the issue of "inequitable access," which defines the differential vulnerability patterns in the water crisis picture as it exists today. About 700 million people in 43 countries fall below the water-stress threshold of 1,700 cubic metres per person (see figure). By 2025, this figure will reach 3 billion, with prominent areas of concern lying in China, India and Sub-Saharan Africa. Globally, some 1.4 billion people live in river basin areas where water use exceeds sustainable levels.

Figure: Populations of Countries Facing Water Stress or Scarcity



Source: UNDP 2006.

that are dependent on the hydrological system. Water is already a scarce resource for reasons having little to do with climate change: burgeoning population, excessive groundwater extraction, and industrial pollution, among others. Projections of the impact of climate change suggest that it would further exacerbate the water stress felt in many places around the world. As the causes of water quality and quantity deterioration become increasingly unclear and diffuse, it will be a daunting challenge for policymakers to attribute responsibility to specific stakeholders for taking corrective action.

One of the more obvious impacts of climate change will be on the world's river systems, many of which will initially see increased flows due to glacial melt followed by decreases

as their source runs out. The Himalayan glaciers extend over 17 percent of the mountain area and contain life-supporting repositories of water that feed the perennial rivers and supply the fertile Indo-Gangetic plains.[4] The annual runoffs in megadeltas, such as the Brahmaputra and Indus, are projected to decline by 14 percent and 27 percent, respectively.[5] This could cause a significant drop in productivity in agriculture and other climate-sensitive sectors. Developing countries in Africa and Asia are especially vulnerable because the impacts are likely to be severe and their coping capacities are weak. India and Pakistan depend on cultivation of arid and semi-arid lands, and hence are likely to face severe impacts in the agriculture sector. For Bangladesh, climate change may cause a shifting of arable zones to the steep slopes in Bhutan. Impact on river water flows would also affect hydroelectricity generation. In Bhutan and Nepal, where hydroelectricity is the source for over 90 percent of the electricity generated (of which a major share is exported), lean flows could significantly affect economies.

There are wide disparities in water distribution between countries and within countries. While there are places with overabundant water resources, there are many that are extremely water-stressed. Climate change could aggravate these disparities by affecting the hydrological parameters that govern the availability of water and by exacerbating the conditions of the poor and vulnerable, thereby limiting their capacity to utilize water as a resource.[6] Effective water resource management needs to address the demand and supply sides simultaneously (see table 1). Conservation practices and technologies, such as better irrigation techniques and water-efficient crop varieties, can significantly reduce the demand stress on the system.[7]

Table 1: Possible Adaptation Options for Water Supply and Demand

Supply side	Demand side
Prospecting and extraction of groundwater	Improvement of water-use efficiency by recycling water
Increasing storage capacity by building reservoirs and dams	Reduction in water demand for irrigation by changing the cropping calendar, crop mix, irrigation method, and area planted
Desalination of seawater	Reduction in water demand for irrigation by importing agricultural products, i.e., virtual water
Expansion of rainwater storage	Promotion of indigenous practices for sustainable water use
Removal of invasive nonnative vegetation from riparian areas	Expanded use of water markets to reallocate water to highly valued uses
Water transfer	Expanded use of economic incentives including metering and pricing to encourage water conservation

Source: Z. W. Kundzewicz et al. 2007.

Threat to Food Security

With large parts of the world dependent on rain-fed agriculture, reduction in water availability coupled with unpredictable changes in rainfall could affect millions of farm-based livelihoods and jeopardize food security. In particular, climate change will result in mixed and geographically varying impacts on food production and create new situations of inequitable access to food. Droughts affect rain-fed agricultural production as well as water supply for domestic, industrial, and agricultural purposes. Some semi-arid and sub-humid regions of the globe (e.g., Australia and the western United States) have suffered from more intense and multi-annual droughts, highlighting the vulnerability of these regions to the effects of climate change.[8] Sub-Saharan Africa is doubly vulnerable owing to high dependence on rain-fed agriculture and abject poverty.

Rising Incidence of Extreme Natural Events

Climate change can lead to an increase in the frequency and intensity of droughts, floods, and other extreme events in water-stressed areas throughout the world. The socioeconomic impacts of droughts arise from the interaction between natural conditions and human factors, including changes in land use, land cover, and the demand and use of water. Excessive groundwater withdrawals exacerbate these impacts.[9] The Intergovernmental Panel on Climate Change (IPCC) reports that projections of rising sea levels range from 0.18 to 0.59 meters by 2100, to which low-lying coastal areas such as Bangladesh and Sri Lanka are highly vulnerable.[10]

Glacial Melting

In several parts of the world, glaciers act as water repositories and feed into the channels for social and economic development of the downstream populations. Over one-sixth of the world's population resides along glacier-fed river basins, and these people would be affected by any change in seasonal flow patterns. Many parts of Central Asia, Latin America, and South Asia depend on glaciers for their livelihoods and sustenance. The glaciers of the Himalayas and Tibet alone feed seven of the world's greatest rivers—the Brahmaputra, Ganges, Indus, Irrawady, Mekong, Salween, and Yangtze—and provide more than 2 billion people with water.[11] Glacial melting that would result from rising global temperatures will lead to initial flooding and heavy flows, and eventually to low flows. This would have severe implications for populations dependent on seasonal rivers fed by glacier melt.[12]

Health Impacts

Changes in the hydrological cycle are certain to affect human health. Climate changes can create conditions in which pathogens can thrive and propagate. South Asia already has the highest prevalence of diarrheal deaths among children below five years of age.[13] The

region has the lowest proportion of rural population with access to decent sanitation, which can increase the spread of disease even more so under conditions of climatic stress.[14]

Key Dimensions Mediating the Interface between Climate Change and Water

Tackling climate change will require a multipronged strategy at the political, institutional, environmental, and epistemic levels. One of the most daunting challenges facing scientists and civil society actors is integrating adaptation and mitigation policies with a country's larger development policies. Initiatives such as afforestation and improved coastal and river management practices would be effective only in tandem with enabling policies in other sectors, such as regulating land use and instituting appropriate incentive structures for users. At present, there exists a high degree of fragmentation and lack of policy coordination among the central ministries. There is an absence of climate change policy linkages among government bodies at the national and subnational levels, and among state and civil society actors at the local, regional, and transnational levels. These together create dissonances at the international level, where negotiators engage with one another in multilateral institutions. Policy incoherence at the national level is often reflected at the international level, where government representatives pursue contradictory or independent negotiation stances in different multilateral forums. However, there is a key variable, critical in explaining the levels of effectiveness of such transnational initiatives, that is often overlooked in most analyses of climate change policy: the nature of a state's political system. To a great extent, the political system and practices determine the degree of openness to a given issue. The political system also determines the nature and extent of participation of civil society actors in policy formulation and service delivery. Access to information on climate change impacts, key to fruitful engagement with other stakeholders, is also a function of a state's political order.

Governance

The nature of the political system has two significant implications for the way environmental change is tackled domestically. First, more open political systems that allow for free expression and flow of information can compel government agencies to respond to environmental crises. A vigilant civil society can act as an early warning system, which, together with inputs from other specialized agencies, draws the attention of the government to imminent crises that require urgent action. However, civil society mobilization is dependent on the availability and accessibility of information, which in most countries is stringently regulated by government agencies.[15] Second, the functioning and efficiency of a political system directly affects its approach to environmental change. For instance, watershed management in India has seen heavy investments in structural activities such as

building check-dams, whereas expenditure on activities aimed at capacity building of local communities through watershed management groups is relatively low.[16]

The State: Speaking in Many Voices?

The internal devolution of powers determines how well equipped implementation-level agencies are to execute region-specific and sector-specific response strategies. All these key dimensions of climate change policy underline the significance of the state as a key actor when it comes to negotiating on a transnational issue such as climate change.[17] But what is often overlooked in analyzing multilateral negotiations is that, far from being a faceless monolith, the "state" is comprised of many actors who at times speak in different voices. Apart from the staple line-up of ministries and bureaucratic entities, many forces seek to have their interests accommodated in any cooperative arrangement. These forces include regional organizations and subnational government bodies, transnational civil society networks, and user associations, each exhibiting its own policy preferences and priorities. It is also possible to identify direct and indirect stakeholders within a water governance framework. Direct stakeholders are those whose livelihoods and sustenance are dependent on water, such as fishing communities, farmers, and pastoralists. The vocations of direct stakeholders are climate-sensitive, making them most vulnerable to climate change. Indirect stakeholders are civil society actors, scientists, specialized agencies, and the state apparatus that participates in governing the resource.[18] Their differing perceptions on what a fair benefit distribution should entail highlight the fact that transboundary treaties seldom rely on objective assessments of benefits. Notwithstanding the desirability of an inclusive regional framework, stakeholder participation in such initiatives has been largely muted in the history of transboundary negotiations.[19]

Governing Water

As with any other issue area, water governance requires making the political system responsive to the exigencies and dynamics of its ecology.* It also demands that policymakers be attentive to the rights of people, to the sustenance and livelihoods of those who are dependent on water.[20] Fashioning an adaptive governance structure that is responsive to the contingencies of time and situation requires significant departures from conventional modes of governance. The conventional approach places centralized institutions in a dominant position with low levels of popular participation. It also demands relatively low levels of accountability and transparency of the implementing agencies. The governance apparatus functions on the assumption that there is a consistent flow of information and feedback into the system, an

* According to the United Nations Development Programme, water governance is "the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society" (Joy, Paranjape, and Kulkarni 2008).

ideal seldom found in actual functioning. In practice, information flows are punctuated by inputs from many actors, which can render the system excessively cumbersome.

New approaches stressing adaptive environmental governance seek to locate natural resource management within the larger ecological context. The ecosystem-based approach not only contextualizes the assessment and management of specific resources within their environmental settings, but also factors in the social ramifications of sustainable initiatives undertaken.[21] Adaptive governance structures recognize the entanglement of the social and ecological spheres and so emphasize the need to integrate diverse knowledge systems to better manage the ecosystem. This entails the continuous and dynamic adjustment of management practices through monitoring and feedback mechanisms. In this model, governance moves away from the state as the chief actor in policymaking to engage with a host of other nonstate actors from the civil society and the epistemic community. Information flows are punctuated by inputs from several actors, involvement of which renders the system complex. An adaptive governance system, then, adapts to such contingencies—information deficiency, contending interpretations of data, and eliciting cooperation from other actors—and formulates adequate response strategies.

In actuality, however, there is often a lack of synchrony between governance mechanisms and the nature of water as a resource. India offers an illuminating example. Here there is a high degree of polarization on the water debate, particularly in the interface between state agencies and civil society actors.[22] Furthermore, water management projects tend to be under the command of experts who have abundant technical knowledge but a narrow perspective on resource management. Engagement with policymakers and experts/advocates on other dimensions of water use is necessary for sustainable and equitable resource management. Such an engagement can be worked out within cross-border mechanisms of water governance.[23]

The Issue of Scale

Global climate change is a particularly complex problem since it operates at different scales, simultaneously involving macroprocesses and microbehavior. Hence, local and global issues must be studied in tandem. Localized problems such as pollution and resource depletion build up to create a reduced capacity to cope with climate change impacts. At the systemic level, climate change is compounded by further greenhouse gas emissions. Despite its multidimensional nature, climate change has almost always been approached from a top-down perspective. Global models yield climate change scenarios, which are then interpreted within local contexts. Tackling climate change at multiple scales would entail instituting cooperative arrangements at international and national levels.

The International Dimension

The key to a functional transboundary water arrangement is to regard water as a flow rather than a stock, taking into account basin dynamics and avoiding fixed water allocations to riparians. This explains why most water treaties do not specify set allocations to each participating country.[24] State and nonstate actors increasingly find themselves having to share space, rights, responsibilities, and benefits with one another to manage water expeditiously. In a climate-affected world, statements of intent within multilateral frameworks would need to be expanded to include the sharing of benefits among partnering nations and the sharing of burdens created by climate impacts. Mitigation and adaptation policies would have to be undertaken by all concerned participants for two key reasons. First, since climate change is a porous problem, the solutions must be so as well. States need to accept shared responsibility in any collaborative action plan that is drawn up, especially since isolationist and unilateral policies would be ineffective in combating a global phenomenon. Second, burden sharing requires taking action at different political levels (local, regional, and sub-basin) and involving diverse actors (civil society groups, industry, and scientific monitoring bodies). Working out the nuts and bolts of any burden-sharing mechanism would entail the distribution of costs, compensatory arrangements, and staggered implementation, all of which would necessarily require the financial and infrastructural support of different states.

Benefit sharing is widely touted as the solution to water conflicts around the world, although operationalizing the concept is proving to be tricky. Benefit sharing is appealing because it shifts away from a volume-driven approach to a more ecological approach that specifies and shares the benefits derived from the water source. For countries to participate in a cooperative framework, benefit sharing must offer rewards greater than those of unilateral action. Far from being straightforward, the identification of benefits and the complementarity of interests accruing from a shared water source are a contentious exercise. Costs and benefits usually vary across time frames, typically requiring parties to assume the individual costs before garnering the collective benefit. The mutual gains eventually identified often involve trade-offs among participating countries within a cooperative framework. The more inclusive a regional initiative is among riparians, the greater the likelihood is of forging issue-based linkages over water. It must be stressed, however, that the absence of multilateral arrangements is not necessarily lamentable; successful instances of bilateral agreements exist among countries that constitute a river system subregion. The Indus treaty between India and Pakistan is one such case in which countries draw benefits from a certain sector of the river without significantly impinging on riparians extraneous to the arrangement. Derivable benefits from a particular river system include mitigation of floods and droughts, potential for hydropower generation, agricultural productivity, and enhanced water resource management. These hold wide-ranging implications for current development activities, operational technologies, employment patterns and levels, the economic and health vulnerabilities of populations, and the environment. Benefits vary across time

frames, with immediate gains, such as shared costs of flood mitigation, and long-term gains, such as a well-developed and integrated regional agricultural sector.[25]

The National Dimension

Any analysis of interstate water arrangements must also factor in the subsequent internal distribution of benefits within countries. Leaving aside the centrality of the river basin as a viable unit of analysis, the state remains a key actor at both ends of a water crisis: its cause and its solution. Domestic mismanagement of river water affects the quantity and quality of water available to downstream countries. Similarly, operationalizing any benefit-sharing arrangement would necessarily imply suitably modifying national water policies within a region. Taken together, domestic measures are instrumental in ensuring the effectiveness of any transboundary initiative. Furthermore, allied policies determining the pricing and subsidization of agricultural inputs, such as fertilizers, seeds, electricity, and water itself, have an impact on the level of water efficiency that is achieved in agriculture. It is important to remember that developing efficient solutions on the demand side for existing water sources is more economical than developing new ones altogether.

Moving away from the discourse on water as the sovereign prerogative of a state or a regional resource, another debate has caused more heat than light in the domestic arena. At the center of the debate, which draws in players from industry, donor agencies, and regional organizations, is the issue of whether water should be considered a public good or an economic commodity. It is chiefly a public good in that it is indispensable and has multiple beneficiaries. However, a nuanced approach that factors in competing claims is order. It is here that multi-stakeholder involvement is instrumental in arriving at a middle ground. It must be emphasized that multi-stakeholder participation should not be seen as substituting for certain state functions, such as instituting political processes and arbitrating parallel engagements. While the role of the state is indisputable in decision making, stakeholder involvement ensures that participants become attentive to the stakes of others in the process through continual engagement.[26]

R&D

Scope for Regional Collaboration

Respecting ecosystem dynamics underscores the rationale of regionalism in implementing environmentally sustainable initiatives. The region as the site of resource governance has gained currency in recent times since the sustainable management and consumption of water is optimized at the regional level, thereby reducing environmental stress.[27] Multiple uses and benefits can be derived from regional water resource management, one of which is benefits exchange. For example, the India-Nepal dialogue on river basin management

led to identification of diverse benefits that extend beyond water allocation in a host of other areas, including hydropower and fishing. Initiatives by India such as afforestation drives upstream to contain sedimentation have proven successful in this regard.[28] Emphasis should be placed on Track II initiatives that function through unofficial channels creating a constituency of support in concerned countries. Such initiatives can play a valuable role in preparatory processes, as in the Track II initiatives in the Ganges Treaty in 1996.

Flow of Information

The effectiveness of any transboundary water arrangement depends in large part on the accuracy and availability of data.[29] Transboundary water arrangements vary in the level of collaboration they involve, from data-sharing mechanisms to collective financing and ownership of infrastructural projects. The seemingly elementary exercise of information sharing can pose significant hurdles to cooperation. For one, states, especially upper riparians, often use information as a potent bargaining chip during negotiations. The condition of bilateral political ties influences the extent to which countries want to withhold or share information with other riparians. Beyond the uncertainties associated with information sharing, states disagree on what constitutes credible data. A solution to contending versions of hydrologic data is collaboration on data generation and sharing. For instance, China and India have signed a memorandum of understanding that enables the sharing of hydrological data on the Brahmaputra. Such information will be instrumental in instituting early warning systems and better flood management in the future.[30]

Integrated Impact Assessments

A holistic understanding of the linkages between changes in climatic variables and subsequent impacts on the hydrological cycle is imperative in order to undertake substantial response measures. The availability of models capturing flow changes at the basin level will be crucial in formulating local adaptation measures. It is also essential to downscale climatic data and forecasts for regional or basin-level analysis.[31] The process of stakeholder engagement can be instrumental in arriving at such integrated impact assessments, particularly pertaining to allied activities in different sectors, regions, and communities. However, one of the challenges facing effective stakeholder dialogue is the lack of credible information. This is especially so when opposing parties in water disputes cite different data sets to justify their positions. Furthermore, data access itself becomes an issue since information is often guarded by government agencies as confidential and kept from the public domain. Indeed, stakeholder participation can enable participants to arrive at a consensus on what counts as reliable data.[32]

Response Mechanisms

Formulating river policy at the regional, national, and local levels must situate the river within the larger ecosystem dynamics of which it is a part, recognizing the complex

interlinkages among the social, environmental, cultural, and economic dimensions of the resource. Localized solutions, such as water harvesting for regions facing water scarcity, would offer appropriate response measures while avoiding, as far as possible, reliance on external sourcing. Although significant hurdles exist, cooperative mechanisms that take the sub-basin as the unit must be formulated, and regulatory structures ensuring the sustainable use of water must be instituted.[33]

Conclusion

Important as they are, regulatory and technological measures do not add up to a sustainable water policy. That requires going beyond treating water as a tradable and quantifiable commodity, and grasping its vital significance to sustaining natural and human systems.[34] Any effective governance structure should straddle both the multiple scales (local watershed management and regional initiatives) and parties (actors or stakeholders) within its compass. Given that the involvement of multiple stakeholders implies the articulation of different perspectives on competing water uses, the outcome of such a dialogue need not always yield treaties and agreements. Even negotiations deemed "failed" because of the absence of explicit consensus are valuable for facilitating conversations and channeling dialogue toward new approaches to water resource management.[35] Several current policies and plans have elements that address the issues of water scarcity, degradation of freshwater ecosystems, inequitable access, and their associated consequences. But there is a need to bring together the appropriate elements in order to facilitate adaptation in the water sector to the impacts of climate variability and change. For example, integrated coastal zone management plans and watershed plans could go a long way in assisting adaptation. It is essential that the projections of future trends in water availability and use, flow patterns, and changes in climatic variables form crucial inputs into the planning process. In this regard, policy formulation should factor in traditional forms of knowledge involving conservation practices and water use.[36] Such methods include storage of runoff and the diversion of water from abundant to scarce regions. Response measures should also tap into nonconventional methods such as water reuse and desalination, artificial recharge, and rainwater harvesting.

The nature of new responsive governance mechanisms will be critical in facilitating the coping capacities of the poor and underprivileged. In areas that are vulnerable due to high exposure to climatic extremes and extreme socioeconomic conditions, it becomes crucial to identify possible points of intervention where there is a need for new policy reforms that can ensure equitable allocation and management of water resources.[37] Multilevel governance calls for the harmonization of policies at different political and administrative levels as well as among diverse actors in civil society, industry, and community. This alternative perspective on governance advocates the creation of decentralized institutions that

allow people to participate in designing disaster management strategies.[38] The accountability and transparency of implementing agencies is ensured through feedback mechanisms, and disaster mitigation is built into the development process itself. Forging relationships among the various user groups will be instrumental in mitigating conflicts.

The interlinkages between climate change and water manifest themselves in complex ways that straddle states, continents, sectors, and ecosystems. This requires that policymakers be cognizant of the implications their policies have on other states—a significant departure from the manner in which transnational issues are dealt with today. Currently, there is a general lack of policy direction and political will in tackling the fallout of climate change precisely because states continue to regard natural resource management as a sovereign prerogative where responsibilities and repercussions are clearly demarcated along national and international lines. This is not to wish away the functionality of borders altogether, but there is a growing need to bring national and global agendas on climate change onto the same plane. Furthermore, there exists a significant institutional gap that is indicative of the inability of existing regulatory agencies and legal processes to address the impact of climate change on water at multiple levels. For that, it is imperative to support multilateral and regional institutions, such as the United Nations and the South Asian Association for Regional Cooperation in facilitating coordination efforts among different countries. It is equally necessary to supplement official developments with informal dialogues, which can be instrumental in creating an atmosphere conducive to sustained engagement. Ironically, the very environmental crises created by isolationist and unilateral national policies could compel actors to seek solutions within cooperative frameworks.

Perspectives from the Regions

South Asian Perspectives on Climate Change and Water Policy

Ashok Jaitly

South Asia—Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka—covers 3.3 percent of Earth's terrestrial area, but supports more than one-fifth of the world's inhabitants. According to UN statistics, the region's population will rise by another 800 million people by 2050.[1] Historically, the South Asian region has been perceived as having plentiful water resources, including the magnificent Himalayan snows, a vast network of perennial rivers, high monsoon rainfall, and rich groundwater aquifers. However, with the rapid population growth during the last century, pressure on these water resources has reached alarming proportions. Water availability per capita has decreased by almost 70 percent since 1950, and it is projected that by 2025, most of the region will be facing either physical or economic scarcity of water (when human, institutional, and financial capital limit access to water resources even though they are naturally available).[2] Significantly, the countries of South Asia share common water resources and common water usage patterns, and so also share common water management challenges. First among them is a widely accepted notion that South Asia is one of the least integrated regions in the world.

In addition to population pressures, intensifying agriculture and expanding industrialization have contributed to an inexorably increasing demand for fresh water. What is more, steadily growing incomes and rapid urbanization have brought a dramatic change in lifestyles that affect the amount and distribution of water demand. There are inherent limitations in strategies to address these problems, but efforts include augmenting supply by developing greater storage in dams and reservoirs, facilitating interbasin transfers, and creating underground storage and transfer structures. These have yielded some positive results and also have potential for further extension. Although water is usually considered a renewable resource (with the exception of underground fossil water), it is actually a finite one with physical limits on its sustainability. The capital stock of water is gradually being eroded. With several river basins becoming parched and the uncontrolled extraction (even "mining" in some locations) of groundwater, supply in absolute terms is decreasing in many parts of South Asia.

Apart from the physical scarcity of water, the imbalance between demand and supply has put a severe strain on management and institutional systems. The irrigation sector, which is the region's primary water user, is facing a serious crisis of low efficiency levels, technological obsolescence, and financial nonviability. The public utilities responsible for domestic water supply are unable to deliver satisfactory service because water tariffs and returns on investment are too low even to enable adequate maintenance, let alone overdue improvements. In the absence of effective regulatory mechanisms, the increased utilization of water by industry is causing problems of waste, pollution, and deteriorating water quality. Consequently, physical scarcity of water is compounded by economic scarcity. The system can neither meet current needs nor generate the resources for creating future infrastructure. This is an unsustainable situation.

To add to this basket of woes, climate change introduces a whole new dimension to the water challenge. The impact of climate change on rainfall patterns, river flows dependent upon glacial melt, and sea levels has only recently begun to be scientifically assessed with any degree of accuracy. Nevertheless, a recent report of the Intergovernmental Panel on Climate Change (IPCC) concludes that it is "very likely (a greater than 90 percent probability) that…most river basins are likely to become drier leading to persistent water shortages."[3] Moreover, glacial melt that today supplies 80 percent of the dry season flow to the major northern rivers could see this contribution reduced to 30 percent over the next 50 years.

There has been some official recognition of the impending crisis. In recent years, the governments of all countries in the region have brought water issues into the forefront of their national agendas with greater emphasis. Bangladesh, Bhutan, and India have formulated national water policies. However, the institutional structure for policy formulation and program implementation is highly fragmented, with a number of central and state ministries mandated to address climate- and water-related issues. The resultant turf battles detract from the pursuit of comprehensive and cohesive agendas.

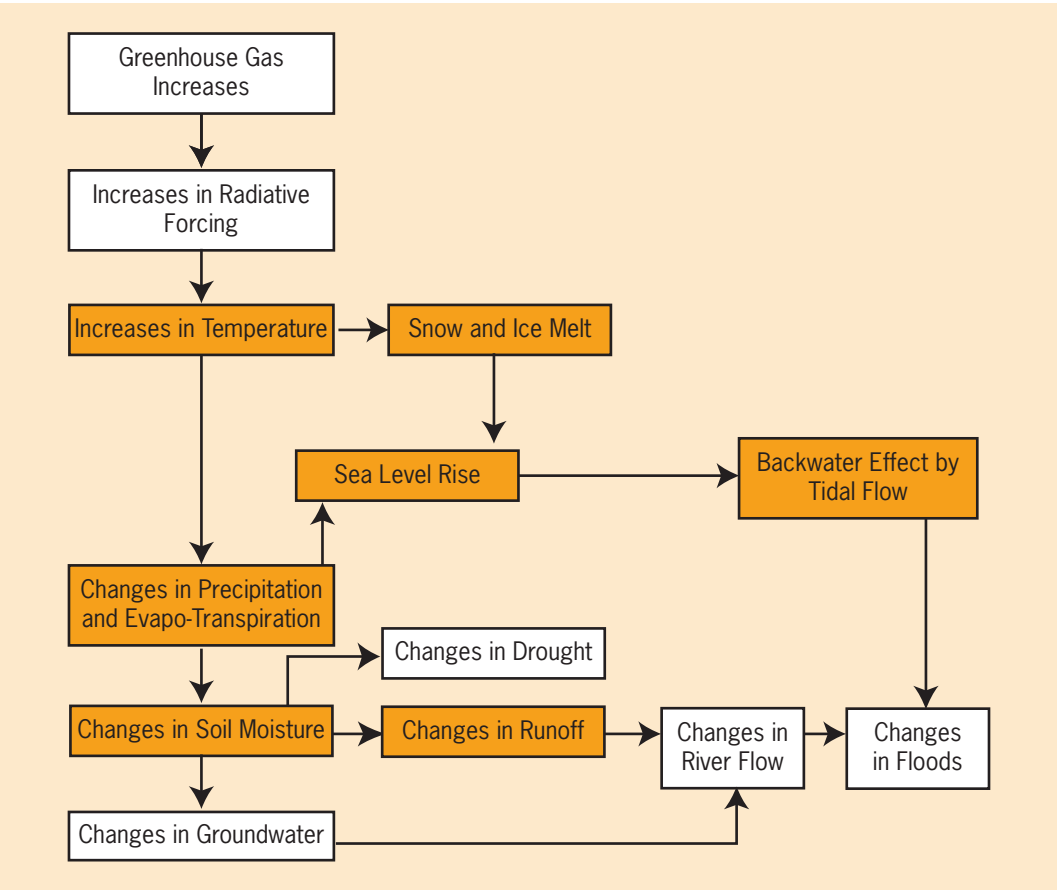
At the regional level, there has also been a welcome recognition of the threats posed by global warming and the associated vulnerability and adaptation capabilities of different economic sectors. The joint declaration adopted by the South Asian Association for Regional Cooperation (SAARC) environment ministers in July 2008 expressed the concern that "SAARC is the most vulnerable region to climate change that is seriously affecting our agricultural production, crippling our vital infrastructures, diminishing our natural resources, and limiting our development options for the future."[4]

What the joint declaration did not touch upon, perhaps for reasons of diplomatic nicety, is that the threat to water security has the potential to spill over and accentuate regional political tensions. Water has long been a contentious issue among the nations of South Asia,

which share major transnational river basins. A report by International Alert that identifies 46 countries where climate change and water-related crises create a high risk of violent conflict includes Bangladesh, India, and Pakistan.[5] Water has also been a source of intranational dissension, such as a dispute between the Sindh and Punjab provinces over the Indus River, and one between the Indian states of Karnataka and Tamil Nadu over the Cauvery River. Clearly, increased water scarcity as a result of climate change has implications not only for the region's socioeconomic development and the war against poverty, but also for its overall peace and political stability.

As detailed in figure 1, the relationship between climate change and the hydrological system is extremely complex. This paper seeks to examine these linkages in the context of South Asia and to draw out the consequent implications for water policy in its multiple dimensions. The fact that significant uncertainty makes it difficult to precisely estimate the impacts of climate

Figure 1: Climate Change and Water Resources in South Asia



Source: M. Monirul Qader Mirza and Q. K. Ahmad, eds., Climate Change and Water Resources in South Asia (London: Taylor & Francis Group, 2005).

change cannot be an excuse for inaction. The broad emerging trends provide enough guidance for addressing potential outcomes. Clearly, there is an urgent need to do so.

Climate Change and Water Resources

South Asia is a region of diverse climates. From the arctic temperatures of the Himalayas covering the northern parts of Afghanistan, Bhutan, India, Nepal, and Pakistan through the arid areas of southeastern Pakistan and western India to the intense tropical humidity of Bangladesh, southern India, the Maldives, and Sri Lanka, these varying climatic conditions bear directly on production patterns, livelihoods, and socioeconomic structures. Climate is a major determinant of water availability in South Asia. The primary sources of water are the snow melt from the Himalaya and Hindu Kush mountain ranges and the cyclical monsoons. The Himalayas are described as the "water tower" for South Asia. Whereas the three largest river systems of the Indus, Ganges, and Brahmaputra are partially fed by snow and glaciers, the Southwest Monsoon accounts for 70 to 90 percent of the annual rainfall over most of the region. For Sri Lanka and the Maldives, the Northeast Monsoon is the dominant factor. There is considerable spatial and temporal variation of monsoon activity within the region, and, consequently, sharp contrasts in water availability and consumption. For instance, annual precipitation in northeast India and north Bangladesh can reach up to 5,000 millimeters,[6] while most parts of Afghanistan and the desert areas of Pakistan and India receive very scanty rainfall.

Global climate change due to the enhanced greenhouse effect has emerged as one of the most challenging environmental issues for the 21st century. Emissions resulting from human activities are contributing substantially to an increasing warming of the Earth's surface. According to the Fourth Assessment Report of the IPCC, global mean surface temperature has increased by some 0.6°C over the last 100 years and will continue to rise during the current century, with regional variations. As a result, the hydrological cycle will be affected, producing an expected rise in the global mean sea level of 0.18 to 0.59 meters by 2100, and an increase in the frequency and intensity of precipitation.[7] Indeed, a number of studies indicate that there has been an increase in the interannual and intraseasonal variability of rainfall because of general warming, and that relatively small climatic changes can lead to droughts and floods on a fairly wide scale.

Extreme climatic events, such as floods, droughts, and cyclones, that recur periodically already often result in large-scale destruction of infrastructure, property, and human lives. In addition, rising sea levels are increasingly exacerbating saltwater intrusion into coastal freshwater systems. In the Indian districts of Tamil Nadu and Gujarat, increasing groundwater salinity caused by seawater penetration into the subsurface aquifer has become a major cause for concern. And in the eastern coastal areas of West Bengal and Orissa, the appearance of arsenic in fresh water as increased groundwater usage draws down the water

table is endangering human lives. Future changes in climate are likely to exacerbate these problems and affect millions of people, especially the poorest, most vulnerable, and marginalized populations.

South Asia's water supplies are especially vulnerable to shifts in glacial melting. The Himalayan glaciers extending over 17 percent of the mountain area form the life-supporting repositories of water feeding the major river systems of the Indus, Ganges, and Brahmaputra. There is a serious dearth of accurate data about these glaciers. A better understanding of glacier dynamics and hydrology is vital for future water policy and management. Still, on the basis of available evidence, scientists agree that the Himalayan glaciers are receding at a faster rate than those in other parts of the world.[8] In the short run, melting glaciers would supply more water to the dependent perennial rivers in India and Pakistan. The same process, however, would also bring more sedimentation into dams and reservoirs, thereby reducing their economic life. Accelerated glacial retreat would also increase the risks of glacier lake outburst floods in Bhutan and Nepal, as melting ice would open breaches in the ice walls that water in glacial lakes. In the longer term, upstream flows would greatly diminish as the glaciers declined, posing serious problems to water supplies for drinking, agriculture, and other livelihoods, as well as reducing hydropower potential.

Groundwater is another important source of supply in many parts of South Asia, and is being increasingly exploited by farmers because of its easy accessibility, amenability to greater control, and better quality than polluted surface water. In contrast to an earlier reliance on state-managed canal irrigation, private tube wells have come to play an increasing role in supporting agriculture. With improvements in technology, rural and urban drinking water supplies have also become increasingly dependent on groundwater extraction. Similarly, more and more industries are opting to use private tube wells for their water requirements rather than depend upon unreliable state sources. In Bangladesh, groundwater makes up 75 percent of total water use in irrigation,[9] and a majority of the country's population gets its domestic supply from hand pumps. In India, about 1 million large and small mechanized wells are built every year.[10] The reliance on groundwater might compensate for inefficiently run public infrastructure, but misguided populist policies (e.g., generous electricity and diesel subsidies encouraging mechanized wells) and weak regulatory mechanisms, including permissive laws, have led to gross overexploitation and resource degradation. As climate change increasingly threatens freshwater supplies, increasing demand will likely fall on the remaining stores of groundwater.

Water Demand and Supply

The South Asian region has experienced a steady decline in physical water availability due to changing demographics, expanding economic activity, rapid urbanization, and changing consumption patterns. Other factors such as technology (cropping patterns and irrigation

systems), institutional structures, and pricing policies also play a significant role in determining water demand and usage. The Falkenmark water stress indicator provides one metric for gauging the adequacy of water supplies; this indicator considers 1,700 cubic meters per person per year to be the national threshold for meeting water requirements for agriculture, industry, and domestic use. Availability below 1,000 cubic meters represents a state of "water scarcity," and below 500 cubic meters reflects "absolute scarcity." Per capita water availability in South Asia has fallen from about 21,000 cubic meters per annum in 1960 to about 8,000 cubic meters in 2005. Should this trend persist, the region will be faced with widespread water scarcity by 2025.[11]

In most countries in South Asia, agriculture continues to be the most important sector of the economy in terms of its contribution to GDP, food security, and employment. It is also the largest consumer by far of freshwater resources (see table 1). Despite the high growth rates in the industrial and service sectors, this demand structure is largely expected to persist for the foreseeable future. Projected water allocations suggest that by the year 2025, agriculture will continue to be the primary user of fresh water, even as domestic and industrial demands, including energy, increase sharply. Given the overall scarcity condition, even small changes in sectoral allocations can generate social tensions, and this has to be taken into consideration when formulating policy. There are already several instances of farmers objecting to new industrial units being built in water-stressed areas, and communities protesting over water pollution being caused by industrial effluent.

The widely acclaimed successes of the "green revolution" across South Asia, initially led by Pakistan and India, were primarily driven by the expansion of irrigation infrastructure. Whereas the dramatic increase in cereal production was instrumental in moving toward

Table 1: Countrywide Freshwater Withdrawal by Sector, 2000 (Percentages)

Country	Agricultural	Domestic	Industrial
Afghanistan	98.19	1.81	0.00
Bangladesh	96.17	3.19	0.65
Bhutan	95.24	4.76	1.19
India	86.46	8.09	5.45
Nepal	96.46	2.95	0.59
Pakistan	96.03	1.93	2.05
Sri Lanka	95.24	2.38	2.46
Average	94.83	3.59	1.77

Source: FAO, AQUASTAT database.

attaining food self-sufficiency, the accompanying technological innovations, such as fertilizer and insecticide application, were both capital and water intensive. As a result, irrigation intensity (the degree of multiple cropping in an area of irrigation) has increased considerably across the region. While global irrigation intensity is 117 percent, in the two largest South Asian economies of India and Pakistan, it is 132 percent and 123 percent, respectively.[12] There has also been a significant change in the pattern of irrigation. During the early stages of agricultural transformation in the region, surface irrigation through dams, reservoirs, and canals accounted for most of the irrigated area. With time, the efficiency levels of the highly subsidized, state-managed system dropped and farmers turned to exploitation of groundwater, which was more directly under their own control and provided access to timely availability. Now, in Bangladesh, India, and Pakistan, groundwater irrigation accounts for the larger part of additional irrigated area. In Bangladesh, which had hardly any groundwater irrigation until 1960, the area irrigated by wells expanded from 4 percent in 1972 to 70 percent in 1999 (see table 2). While there is no denying that groundwater has been a major contributor to the increase in agricultural productivity and food security, overextraction, and indeed "mining" (tapping deeper aquifers) in many water zones is taking a heavy toll on both the quantity and quality of fresh water. In several places in Pakistan and India, groundwater levels are falling by 1 to 3 meters per year. The motivation to rely more upon groundwater has been fueled by populist policies that provide heavy subsidies for electricity, fertilizer, and pesticides, backed up with generous support prices for food grains. While the need to regulate and control groundwater extraction is generally acknowledged, the ambiguous legal framework is equivocal concerning water rights and ownership. In the absence of specific laws, ownership of water resources is equated with land ownership, and therefore the power of the state to restrict utilization is circumscribed. Indirect regulatory mechanisms, such as environmental laws, have not thus far been effective in curbing this trend. Given the political clout of the landowning class in these countries, the prospects of implementing fundamental legal reform measures are not

Table 2: Groundwater Irrigation in South Asian Countries

Country	Total hectares under groundwater irrigation	Groundwater-irrigated area as share (%) of			
		Global groundwater-irrigated area	Country's total area	Country's total cultivated area	Country's total irrigated area
India	26,538,000	38.6	8.1	15.6	53.0
Pakistan	4,871,000	7.1	6.1	22.0	30.8
Bangladesh	2,592,000	3.8	18.0	30.8	69.1
Afghanistan	36,0007	0.5	0.6	4.6	11.5

Source: Shah et al. 2000.

very good. Instead, groundwater policy will need to reduce—and preferably gradually eliminate—subsidies that encourage unlimited groundwater exploitation, introduce disincentives through more realistic pricing mechanisms, and promote artificial recharge technologies.

Climate change poses an added threat to groundwater resources in the coastal areas of Bangladesh and India. In Bangladesh's southwest, water and soil salinity have been increasing because of reduced dry season flows that result from excessive upstream withdrawals in India. This process could be expected to intensify as river flows change due to melting glaciers and variations in precipitation. At the same time, rising sea levels lead to saltwater intrusion into coastal aquifers, which affects agriculture and drinking water. More intense storm surges may also inundate low-lying coastal deltas, tainting freshwater stores.

In the agricultural sector, water resources are under stress not only because of overextraction of groundwater, but also because of inefficient practices and the externalities associated with intensive irrigation. Of all sectors, agriculture has the lowest water use efficiency and the lowest output per unit of water. What is more, with higher incomes and consequent changing dietary patterns, there is a growing demand for meat and dairy products, which require even greater water inputs. Given the limited possibilities for bringing more land under cultivation in the countries of South Asia, it cannot be assumed that the increasing demand for food will be met by expanding the area under irrigation. Thus, the importance of better water management cannot be overstated. Despite exhortations from policymakers and the scientific community, the entrenched water bureaucracies have, so far, successfully resisted institutional reforms.

As noted earlier, there are limits to the augmentation of supply, but international financial institutions, such as the World Bank, have been strenuously promoting greater investments in water infrastructure. For example, rich countries such as the United States and Australia (which are also facing water stress problems), have built over 5,000 cubic meters of water storage per capita; middle-income countries, such as South Africa and Mexico, can store about 1,000 cubic meters per capita. But India has only developed a storage capacity of 200 cubic meters per person. With increased variability of rainfall and rapid glacial melting, many experts argue that the need for storage will become even more important.[13] While there is a general consensus about this, there is strong disagreement about how best to create more storage. The World Bank, joined by water bureaucracies in the region, asserts that mega-projects, including large dams and interbasin transfers, are the answer. Environmentalists and social scientists disagree, maintaining that the ecological and social costs of such a strategy are prohibitive and contradict fundamental principles of sustainable development. Instead, these analysts advocate the adoption of an alternative approach that emphasizes integrated water resources management, microwatershed development, rainwater harvesting, and the revival of traditional structures, such as tanks and ponds. This ongoing debate is critical and demands the serious attention of policymakers.

On the other hand, there should be no doubt about the imperative for a major initiative in better demand management. This could be achieved through a combination of measures aimed at reducing water losses in the surface-irrigation system and adopting water conservation technologies and practices. There can be little justification for continuing to accept a situation in which negligible user charges and bloated administrative costs result in 40 to 60 percent efficiency levels, and fail to generate adequate revenues to finance even normal maintenance costs, let alone investment in upgrading the system. However, lack of political will prevents initiatives that would introduce innovative pricing mechanisms and cost-reduction measures. Similarly, while there is a strong case for introducing a package of incentives to promote the use of water-saving technologies, such as drip and sprinkler irrigation, as well as disincentives to discourage inappropriate cropping patterns, faulty policies continue to lead farmers in some water-scarce areas of Pakistan and India to opt for water-intensive crops such as rice and sugarcane. The economic and environmental costs of such exploitative agricultural practices are increasingly being felt. For example, a study conducted by three UN agencies came to the alarming conclusion that the countries of South Asia suffer losses of about US$10 billion annually because of land degradation.[14]

Water and Energy Linkage

The large quantities of water resources in the mountainous parts of South Asia provide abundant raw material for hydropower generation in Bhutan, India, Nepal, and Pakistan. According to UN statistics, developed countries utilize about 70 percent of their hydroelectric potential, whereas the developing world has used only 15 percent. Nepal has an untapped hydroelectric potential estimated at 45,000 megawatts, while that of Bhutan is about 30,000 megawatts. Apart from meeting their own internal demand for energy, hydropower is viewed by these countries as a valuable exportable commodity, with markets in their energy-hungry neighbors, India and Bangladesh. However, variations in water availability resulting from rapid glacial recession, erratic precipitation, and other factors could adversely affect their hydropower potential. There is also concern that existing or future hydro projects based on rivers that have moraine-dammed lakes (naturally dammed with debris deposited by glaciers) at their head could be threatened by more frequent glacial lake outburst floods. Further, higher rates of sedimentation caused by increased river flows and flooding would reduce the economic life of reservoirs and their generation potential.

Droughts and Floods

The countries of South Asia are already vulnerable to periodic droughts and floods. Failure of the monsoon or subnormal rainfalls frequently create drought in Bangladesh, India, Pakistan, and Sri Lanka. Floods and landslides are a regular occurrence in Nepal, which is also particularly exposed to glacier lake outburst floods. The seasonal variation of water flows in the Ganges-Brahmaputra river basins can be extremely wide and unpredictable,

causing extensive inundation every year in India and Bangladesh. Climate change, which brings about changes in rainfall patterns, will only exacerbate the situation and introduce even greater uncertainty. According to the IPCC, general warming superimposed on erratic monsoon activity over the semi-arid parts of India and Pakistan would increase their susceptibility to droughts.[15] Heightened monsoon activity over the eastern parts of the Indo-Gangetic Plain would increase the intensity and frequency of floods.

Both droughts and floods have a direct impact on agriculture, the mainstay of millions of people in the region. Since South Asian countries have a limited capacity to cope with disasters because they lack accurate forecasting systems and effective institutional structures, the impacts have historically been all the greater, particularly on the rural poor. For instance, the Bangladesh flood of 1974 resulted in a loss of 1.4 million tons of rice and severe scarcity in the local markets. The consequent price rise meant that large numbers of poor were unable to purchase food grains, resulting in widespread famine deaths. This led to increased migration into neighboring India. The presence of people who have been described as "environmental refugees" has become a source of social and political tension between the two countries. Similarly, in 1993, Nepal experienced its worst natural disaster when torrential rain triggered landslides and major flooding, causing immense loss of property and livestock. The social cost of floods is often compounded by the spread of disease and damage to infrastructure.

Disaster preparedness capacities of the administrative apparatus in all the countries of the region need considerable strengthening and improvement. In recognition of the need for an effective communication network for the timely exchange of weather forecasts and longer term climate data, the SAARC Meteorological Research Centre was set up at Dhaka in 1995. Subsequently, the SAARC Coastal Zone Management Centre in the Maldives and the SAARC Disaster Management Centre in New Delhi were established in 2005 and 2006, respectively. However, the functioning of these institutions is totally dependent on inputs from corresponding national agencies, and turf disputes often create obstacles. Instead of addressing obstacles to effective cooperation head on, the only outcome of the recent July 2008 meeting of SAARC environment ministers in Dhaka was, yet again, to call for an "action plan" for the exchange of information on meteorological data, disaster preparedness, extreme events, and climate change impacts. A concerted multilateral regional agenda for reorienting national policies and institutional structures is yet to be developed.

Water Conflicts

Conventional wisdom suggests that distribution of natural resources in the context of scarcity conditions would in all probability create a conflict situation. In a dramatic articulation of such an eventuality, which many have considered unnecessarily alarmist, Ismail Serageldin, the first chairperson of the Global Water Partnership, declared in 1995, "If the

wars of this century were fought over oil, the wars of the next century will be fought over water—unless we change our approach to managing this precious and vital resource."[16] More recently, and in a similar vein, addressing a gathering of business leaders at the World Economic Forum at Davos, Switzerland, in January 2008, UN Secretary General Ban Ki-moon cautioned, "A shortage of water resources could spell increased conflicts in the future. Population growth will make the problem worse. So will climate change. As the global economy grows, so will its thirst. Many more conflicts lie just over the horizon."[17]

Given the vulnerable water scenario in South Asia, the region should be one of the leading contenders for violent conflicts over water sharing—more so in light of its several other political disputes. Mercifully, such has not been the case, so far. On the contrary, while there are outstanding contentious problems among neighboring countries, South Asia does have a commendable track record of making serious efforts toward institutional cooperation over water-related issues in both maritime and riparian areas. Apart from several maritime agreements among member countries, the treaties over the Indus—between India and Pakistan—and the treaties over the Ganges and the Mahakali—between India and Bangladesh and Nepal, respectively—have stood the test of time despite periodic hiccups. However, even these can only be described as interim arrangements to settle differences within a limited context, and by no means establish integrated systems for the optimum development of shared water resources.

The Indus River system is the largest contiguous irrigation system in the world, with a command area of 20 million hectares and an annual irrigation capacity of over 12 million hectares. Although the source of the main Indus River is located in China (Tibet), the headwaters of the basin lie in India, and the bulk of the command area falls in Pakistan. The distribution of the waters is governed by the Indus Waters Treaty, which was brokered by the World Bank and signed by India and Pakistan in 1960. Internationally, the treaty is often cited as an outstanding example of a mutually beneficial agreement that has withstood the vicissitudes of the otherwise strained relations between the two countries, including four wars. Interestingly, however, despite its international acclaim, there is a body of opinion in both countries that the division of waters under the treaty is unfair. The Indian perception is that the state of Jammu and Kashmir has been deprived of storage rights, thus reducing irrigation potential, and that hydropower projects on the western tributaries (Tulbal on the Jhelum and Baghlihar on the Chenab) are stalled because of Pakistan's intransigence. On the other hand, Pakistani dissatisfaction over its share, as a lower riparian user, has found expression in various international forums. In particular, the Pakistani military establishment harbors a persisting mistrust, often voiced, that India could always use its upstream location to disrupt water flows into Pakistan. Indeed, recent media reports indicate a growing demand for renegotiation of the treaty. Another issue that has so far remained intractable between India and Pakistan is the dispute over the Siachen Glacier. Here, armed

hostilities have prevented any study of the glacial behavior that is essential for determining water flows into the Nubra Valley in Ladakh and the Skardu region which, further downstream, also merge into the Indus Basin.

The complex interactions between water issues and political relations are similarly reflected in the periodic tensions over the sharing of the 54 big and small rivers that flow from India into Bangladesh. Although a Joint Rivers Commission was established in 1972 as a reconciliation mechanism, and was complemented by the Ganges Water Agreement in 1977, several disagreements persist. Each state holds the other responsible for causing erosion to the river banks. Bangladesh has accused India of reducing water flows in the Ganges, known as the Padma in Bangladesh, through construction of the Farakka Barrage, which was designed to facilitate the flushing of silt from the port of Kolkata. However, the variation in the river flow has perhaps stemmed more from the absence of basin-wide integrated planning and management than from the barrage itself. This is another indicator of the need for more constructive interaction between the two neighbors. Dhaka has also accused India of withholding data regarding river flows for flood control operations, and has vehemently opposed India's plans for the ambitious US$15 billion Inter-Linking Rivers Project, to transfer excess water from the north and east of that country to the water-deficient states of the south and west.[18] For the most part, the water-related tensions between the two states seem to represent the twin dangers of big-country insensitivity and small-country paranoia because, in fact, they are both vulnerable to virtually the same threats from the impacts of climate change and could foster a win-win relationship with greater understanding and cooperation. In the prevailing atmosphere of mutual recrimination, both stand to lose.

Nepal is a relatively small, landlocked country that shares boundaries with India and Bhutan. A large number of rivers and streams flow from Nepal into India. All of them eventually join the Ganga River system and account for a significant part of its flow. The troubled history of water relations between the two countries is yet another example of the intrinsic mistrust small nations can harbor toward a considerably larger neighbor. One effort to overcome this has been the signing of the Mahakali Treaty in 1996 for integrated development of the river, including hydropower generation. In addition to the serious doubts about the treaty surrounding the environmental implications of undertaking large hydroelectric projects in a seismically active Himalayan region, its implementation has fallen into an impasse because of subsequent Nepali misgivings about excessive and unequal dependence on India's energy demand. These have not been satisfactorily resolved.

Thus, while the countries of South Asia have made periodic efforts to cooperate in the sharing and utilization of common water resources, the essential scarcity situation, juxtaposed with extraneous political frictions, has aggravated bilateral differences. The impending impacts of climate change will likely further aggravate the situation. For instance, reduced

water flows on account of glacial melt would increasingly compromise the Indus and Ganges river basins, affecting all stakeholders. There are signs of growing anxieties in Pakistan, as the lower riparian, reflected in the demand for revisiting the Indus Waters Treaty to include elements of climate change. Similarly, the all-too-real threat of more serious flooding would involve unimaginable loss of production, livelihoods, and even human life in both India and Bangladesh. The risk that increasing numbers of environmental refugees could migrate from vulnerable areas of Bangladesh into northeastern India would only unsettle an already fragile sectarian balance.

Some more optimistic analysts have espoused an alternative perspective, stressing that these potential environmental challenges should instead be viewed as opportunities for confidence building and conflict resolution among nations. Yet while dialogue and negotiation are certainly the best ways to address disputes, the countries of South Asia must also recognize the essential commonality of water and internalize this in agreements to ensure future sustainability. It would be prudent to guard against a doctrinaire approach to the question of bilateralism versus regionalism. Preparing for the security threats of climate change means not only striving to render these risks less likely, but also developing mutually reinforcing capacities to deal with their effects. The latter cannot be secured by adopting a "fortress" mindset, sealing borders and strengthening defensive capability, but by focusing on the collaborative distribution and management of resources. As Pakistan's former foreign minister, Khurshid Ahmed Kasuri, acknowledged at the SAARC Summit in New Delhi in April 2007, melting glaciers and other common sources of water compel Pakistan, India, and others to cooperate.[19] Such cooperation must go beyond well-meaning rhetoric.

It is incumbent upon the leaders of South Asia to be vigilant to the common threats of climate change and to engage seriously in a new multilateral dialogue to create appropriate regional policies, institutions, and coping mechanisms. This would help allay the apprehensions of relatively small countries such as Bhutan, Nepal, and Sri Lanka, which often find it difficult to negotiate on equal terms with a bigger neighbor such as India. Given the interdependence of natural resource distribution, there are several water-related issues that provide opportunities for regional collaboration. This has not been forthcoming in adequate measure so far. Can the threats posed by climate change provide the catalyst for a new and purposeful initiative in this direction? There are undoubtedly many strong arguments to strengthen the case. South Asia's "water tower," the Himalayas, needs special protection measures. Rapidly receding glaciers and the increased frequency of glacial lake outburst floods pose serious risks to the mountain states of Bhutan and Nepal, and downstream, to India and Bangladesh. The most effective coping strategy would be a mechanism for integrated basin planning and management of the Ganges, Brahmaputra, and Meghna Rivers. The alarming incidence of water logging and salinity in the Indus Basin equally affects Pakistan and India, and the spread of arsenic contamination in groundwater is a major health

hazard in Bangladesh and eastern India. The institutional framework of SAARC, which has achieved little so far, needs to be strengthened and made more purposeful so as to promote the exchange of information and experience as well as joint research and collaborative projects. This is the real challenge for diplomacy in the region. Further, intercountry cooperation can be extended beyond governments and academic institutions to corporate bodies and civil society. The Global Water Partnership, South Asian Farmers Forum, South Asian Integrated Water Resources Management Consortium, and the International Centre for Integrated Mountain Development are some of the NGOs making efforts to bring about greater regional cooperation.

Another important strategic issue for the geopolitics of water in the region is China's plan to harness the immense water resources of the Tibetan plateau. Tibet's massive glaciers, deep alpine lakes, and innumerable water bodies feed one of the planet's greatest river systems. Almost half the world's population (Bangladesh, Bhutan, Cambodia, China, India, Laos, Myanmar, Nepal, Pakistan, Thailand, and Vietnam) lives in the watersheds of these eight major rivers (Brahmaputra, Indus, Karnali, Mekong, Salween, Sutlej, Yangtze, and Yellow). Over the last two decades, along with the development of infrastructure, such as paved roads and the Lhasa railway, have come new mining and manufacturing activities, resulting in more air and water pollution. Tibetan protestors drew attention to these environmental threats during the widespread demonstrations in March 2008.

Chinese engineers and hydrologists have trained their sights on harnessing the huge untapped reserves of water and energy from the gorge formed by the Brahmaputra (Tsangpo) just before it enters India in the state of Arunachal Pradesh. The highly ambitious Great South-North Water Transfer Project, designed to transfer waters of the Brahmaputra in the Tibetan highlands to the parched Yellow River, has generated considerable controversy as it involves building deep tunnels and huge dams through high mountains. Apart from the technical difficulties and substantial costs, the environmental impact and their cascading effects on Bangladesh and India are matters of concern. According to the IPCC, the region's warming climate is already causing glaciers to withdraw almost 1 meter per annum, portending substantial impacts on future water flows. While China's water resources minister, speaking at Hong Kong University in 2006, described this ambitious project as not viable, the director of the Yellow River Water Conservancy Committee has stated publicly that the project has official sanction and could be started in 2010.[20] If so, it would call for serious concerted deliberation by South Asian countries which would do well to heed the words of Peter Gleick, president of the Pacific Institute for Studies in Development, Environment, and Security and an eminent water expert: "The water of Tibet may prove to be one of its most important resources in the long run—for China and for much of Southern Asia. Figuring out how to sustainably manage that water will be a key to reducing political conflicts and tensions in the region."[21]

Research Agenda

It is now generally accepted that almost all the countries of South Asia are facing a water crisis even while variations in national contexts remain. Several factors on the demand and supply sides drive the pressures on water resources. A vast body of ongoing research has provided significant insight into different aspects of the problem and needs to be pursued with vigor. The impacts of climate change on the availability and quality of fresh water have only recently come into focus, and there is much less clarity and certainty about their manifold implications.

Climate change is neither a static nor a unidimensional phenomenon, and assumptions based upon past patterns could be misleading. To the contrary, certain threshold events could become more probable, and nonlinear changes should be expected. The extent and nature of prospective climate change in the South Asian region is a highly contentious issue, primarily because it has not been scientifically investigated in adequate depth. This is even more so when it comes to its impact on water resources, which are susceptible to a greater degree of vulnerability. Thus, there is a pressing need for a much bigger research program with a substantial input of human and financial resources.

One of the most fundamental elements of such a program must be to develop national- and regional-level climate change models distinct from the global models that have been the basis for future projections so far. To facilitate this, serious attention needs to be given to building a stronger and more accurate meteorological and hydrological database and to developing appropriate analytical tools for better forecasting and planning. It is equally important to capture the myriad dimensions of climate change impact through multidisciplinary studies into the relevant cross-cutting socioeconomic issues. For instance, many communities have long traditions of coping with extreme events such as droughts, floods, and cyclones. That local knowledge is invaluable for a fuller understanding of climatic risks and for evolving pragmatic responses. In fact, the involvement of the community is essential for the success of any strategy.

Given the commonality of water resources, the commonality of their utilization, and the commonality of the emergent issues, there is clearly a strong case for meaningful interaction between scientific institutions and water management agencies across the region. This would include information sharing, collaborative studies, capacity building, and technology exchange. Unfortunately, such cooperation is often stymied by mutual suspicion at the governmental level, with the result that instead of promoting many more joint research efforts, even basic data are shared reluctantly. An inclusive dialogue among policymakers, managers, scientists, and civil society would go a long way to bridge these chasms. With the growing realization that climate change is a reality that can be addressed only within an integrative framework, there is hope for a new approach toward policy formulation and regional cooperation.

Climate Insecurity in Southeast Asia: Designing Policies to Reduce Vulnerabilities

Khairulmaini Osman Salleh

The interaction of climate change and poverty will have profound effects on human security and societal well-being. In underdeveloped and developing nations, poor and marginalized communities often depend directly on the environment for their livelihoods, mostly through subsistence agriculture. Climate-sensitive industries, such as agriculture, energy, and tourism, also drive much of these countries' economic growth. When human welfare is threatened, climate itself will likely become a security issue and lead to population stresses, conflicts, and perhaps even war. Such calamities are certain to perpetuate poverty. But even without them, environmental insecurity, or the inability of the environment to sustain ecological and human value systems, could become the defining factor of human security in the next century.

Sir John Houghton, former co-chair of the Intergovernmental Panel on Climate Change's (IPCC's) scientific assessment working group, has described the impacts of global warming as a "weapon of mass destruction," which, like terrorism, knows no boundaries.[1] It can strike anywhere, in any form: a heat wave or drought in one place, a flood or storm surge in another. The UN Millennium Project has also emphasized the emerging importance of environmental security/insecurity issues, arguing that climate change and environmental degradation threaten to unravel progress toward achieving the Millennium Development Goals and undermine the very basis of sustainable economic growth.[2] Similarly, Sir Nicholas Stern, head of the UK Government Economic Service and a former chief economist of the World Bank, suggested in his landmark report on the economics of climate change that global warming threatens to create the greatest and widest-ranging market failure ever seen.[3] In the United States, the linkages between climate change and security were recognized in the very name of the Lieberman-Warner Climate Security Act of 2008.

Currently, Southeast Asia is still considered relatively "safe" from the impact of climate change, but this may be only because limited climate data hinder the ability to relate weather and oceanic events to global warming. Tropical storms and monsoons are a normal part of the region's climate system. However, recent changes in the hydrometeorological

processes of major river basins and the degradation and inundation of the region's coastal regions imply that Southeast Asia will not be "safe" for long. Indonesia, Malaysia, the Philippines, Thailand, and Vietnam are all experiencing changing patterns of floods, coastal storm surges, and erosion. As a developing region, Southeast Asia's GDP is very dependent on the condition of her environment. Regional climate changes could seriously affect agriculture, urban commerce, and the booming tourism industry, among other sectors.

In Southeast Asia, climate change will especially affect the low-income populations of urban, highland, and coastal-island regions. It will also have serious repercussions for modern production systems that are climate driven and environment dependent, such as agriculture, energy, fishing, and certain service industries such as tourism. The objective of this paper is to discuss these vulnerabilities in the context of the potential effects of global warming on regional environmental systems; examine why these systems are vulnerable; and explore the adaptation, mitigation, and policy implications.

Theoretical Framework

Vulnerability to climate hazards refers to susceptibility to being harmed by these threats. Social scientists and climate scientists have different interpretations of the term "vulnerability." Social scientists view the term as representing the set of sociocultural, economic, political, and demographic factors that determine a system's ability to cope with stress or change—sometimes also referred to as "inherent vulnerability." Climate scientists view it as the likelihood that weather- and climate-related hazards will affect society and systems—in terms of external stresses such as the frequency and duration of rainfall, temperature, wind speed, or water level. Vulnerability in climate change studies should integrate these two definitions. Using the climate scientists' viewpoint, the potential impact of a decrease or increase in seasonal rainfall on basin agriculture can be examined. However, this study would be incomplete without a social scientist's knowledge of the inherent state of a system before it encounters a hazard event, such as the local water retention systems in the basin.

This integrated perspective is used in the IPCC *Third Assessment Report* and in the *Fourth Assessment Report*, which describes vulnerability as "the degree to which a system is susceptible to, and unable to cope with [inherent vulnerability], adverse effects of climate change, including climate variability and extremes [external stresses].[4] *Vulnerability* is a function of the character, magnitude and rate of climate change and the variation to which a system is exposed, its sensitivity and its adaptive capacity." A vulnerable system needs to increase its resilience by either reducing the effect of the external stresses or adapting to these threats. To reduce the effects of external stresses is costly and usually involves mitigating measures. In Southeast Asia, the immediate need is to increase resilience through adaptation. It is important to understand the regional environmental stresses, the vulnerable

systems, and possible adaptation and mitigation measures. An understanding of the relationships of these three components will influence what kinds of policies are needed to address the climate change threat in the region.

Regional Environmental Stresses

Southeast Asia consists of the 10 member countries of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. These countries lie on the waters of the Pacific Ocean, Indian Ocean, Andaman Sea, and South China Sea. The region stretches more than 3,300 kilometers from north to south, and 5,600 kilometers from west to east. Cambodia, Laos, Myanmar, Thailand, and Vietnam are located in the Indochina subregion (commonly referred to as Mainland Southeast Asia), while Brunei Darussalam, Indonesia, Malaysia, the Philippines, and Singapore are located in a subregion commonly referred to as the Malay Archipelago, also known as Maritime Southeast Asia. Of the 10 member countries, only Laos is landlocked; the others have direct access to the sea.

The climate of the Southeast Asia region is dictated by the behavioral patterns of the monsoons, the El Niño event of the South Pacific Ocean, the low oceanic pressure cells (LOPCs) of the western Pacific Ocean–South China Sea region and the Bay of Bengal–Indian Ocean region, and, to a certain extent, by the Indian Dipole Oscillation (IOD) of the Indian Ocean. Monsoons are an annually recurring weather phenomenon, triggered by the Earth's tilt in relation to the sun. They develop as a result of changing patterns of atmospheric pressure caused by the varied heating and cooling rates of continental landmasses and oceans. The summer monsoon, which blows southwesterly across the Indian Ocean, is extremely wet. The winter monsoon blows northeasterly and is generally dry.

El Niño is an oscillation of the ocean-atmosphere system in the tropical Pacific. In normal, non-El Niño conditions, the trade winds blow west across the tropical Pacific. These winds pile up warm surface water, so that the sea surface temperature is much higher in the Southeast Asia region and northern Australia than in western parts of South America. Rainfall is found in rising air over the warmest water. During El Niño, the trade winds relax in the central and western Pacific, with a backward sloshing effect of sea surface temperatures. Rainfall follows the warm water eastward, with associated flooding in Peru and drought in Indonesia and Australia. This century has witnessed an increasing frequency and intensity of El Niño events in 1982, 1987, 1991, 1994, and 1997, with the last being the worst. Experts anticipate that a much more intense El Niño will occur in the not-so-distant future. Dry weather associated with El Niño events not only brings about drought in many parts of Southeast Asia, but also contributes to the combustion of extensive peat lands and the intensification of atmospheric haze pollution. To a lesser extent, Southeast Asia is also influenced by La Niña events, which are characterized by stronger than normal (easterly)

trade winds over the Pacific Ocean, and result in higher rainfall in the Southeast Asia region. Important La Niña events occurred in 1988, 1996, 1998, 1999, and 2000.

LOPCs are low-pressure systems, or tropical depressions, that develop in the western Pacific Ocean–South China Sea region and in the Indian Ocean–Bay of Bengal region. These low-pressure systems usually start off as low-pressure depressions, intensify into tropical storms, and become full-blown typhoons in the western Pacific Ocean–South China Sea region and cyclones in the Indian Ocean–Bay of Bengal region. LOPCs are becoming more frequent, as evidenced by recent storms that affected Myanmar, the Philippines, and Vietnam.

The Indian Dipole Oscillation occurs interannually in the tropical parts of the Indian Ocean. During a positive IOD event, the sea-surface temperature drops in the southeastern part of the Indian Ocean—the northern coast of Australia, the eastern coast of Japan, and throughout Indonesia—while it rises in the western equatorial Indian Ocean, off the eastern coast of Africa. A positive IOD brings heavy rain to East Africa and droughts to Indonesia and parts of Australia. There is an analogous negative IOD, which is, in effect, the reversal of the positive IOD. Studying and monitoring the IOD will not only increase weather- and climate-forecasting capabilities in the Indian Ocean, but also contribute to general understanding of ocean-atmosphere dynamics, which has the potential to provide new insight into the puzzle presented by current global climate variability.

These atmospheric and oceanic systems control river basin hydrological processes, such as floods and droughts, and thus they also govern the evolution of major human settlements and the development and sustenance of the region's economic activities. These basins include the Mekong, the Menam Chao Phraya, and the Irrawaddy in Mainland Southeast Asia, and a number of much smaller basins in Borneo, such as the Rejang and Kinabatangan Rivers. Changes in the behavioral patterns of ocean-atmosphere weather systems will bring about changes in the time of onset and increase the intensity, frequency, magnitude, and duration of low-pressure storms, floods, and droughts. The impacts of these climatic shifts risk fostering new threats, such as the emergence of diseases in new regions (such as highlands), accelerated erosion, rapid slope failures and landslides, and other forms of climate-induced hazards.

In Southeast Asia, the greatest threat of changing basin hydrology is to agriculture, with the associated decline of food security and rise of poverty. Southeast Asia is very much an agrarian region, with a mix of small-scale cultivation and major plantations. Agriculture employs a huge population of manual and low-income labor. Similarly, the threats posed by floods; atmospheric haze; slope failure; droughts; and outbreaks of dengue, malaria, and the Japanese encephalitis virus are directly or indirectly related to climate and climate-induced hazards. They have the potential to threaten people's well-being, health, and livelihoods.

Already, the IPCC has found that temperatures in Southeast Asia rose at a rate of 0.1°C to 0.3°C per decade over the second half of the 20th century (1951–2000). The region saw extreme weather events associated with El Niño grow more frequent and intense in the past 20 years. Similarly, the strength, frequency, and damage caused by tropical cyclones has increased since 1970. Over the course of the 21st century, the IPCC projects average temperatures will warm another 2.5°C, rainfall increase 7 percent on average across the region, and sea levels rise by at least 40 centimeters even under the most conservative scenario. The IPCC also expects that extreme events such as floods, droughts, and heat waves will strike Southeast Asia more often; tropical cyclones will increase in intensity by 10 to 20 percent.[5] With this in mind, the 2008 inaugural meeting of the ASEAN environmental ministers called for a reassessment of each country's development policy so as to begin incorporating climate change considerations in order to be better prepared for any form of climate change-related threats in the future.[6]

Mapping Vulnerabilities

Defining Poverty

As in most developing regions, many of Southeast Asia's rural economic practices and modern economic production systems are governed by the condition of the environment and behavior of the seasons. Increasing climate extremes and variability will severely affect the region's natural environment. Indonesia, Malaysia, the Philippines, and Vietnam, which have very long coastlines and many islands, are threatened by sea-level rise. Southeast Asia's biodiversity-rich forests, water resources, and marine ecosystems, including its very rich coral reefs, are threatened by increasing land and sea temperatures. Damage to any or all of these could have serious ramifications for agriculture, fishing, tourism, energy, rural-urban commerce, and international trade.

The region needs to assess its present vulnerability and resilience to climate change threats and carry out adaptation and mitigation programs. Particular attention should be given to the fact that while major economic systems may have the capacity to adapt, the traditional, low-income economic systems predominant in many parts of the region may not. To understand the linkages between climate change and poverty, however, one must define "poverty" in a broader context. The first and most important step in studying poverty is determination of the poverty line. Poverty lines are used in estimating the incidence of poverty and in examining the nature and severity of poverty, and they can vary according to geographical region (e.g., rural versus urban) or household size and composition. Though there are major debates over what indicators should constitute the poverty line, there is agreement that the threshold value should be able to provide for a comfortable and decent living of household members without any breakdown of social structures. This threshold value also describes the level of vulnerability inherent in the household unit and its ability

to adapt to conditions that could undermine its stability and sustenance. Thus, poverty-reduction programs in this region have two main objectives: to reduce vulnerability, and to increase the adaptive capacities of individual households to achieve and sustain a certain quality of life.

The latest available national estimates of poverty based on national studies show that 36 percent of the population of Cambodia lives below its national poverty line, 17 percent of Indonesia, 32 percent of Laos, 5 percent of Malaysia, 27 percent of Myanmar, 30 percent of the Philippines, 12 percent of Thailand, and 27 percent of Vietnam.[7] Adapting to climate change will cost individual households as they attempt to sustain their comfort, health, and livelihoods; the costs will increase as climate change worsens. However, climate change is not currently one of the elements used in computing poverty lines. Even for developed economies such as the European Union and the United States, whose poverty line index is much higher, the population's adaptive capacities to climate change are not unlimited. Hurricane Katrina, which hit the Gulf Coast of the United States in August 2005, brought about destruction in the billions of dollars, population displacements, and more than 1,000 deaths, resulting in increased poverty and changing social structures. In all countries, there is a substantial percentage of the population whose household income might be higher than the poverty line but that is dangerously vulnerable to climate-related hazards. Although the incidence and nature of poverty in Southeast Asia vary among countries, the present poverty lines do not adequately incorporate the climate change threat.

In Southeast Asia, the vulnerability of people living below or near the poverty line is a function of many factors. These include demographic structure of the household, economic livelihood activities, physical characteristics of the household unit, immediate living environment, exposure to climate induced hazards, inherent coping mechanisms, and the existence of infrastructure and support systems. In addition, limited knowledge and awareness of climate change threats could hinder immediate responses to hazards, which could be costly or fatal.

The Geography of Vulnerability

Low-income populations in Southeast Asia can be grouped into three geographic regions, based on how climate change can affect economic systems and practices dependent on human-environment relationships. These are urban regions, where the urban poor derive their income from informal activities; highland regions, where traditional agriculture and harvesting of forest products are a major source of livelihoods; and coastal and island regions, where the low-income populations generally work in traditional fishing and agriculture. It is important to remember that many of these low-income people are not

significantly below the poverty line. The majority exists on or near the threshold, and may thus not be considered "vulnerable" under standard indicators.

In urban Bangkok, for example, many farmers sell their farm products on boats along the Menam Chao Phraya. Any significant change to the river system's flow would severely affect these informal traders. The highland regions of the Irrawaddy, Menam Chao Phraya, and Mekong Basins, as well as the much smaller river systems of Insular Southeast Asia, are home to thousands of small-scale, rural farms which produce upland *padi* rice, corn, and millet. These regions also have rich forests that play a part in the livelihoods of the local people. Climate change, through its effects on water availability and seasonality, could affect rural agriculture productivity and forest biodiversity. The main rural livelihood activities of the coastal regions of Indonesia, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam are still agriculture and fishing. In many of these areas, irrigation water pumped from underground sources is critical to sustaining agricultural activities. Regional precipitation shifts, temperature increases, evaporation processes, and the impact of El Niño events would severely limit groundwater recharge. The economic performance of the fishing communities of the northeastern region of peninsular Malaysia, the eastern region of Vietnam, southern Thailand, and many parts of the Philippines is largely dictated by weather conditions in the South China Seas, such as LOPCs, El Niño, and the northeastern monsoon.

There are general and specific characteristics that describe the vulnerability of the low-income economic systems of the urban, highland, and coastal-island regions. The main general vulnerability indicator is income, defined as a family's total remuneration and translated into monthly or yearly earnings, since, in general, the source of income is not fixed or consistent. For low-income economic systems, daily income is much more important, as the household's everyday activities are governed by it, with limited savings potential. Whatever limited savings are available are used for social obligations, such as providing for children's education and religious duties, and increasing economic opportunities, such as investing in better machinery and technology. The more specific indicators of vulnerability are associated with local environmental stresses, the sociodemographic profile of the communities at risk, their external and living environment, and cultural practices. Adding to vulnerability are the communities' levels of awareness: whether they perceive environmental stress as part of the normal cycle of the human-environment relationship or as something that is part of a broader climate change scenario that will influence their future relationships with the environment.

People and communities do develop coping strategies to deal with climate variability. These include building social networks as forms of insurance, traditional forecasting, and ingenious means of protecting assets, such as the use of floating seed beds during floods. However, the poor's coping strategies are naturally restricted by lack of assets and other stresses on their livelihoods.

Adaptation to Climate Change and Policy Implications

Determining Adaptive Capacity

Adaptation can be described as the ability or capacity of a system to modify or change its characteristics or behavior so as to better cope with existing or anticipated external stresses. To a large extent, the adaptation process is determined by the nature of the hazard to which a system must adapt and the type of system under threat. A particular hazard could devastate one system while having no impact on others. Similarly, different systems could exhibit different levels of vulnerability and resilience to particular hazards. For example, the presence of early warning systems that detect risks and communicate and mobilize action will enable people and communities to adapt to increasingly frequent climate hazards.

If we were performing a national assessment for a particular country, we might begin by assessing that country's general vulnerability and adaptive capacity in order to identify needs and options for increasing the country's ability to cope with a wide range of hazards. We would then identify the principal existing hazards that already have significant negative impacts on a regular basis and potential future hazards that represent the most likely threats to human welfare and economic development. Existing hazards are easily identified from the recent historical record, while potential future hazards might be identified through modeling studies, historical or paleoclimatic analogy, analysis of existing trends, and a consideration of physical principles.

Once hazards are identified, assessments of specific vulnerability and adaptive capacity can be carried out for each hazard in turn. The identification of priority hazards, and of vulnerability to them, is essentially an exercise in the assessment of outcome risk. Within the context of the framework outlined above, we may view the outcome risk associated with a particular type of hazard over a given time period as a function of event risk and the social/inherent vulnerability of the exposed systems and populations. The way in which event risk is defined will depend on the nature of the hazard. Event risk might refer to the probability of occurrence of a single, unique, or long-return-period event, or to the actual or projected frequency of occurrence of a recurring hazard. We might be interested only in the occurrence of events whose severity exceeds a given physically defined threshold, or we might wish to define event risk in terms of the frequency of occurrence of a particular type of hazard combined with some measure of intensity, perhaps based on mean or peak severity.

The Nexus of Poverty and Adaptation

The climate is becoming more variable and creating additional risks, and the poor are becoming more vulnerable. As climate extremes are "covariant risks" (i.e., simultaneously affecting a wide range of people), current safety nets are likely to be overwhelmed. This includes both formal systems, such as social assistance, and informal systems, such as

social networks. Comprehensive national plans on adaptation to climate change impacts are still in preparatory and planning stages in all countries of Southeast Asia. Many Southeast Asian countries are just beginning to take action to adapt, beginning with an analysis of their vulnerability and implementing some limited policies.

There are a number of climate-related adaptation strategies already practiced in the region, and there is talk of mainstreaming climate change concerns into existing practices. Indonesia and the Philippines, for example, have expressed a strong interest in linking adaptation with disaster risk management and planning. In Indonesia, the disaster risk-response infrastructure is in place, thus presenting an opportunity to link with climate risk management. National governments in the region have been implementing and accumulating substantial relevant experience in programs that address poverty, disasters, weather monitoring and forecasting, and environmental issues.

There are also focused national measures that address climate risk management and impacts on specific sectors. In the farming sector of the Lower Mekong countries, these involve financial support to farmers; support for transition to other crops and more diversified farming systems; support for marketing of village products; R&D into new seed varieties; development of rural infrastructure; and providing information for farm management, including seasonal forecasts. These sector-specific measures have been implemented in Laos, Thailand, and Vietnam, with low to moderate effectiveness.

It is necessary to widen the practice and understanding of climate risk management to include livelihoods. Generally, there are two types of local adaptations to climate change in the region: those initiated and driven by the provincial, municipal, or commune/village-level governments, and those implemented by NGO—often international—intermediaries. In a number of Southeast Asian countries, local officials have a low level of knowledge and awareness of climate change impacts, mitigation, and adaptation measures, insufficient to prompt them to formulate proactive and anticipatory action agendas. However, many local governments have long been responding to extreme events, such as flooding, storm surges, and typhoons, in their own areas. These concerns fall under the conventional mandate of local governments for disaster preparedness, relief, and rehabilitation.

It has often been observed that in the strategic management of extreme events, local governments exhibit a strong propensity—with support from national governments—to employ purely technical fixes by constructing physical structures such as seawalls, breakwaters, and flood control systems. Yet many local governments have also employed "soft technologies" for disaster preparedness. According to a study of four provinces in the Philippines (Batangas, Cebu, Davao, and Pangasinan), local government actions in disaster preparedness included the creation, enhancement, or strict implementation of coastal laws and land regulations, general coastal management, and disaster programs.[8] Vietnam has

similarly moved to create proactive adaptation programs to build on ground-level disaster risk management measures that have been largely emergency response–oriented. In 2004, the provincial government of Thu Thien-Hue forged a three-year project partnership with the Canadian Centre for International Studies and Cooperation, an NGO funded by the Canadian International Development Agency. The joint program focused on strengthening capacity to plan and implement community-based anticipatory adaptation strategies through disaster preparedness and integration of risk reduction and mitigation with local development planning. The project covered four communes and a total of eight villages.

International and domestic NGOs, in partnerships with local people, have also been the drivers of planned adaptation measures focused on vulnerability reduction and strengthening the adaptive capacities of households and village communities. Examples include community-based disaster preparedness projects in the Philippines to reduce vulnerability and implement disaster management strategies; the International Federation of Red Cross project in urban Jakarta setting up community-based action teams to strengthen disaster response capacity; water supply provisioning in six villages in the Kravanh district of Pursat in Cambodia; and livelihood projects conducted by Oxfam GB in four provinces of Vietnam for poor farmers and laborers, delivering humanitarian assistance and disaster preparedness, and empowering people by facilitating their inclusion in the policy process. Also in Vietnam, international and domestic NGOs have started a forum to discuss ways of integrating the climate change agenda into their ongoing programs as they build adaptation capacity for vulnerable people and places. While their current local programs are not explicitly called climate change adaptations, they nevertheless are oriented toward generic vulnerability reduction and enhancement of household adaptive capacities through empowerment and welfare projects.

Vulnerability to climate variability has significant implications for the achievement of the Millennium Development Goals. Development must be based on understanding existing and future vulnerabilities to climate risk if it is to be resilient enough to cope with climate change. In some cases, climate change adds urgency to current activities to improve policies and institutional mechanisms that affect the poor. In other instances, there may be a case for changes in planning or institutional reform to take account of climate risks, or for building additional capacity into infrastructure investment. Whatever the response, managing climate risks should be an integral part of development planning. Policymakers must recognize the impact of climate variability on the poor, which includes improving the understanding of their vulnerability to all external shocks and trends, as well as of their native coping capacities and strategies.

Multilevel Adaptation Policy

Adaptation to climate change needs to be mainstreamed into development policy and practice at national, international, and regional levels. Particular attention needs to be paid to

supporting community-based approaches to adaptation. It is essential to build on the considerable body of knowledge already possessed by low-income people. For instance, rural farmers of the upland regions of Mainland Southeast Asia can learn from the practices of the farmers in the Yamuna River area of Rajasthan, India. There, poor communities have revived traditional rainwater harvesting methods in the form of *johads*—small semicircular dams—which have helped recharge groundwater and virtually drought-proofed their villages.

There are many examples of local-level adaptations in Southeast Asia that people already use to cope with climate events. In upland Pantanbangan, in the Philippines, floods from prolonged rains prompted farmers to dig canals and install drainage systems, diversify crops, and plant rain-tolerant species. In the El Niño–prone uplands of Sulawesi, Indonesia, farmers proceed with standard crop management both in nondrought and drought seasons, but they reduce their household expenditure on food, clothing, and housing during drought periods. In lowland Java, farmers' adaptation to El Niño impacts takes the form of reducing the area planted. In lowland, rain-fed rice farms in Kandal Province, Cambodia, farmers adapt to rainfall uncertainty by dividing their rice plots—utilizing conventional wet-paddy rice techniques (resistant to heavy precipitation) on one half, and applying the system of rice intensification (a drought-resistant cultivation technique) on the other. In the floodplains and wetlands of the Lower Songkram River Basin, Thailand, farmers minimize the uncertainties and risks of floods and drought through livelihood diversification that includes farming, fishing, raising eucalyptus and rubber trees, and nonfarm occupations.

At the country level, climatic change is just one aspect of the external events and changes to which economies and societies must adapt. Southeast Asian governments can, however, attempt to increase the resilience of their growth strategies to the impacts of increasing climate variability. Although there is still little experience of best practices of adaptation to climate change on which to rely, experience of more general adaptive economic policies offers some pointers. It is important to maintain the principles of good economic policy that assist adjustment to exogenous factors, such as climate shocks, by encouraging a policy environment conducive to changing market trends. Governments should allow prices to reflect the changing availability of resources and avoid economic instruments, such as guaranteed prices or quotas, that may distort rational decision making at a time when change is needed. Other possibilities exist as well. Policymakers should avoid mechanistic responses that impose direct or indirect subsidies to protect the status quo and that result in increasingly large and unsustainable fiscal burdens. Policy decisions should include contingencies for climatic variability within budget planning processes. Policy should encourage individuals to move away from geographical areas or sectors most affected by climate change. Authorities should remove restrictions that confine the poor to increasingly unsustainable livelihoods or marginal areas. And governments should support technological development and the provision of information in sectors that will allow individuals and markets to adapt

to or mitigate the impact of climate change. These could include new varieties of crops or adoption of more water-conserving technologies by industry.

Governments also have a role in disseminating weather information and climate forecasts, and predicting impacts on natural resources, water resources, and the instance of disease outbreaks. Many Southeast Asian countries have a good core of professional planners and managers who operate in key development sectors, but they are usually unaware of the potential impacts of climate change on their sector. These professionals need to incorporate climate risk assessment into their development activities. Vulnerability to climate change can be reduced or increased by the choice of development path. For example, national investment in large-scale agricultural programs may be misplaced if more droughts or flash floods are expected. Small-scale, drought-resistant agriculture might be more sustainable in the long term. Each country needs its own plans and institutions to ensure adaptation is both mainstreamed into development activities (such as integrated water resources management) and considered at a strategic planning level (for example, planning for increased malaria incidence in the health sector). Incorporating climate change risks into national development activities at both project and strategic levels will require greater institutional capacity in most Southeast Asian countries.

Conclusion

The potential threat of climate change–induced hazards on economic development and progress in Southeast Asia should not be taken lightly. The most recent IPCC analysis reports a comparatively smaller increase in temperature for the Southeast Asia region in the last 50 years or so relative to the warming in higher latitudes. Yet there is general agreement among scientists that the changing behavioral patterns of LOPCs, El Niño, and other weather events are triggering hydrometeorological and geomorphological events such as floods, droughts, haze pollution, and slope failures.[9] To date, the impact of these changes can still be absorbed by the strong foundations of Southeast Asia's environmental management programs and backed by its stringent economic policies, including effective poverty eradication programs. However, this scenario can change if the gradual increase in global warming is left unchecked and leads to threshold breaches where habitats and ecosystems cannot recover their equilibrium.

Southeast Asian countries must strengthen their environmental management programs by integrating climate change concerns. They need to address the issues of vulnerability and the adaptive capacities of their economic systems, with particular attention to the poor and those near the poverty line. To do this, Southeast Asian countries need to reassess their existing poverty line values to take into account the challenge of climate change threat. However, this needs to be done within the context of streamlining the climate change threat into existing environmental management strategies and national economic development programs.

Climate Change in the Arab World: Threats and Responses

Mohamed Abdel Raouf Abdel Hamid

Oil and gas revenues in the Arab world, and especially in the Gulf countries, have enabled exceptional and accelerated development in all aspects of life. These countries have become a hub of intense activity in many spheres: geopolitical, military, economic, industrial, construction, and tourism. However, the scale of energy production and its use have also led to severe environmental problems, chief among them, climate change.

Arab countries have long had to deal with traditional environmental threats, such as desertification, biodiversity loss, pollution of marine and costal areas, air pollution, and problems of water quality and scarcity. Climate change and additional problems have appeared in recent years, including those related to military conflicts and construction and demolition debris. Traditional and emerging environmental threats are often interlinked. For instance, desertification leads to biodiversity loss; livestock increase and overgrazing lead to desertification; waste-dumping releases methane, which adds to the global warming problem, which in turn leads to desertification, water scarcity, and many other ecological disasters.

The Arab World's Vulnerability to Climate Change

The Arab World will be one of the regions most affected by global warming. According to the Climate Change Index (CCI) developed by Maplecroft, a British risk analysis consultancy, it is home to 5 of the top 10 countries most exposed to the impacts of climate change: Djibouti, Egypt, Iraq, Morocco, and Somalia.

Djibouti is ranked globally as the most exposed to the impacts of climate change, scoring 0.00 overall (CCI values closer to zero represent higher levels of exposure to the consequences of climate change). Djibouti's population is already regularly buffeted by tropical storms from the Indian Ocean. With 7.1 percent of the population living less than 5 meters above sea level, Djibouti will be increasingly vulnerable to inland flooding as sea levels rise. Djibouti, like other countries rated "extremely" affected by climate change, will also suffer public health impacts, including more severe heat waves. In many places around the

world, these dangers have already begun to take a significant toll. A World Health Organization study has estimated that the modest warming that has already occurred since the 1970s was responsible for 150,000 excess deaths by the year 2000.[1]

Egypt ranks as the second most exposed country. With the vast bulk of its population concentrated in the Nile Valley and Delta, it is at high risk of inland flooding; it also faces extreme risk of negative health effects. Iraq, fifth most vulnerable, is at high risk for coastal flooding, exposure to extreme temperatures, susceptibility to decreasing food availability, and the negative health problems these create. Morocco and Somalia, at 6th and 10th place respectively, are both expected to experience increased risk of inland flooding and extreme temperatures.

In the critical Persian Gulf, all six countries of the Gulf Cooperation Council (GCC)—Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) —are projected to suffer significant repercussions from global warming. Bahrain, 11th on the CCI, has a relatively small land mass that is in danger of being inundated as sea levels rise with climate change. Qatar is especially susceptible to inland flooding, with 18.2 percent of its land area and 13.7 percent of its population less than 5 meters above sea level. Bahrain and Qatar, together with Kuwait, figure among the countries exhibiting "extreme" vulnerability on the Maplecroft index. Oman, Saudi Arabia, and the UAE are all rated "highly" vulnerable. Many other countries in the region are also expected to be significantly affected by climate change. Yemen ranks among those "extremely" vulnerable, and Jordan, Lebanon, Libya, and Tunisia score "high" on the CCI.

Water Pressures

Most of the Arab world falls under the classification of extreme water scarcity, defined by the United Nations as anything below 1,000 cubic meters per capita of average annual water supply. Many countries of the region already use more than 40 percent of their total available water resources, and more still are projected to do so in the next two decades (see annex 1).

Global warming will exert new pressures on water resources around the world. Shifting precipitation patterns will reduce freshwater supply in many regions, just as rising temperatures will increase demand for such uses as agricultural irrigation. As one expert stated: "There are two major and immediate consequences. First, rising sea levels will affect coastlines and marine life severely and could impact on desalination plants that are the source of water for the region. Second, rising temperatures mean increasing water demand and with falling freshwater levels and increasing salinity in sea water (which affects the efficiency of desalination plants), water scarcity is a fearsome prospect."[2]

Indeed, so scarce are freshwater supplies in the Gulf region that the GCC states now rely on desalination for two-thirds of their water needs on average; Bahrain, Kuwait, Qatar, and

the UAE for more than 90 percent. In fact, 65 percent of all the world's desalination plants are found in GCC countries. Ironically, such plants are very energy intensive, such that greater reliance on desalination could increase the region's greenhouse emissions, adding to climate change. Yet desalination of seawater and brackish groundwater will continue to be a crucial water supply option for a large number of urban centers in GCC countries (see table 1).

Table 1: Past and Present Desalination Schemes in GCC Countries

	1990			2005		
Country	Desalination production (mcm)	Domestic demand (mcm)	Desalination-to-demand ratio (%)	Desalination production (mcm)	Domestic demand (mcm)	Desalination-to-demand ratio (%)
Bahrain	56	103	54	123	133	92
Kuwait	240	303	80	589	610	97
Oman	32	86	37	68	170	40
Qatar	83	85	98	250	252	99
Saudi Arabia	795	1,700	47	1,063	2,458	43
UAE	342	540	63	813	951	85
Total	1,548	2,817	55	2,906	4,574	64

Note: mcm = million cubic meters.

Economic Pressures

The ecological changes likely in the Arab region are relatively small compared to the potentially catastrophic hurricanes and floods anticipated in other parts of the world. But for many Arab countries, the economic impact of confronting climate change will be more severe. Their economies depend on revenues from oil and gas exports. Fossil fuel combustion, however, is the main source for emissions of carbon dioxide (CO_2), the principal greenhouse gas (GHG). If the world shifts soon to renewable sources of energy, the Arab world, and especially the Gulf region, will suffer economically. According to one estimate, the Kyoto Protocol agreement to combat global warming by diminishing global fuel consumption could cut GNP some 3 percent in the GCC countries by 2010.[3]

Besides being the world's main petroleum exporters, the GCC countries have been under fire for carbon emissions from their own large-scale use of fossil fuels. Even though the region's total carbon emissions are very low (only 2.4 percent of the global total), per capita emissions are very high. Qatar, Kuwait, the UAE, and Bahrain, in that order, top

the list of the world's largest emitters of GHGs per capita, with Saudi Arabia close behind (see annex 2). There is thus no doubt that the Gulf countries share responsibility with the rest of the world for climate change, and must work to diversify their energy portfolio and find more environment-friendly energy sources. Yet, while countering global warming is a common responsibility, different obligations must be charted out for different countries.* Those countries with the largest absolute emissions, for example, must shoulder more burdens.

Gulf countries recognize the problems created by their energy production and consumption profiles and are trying to come up with innovative solutions in the renewable energy field to offset this. This is clear in recent undertakings, including Abu Dhabi's Masdar, a carbon-neutral city due for completion in 2009. Indeed, mitigation initiatives have gained a lot of attention in the last several years, and many pioneering projects such as Masdar, and research efforts in the field of renewable energy, energy efficiency, and clean production and technology (especially under the Clean Development Mechanism [CDM]), have been launched. In November 2007, Gulf countries of the Organization of Petroleum Exporting Countries (OPEC) pledged a total of US$750 million to a new fund to tackle global warming through research for a clean environment. Kuwait, Qatar, and the UAE pledged US$150 million each for the fund. Saudi Arabia, the world's biggest oil exporter, will invest US$300 million in the fund which is aimed at finding technological solutions to climate change, notably carbon capture and storage.

Adaptation to the various impacts of climate change, on the other hand, has been very low. The lack of arable land and water resources in much of the region prevents the development of carbon sinks, forests, and green areas. Information acquisition, public awareness, mainstreaming impacts into policies, monitoring, evaluation, and implementing measures have been almost nonexistent.

Most Arab countries still lack clear targets to reduce their GHG intensity. Much work needs to be done to establish, maintain, and improve emission-reduction registries as well as implement a comprehensive range of new and expanded domestic policies, such as tax incentives for renewable energy and clean technology. Finally, cross-sectoral policies

* In 2007, German chancellor Angela Merkel put forward a proposal, praised by a number of scientists around the world, to allow developing countries to increase their emissions per capita while industrialized countries cut theirs, until both sides reached the same level. This proposal, however, would not be very fair for countries such as those in the GCC, which are less populated and currently witnessing an economic boom, because it would entail slowing development. The proposal also does not take into account the expatriate population (especially labor, which moves to booming economies). Furthermore, it might provide a motive for countries to increase their population and in that way create another global problem which will end up increasing emissions instead of reducing them.

to fight climate change need to be developed and integrated with existing policies in the energy, agriculture, transportation, and related sectors.

Climate Change Brings Water Troubles to a Boil

Water is at the heart of the problem of climate change. Accelerated glacier melt, rising sea levels, drought, and desertification are all water-related issues. Historically, civilizations rise near the banks of major rivers and are heavily dependent on their flow for water, agriculture, transportation, and trade. Water has always been both a blessing and a source of conflict. In fact, the English word "rivalry," derived from the Latin *rivalis*, essentially means "one using the same river as another."[4]

Water is also inextricably linked to the health of a population. Fresh water is required for drinking, sanitation, and irrigation of cropland. It has a direct influence on agriculture, which in turn affects harvests and livelihoods, particularly in subsistence farming areas. Changes in saltwater levels could result in saltwater intrusion into aquifers, rendering the groundwater unpotable. Water quality will also be affected by higher surface water temperatures which promote algal blooms and increase bacteria and fungi content.[5]

It is hardly surprising that some of the most parched regions of the world also suffer from perennial unrest. Extrinsic factors, such as rising food prices, can fan civil discord. Yet it is often the dependence of agriculture on scarce water supply that lies at the heart of the problem.

Water Conflicts

Although seldom the trigger for war, the thirst and desperation created by water shortages or a threatened water supply can fuel existing tensions. Perhaps the most recent widely reported violence over water resources is that of the simmering conflict between farmers and nomads in Darfur, Sudan.[6] Drought and desertification in the northern parts of Darfur have spurred migration of the Arab nomads to southern Darfur, where they came into contact with black African farmers, which sparked disputes over land and scarce water resources. What seems to be a dispute caused by ethnic divide has its roots in water resource distribution.

The conflict in Darfur is by no means an isolated example. Table 2 lists several historical water conflicts to illustrate the grave consequences that can arise from threats to water resources. "Genuine water scarcity" refers to situations where there is a real natural shortage of water in the region that is not due to artificial restriction or control of water sources. "Water used as a political tool" refers to the intentional control or stoppage of water flows to extort or threaten neighboring states where water is otherwise sufficiently available.

Table 2: Selected Conflicts Caused by Water Shortage

Date	Parties involved	Description
		Caused by genuine water scarcity in region
1947–1960s	India, Pakistan	Partition leaves Indus Basin divided between India and Pakistan; disputes over irrigation water ensue, during which India stems flow of water into irrigation canals in Pakistan.
1951, 1953	Israel, Jordan, Syria	1951: Jordan makes public its plans to irrigate the Jordan Valley by tapping the Yarmouk River; Israel responds by commencing drainage of the Huleh swamps located in the demilitarized zone between Israel and Syria; border skirmishes ensue between Israel and Syria. 1953: Israel begins construction of its National Water Carrier to transfer water from the north of the Sea of Galilee out of the Jordan Basin to the Negev Desert for irrigation. Syrian military actions along the border and international disapproval lead Israel to move its intake to the Sea of Galilee.
2000	China	Civil unrest erupted over use and allocation of water from Baiyandian Lake, the largest natural lake in northern China.
2004–2006	Ethiopia, Somalia	At least 250 people were killed and many more injured in clashes over water wells and pastoral lands. A three-year drought led to extensive violence over limited water resources, worsened by the lack of effective government and central planning.
2007	Burkina Faso, Ghana, Côte d'Ivoire	Declining rainfall led to growing fights between animal herders and farmers with competing needs. In August 2007, people were forced to flee their homes by fighting in Zounweogo Province.
		Caused by use of water as a political tool
1978–on	Egypt, Ethiopia	Long-standing tensions over the Nile, especially the Blue Nile, originating in Ethiopia. Ethiopia's proposed construction of dams on the headwaters of the Blue Nile leads Egypt to repeatedly declare the vital importance of water, with Anwar Sadat noting in 1979, "The only matter that could take Egypt to war again is water."
1992	Czechoslovakia, Hungary	Hungary abrogates a 1977 treaty with Czechoslovakia concerning construction of the Gabcikovo/Nagymaros project based on environmental concerns. Slovakia continues construction unilaterally, completes the dam, and diverts the Danube into a canal inside the Slovakian republic. Massive public protest and movement of military to the border ensue; issue taken to the International Court of Justice.
1997	Singapore, Malaysia	Malaysia supplies about half of Singapore's water; in 1997, it threatened to cut off that supply in retribution for Singapore's criticizing Malaysian policies.
2000	Kyrgyzstan, Kazakhstan, Uzbekistan	Kyrgyzstan cuts off water to Kazakhstan until coal is delivered; Uzbekistan cuts off water to Kazakhstan for nonpayment of debt.

Source: Adapted from Peter H. Gleick, "Water Conflict Chronology," Pacific Institute for Studies in Development, Environment, and Security, 2008, available at www.worldwater.org/conflictchronology.pdf; accessed January 22, 2009.

Historically, warring states often made use of existing water resources to threaten the opposing country by poisoning wells or controlling access to water supplies that were not necessarily scarce. By contrast, recent conflicts over water have increasingly been triggered by genuine shortage more so than by accessibility. This is a worrying sign. No longer merely a tool of political or military advantage, the control of water supplies increasingly constitutes the spark or object of civil strife or open conflict.

Policy and Social and Institutional Responses

In the most affected areas, a malfunctioning hydrological cycle could cause more serious water shortages and an unprecedented increase in water demand as drought, severe heat, land degradation, and desertification boost consumption for drinking and irrigation and lay waste to previously arable soils. As the freshwater sources dry up gradually over the next few decades, more conflict is likely. While resource management is important in preventing further deterioration, it is only half of the solution.

Effective climate change policy will not tolerate procrastination. GCC governments need to act right now to find ways to reduce their carbon footprint. This is necessary to stave off global warming and secure water needs in the short, medium, and long term for different sectors by using varied policy options, technologies, negotiations that can secure water supplies from friendly countries, and even political pressure.

Water Pricing for Lower Wastage

Consumers in the GCC countries typically do not bear the full costs of their water usage. Proper pricing would make people more conscious of using water efficiently and encourage high-usage customers to cut back. The Dubai Electricity and Water Authority took a step in the right direction in March 2008 by introducing a new system of rising tariffs. However, the tariff does not apply to UAE nationals. Rather than exclude nationals from the pricing system, it would be better to offer them a monetary allowance and charge all users water consumption according to the new tariff.

Sensible Water Usage

Agriculture accounts for about 6.5 percent of GDP in Saudi Arabia, just 3.3 percent in the UAE, and less than 1.0 percent in Kuwait. Yet agriculture continues to be the prime water-consuming sector in the GCC. In fact, agricultural water use has increased from about 73.5 billion cubic meters in 1990 to over 90 billion cubic meters in 2000, exerting immense pressure on the limited water resources.

Many corporations and environmental NGOs around the Gulf have embraced programs for greening the deserts. Yet this is an unwise solution in a water-scarce region, even if the

objective is to plant indigenous species. We have to accept and adapt to our surrounding ecosystem, which is a desert area with scattered indigenous species.

Growing reliance on desalinated water could be a risky policy, considering volatile prices for the oil that powers the plants and volatile revenues from the oil exports that finance them, not to mention the environmental problems these plants create. However, there is no doubt that desalination will remain an important component in the water budget of the GCC countries. More research should be devoted to reducing costs and finding environment-friendly desalination technologies. The sustainable use of groundwater resources should also be considered in the overall integrated water resource management policy of each country.

Striking a balance between self-sufficiency and water resource sustainability in the GCC countries will demand long and continuous struggle. Still, it is important to strive for better, environment-friendly solutions to reduce the effects of climate change and to collaborate on finding improved solutions in water management. The GCC states would be wise to seize the chance to use the Adaptation Fund that became available following the Bali climate negotiations in December 2007. They should also improve regional cooperation and joint project planning to ensure that the possible transnational consequences of water policies are examined and anticipated and that mutual interests are addressed.

Emissions Mitigation in GCC Countries

The Kyoto Protocol established three so-called "flexible mechanisms" for the developed countries that are subject to mandatory GHG controls under the treaty. The mechanisms help them meet their national emissions reduction targets in cost-effective ways. The first of these is an Emissions Trading System: parties that emit less than their assigned levels can sell the extra amounts to parties that exceed their allotments. Second, Joint Implementation allows one developed country to help finance an emissions reduction project in another and receive an emissions credit to count against its own obligations. Finally, the Clean Development Mechanism allows parties in developed countries to finance GHG emissions reduction or removal projects in developing countries and thereby obtain allowances they can apply against their own emissions limits. Such credits can be bought and traded by companies and nations in the developed world and provide incentives for better environmental management and technological innovation that go beyond business as usual.

While India and China, as well as many countries in Latin America, were prepared to follow this path when the Kyoto Protocol was signed in 1997, the Arab states only started to think about emissions trading in 2006, and began implementing projects in 2007. Given that in 2006 the global emissions trading market was worth US$30 billion and that this is

still a new market in the GCC countries, there is a huge potential for Gulf companies to reduce emissions and earn money from generated credits. Currently, there are many CDM projects in Bahrain, Egypt, Jordan, Morocco, and Tunisia.

In the Gulf, many companies and consulting firms have begun to explore this fast-developing field. The UK-based EcoSecurities, for example, has opened offices in Bahrain, Dubai, and Lebanon, and is planning branches in Qatar and Saudi Arabia, as well as intermediates in Egypt and Libya next year. Meanwhile, the Masdar Company of Abu Dhabi is the first local company in the region to pursue a CDM project. Projects are now moving quickly, as public and commercial awareness rises. Doha Bank is planning to launch the Arabian Gulf's first carbon credits exchange in 2009 to tap an emerging market for emissions trading. Moreover, CDM projects in the Gulf are being considered in fields such as renewable energy, waste, and cement. Current CDM projects include the following:

- *A landfill project in Sharjah in the UAE.* This project is in the very early stages but has received Designated National Authority approval.
- *The Dubal CDM Project.* Masdar (Abu Dhabi) will work with Dubai Aluminum Company Limited (Dubal) to develop and register a project to reduce GHGs from aluminum smelting, in order to claim credits of reduced GHGs at a Dubal smelter at Jebel Ali.
- *The Al-Shaheen Oilfield Gas Recovery and Utilization Project.* This Qatar project, registered on May 29, 2007, is aimed at recovery and utilization of natural gas from oil wells that would otherwise be flared. The project received Certified Emissions Reduction status in the second half of 2008.

The Al-Shaheen project is the first of its kind in the region and third CDM project in the petroleum industry worldwide. The Al-Shaheen oilfield has flared the associated gas since it began operations in 1994. Prior to the project activity, the facilities used 125 tons per day (t/day) of associated gas for power and heat generation, and the remaining 4,100 t/day was flared. Under the current project, total gas production after the completion of the project activity will be 5,000 t/day, with 2,800 to 3,400 t/day to be exported to Qatar Petroleum, 680 t/day for on-site consumption, and only 900 t/day still to be flared. The project activity will reduce GHG emissions by approximately 2.5 million t/CO_2 per year and approximately 17 million t/CO_2 during the initial seven-year crediting period.

Still, important questions need to be raised. Why did the region not witness registration of a CDM project until 2007, and why are there not more CDM projects in the oil and gas industry, the dominant industry in the region? The countries of the region will have to surmount several obstacles to make greater use of the CDM. These challenges include the following:

- Political will has been very weak.
- The region wants to develop as fully and rapidly as possible. Until recently, not much attention was given to environmental issues at the policy level; instead, the focus has been primarily on the economy and security.
- There is a lack of education and awareness regarding all aspects related to CDM projects (including how to tax CDM revenues).
- There is lack of infrastructure and capacity (expertise) in both private and public sectors for many environmental fields.
- CDM projects in the region are large scale and take time to plan and develop.
- Implementing CDM projects takes considerable time, especially in big oil companies.
- It is believed that CDM projects do not fit in well with the oil business.
- Petroleum companies do not need the relatively small additional revenue that would accrue out of the CDM.
- The petroleum industry cannot easily stop or change production to accommodate CDM projects, unlike industries such as cement, where swifter changes are possible.

Even so, while development in the Gulf region is rapid, political support and funds are increasingly available for environmental activities, and environmental awareness is growing. CDM projects are now considered an additional revenue source based on carbon credit sales. Potential CDM activities could thus be initiated in areas such as cement, landfills, industrial efficiency, waste management, industrial processes, the agricultural sector, land use change, and forestry inventory. Energy-efficiency projects in the Gulf, for instance, could save millions of dollars and reduce tons of CO_2 emissions while qualifying as CDM projects. In addition, renewable energy, in particular solar energy, holds great potential for the region, similar to biomass in Asia. In the long term, the region could potentially shift from exporting fossil fuel to exporting clean energy to the rest of the world.

In the meantime, while environmental laws exist, some executive regulations may be required to implement these laws and promote CDM projects in the Gulf. All concerned stakeholders should be involved. In Bahrain, for instance, a committee for climate change has been established that includes local NGOs. At the regional level, the GCC also has a multilateral committee on climate change to create a unified position.

Finally, it is worth noting that countries in the region are unlikely to embrace two potential greenhouse policies often advanced by developed country analysts. First, the GCC states will almost certainly not try to solve the carbon emission problem by imposing carbon taxes. These countries depend heavily on petroleum and gas as the main source of revenue for their development plans, and any carbon taxes might hamper this process. Similarly, despite being approved in 2007 by the Convention on the Prevention of Marine Pollution

by Dumping of Wastes and Other Matter (1972 London Convention), the potential for carbon capture and storage in underground or undersea reservoirs is also very limited as a safe way of disposal. From the environmental point of view, carbon capture and storage is not the best solution, as it will only postpone the problem, encouraging more emissions on the premise that the CO_2 produced can then simply be stored. Any leaks in the huge quantities of stored CO_2 could lead to environmental disasters. Small leaks could be fatal to local inhabitants; large leaks could rapidly return significant amounts of CO_2 to the atmosphere.

The Arab World's Growing Awareness of Climate Change

The Council of Arab Ministers Responsible for the Environment is well aware of the possible repercussions of climate change on the Arab region and recognizes that dealing with climate change requires a collective international effort and solidarity of goals. At its 19th session on December 5–6, 2007, the council adopted the Arab Ministerial Declaration on Climate Change. The declaration announced the Arab countries' intention to include climate issues in all sectors of sustainable development policy and to adopt national and regional climate action plans.

Nevertheless, the governments in the region have been slow to formulate solid national action plans for the environment. States party to the UN Framework Convention on Climate Change (UNFCCC) are required to submit a national communication on their implementation of the accord. But the UNFCCC Secretariat has reported that no information is available about the status of the preparation of the national communications of Kuwait, Libya, Oman, Qatar, Somalia, or Syria.[7] Oil-rich Arab countries, particularly Saudi Arabia, have also been accused of actively hindering climate negotiations.

Institutional Developments

On environmental issues, the Arab countries operate internationally and regionally through a number of bodies that coordinate activities and set the framework for regional efforts.

At the state level, environmental ministries, agencies, and councils, which are still fairly new, are struggling to play a significant role in the decision-making processes to address priority environmental challenges facing the region.

Due to the relative inexperience of the new environmental authorities and the lack of institutional capacity, many Arab countries first join international agreements and then seek solutions to fulfill commitments. Still, there have been several notable local developments:

- In November 2007, in recognition of the importance of the impact of climate change, Oman changed the name of the Ministry of Environment and Regional Municipalities to the Ministry of Environment and Climate Change.

- Due to the lack of reliable data on environmental affairs, the Environment Authority in Abu Dhabi (Abu Dhabi Global Environmental Data Initiative) launched an initiative with the World Wildlife Fund–UAE and Global Footprint network to collect and prepare the footprint for the UAE. The Al Basama Al Beeiya (Ecological Footprint) Initiative, launched on October 18, 2007, represents the UAE's national effort to reduce its ecological footprint and ensure a sustainable future. Three key objectives were identified: raising awareness about the project and its mission, facilitating research on vital footprint components, and increasing institutional capacity building across the UAE. The project team is currently engaged in the challenging task of sourcing data on population and energy, which have been identified as priority areas in the project's current phase.

Civil Society

In the Gulf countries, civil society varies between the traditional type of organization that depends upon family and tribal networks, and newer forms, such as NGOs and community-based organizations. There are about 2,000 NGOs in the six GCC countries, a relatively high number in comparatively new societies. Civil society is more developed in Bahrain, Kuwait, and the UAE, as compared to Oman, Qatar, and Saudi Arabia. The activities of civil society organizations in the environment field are mainly centered on greening projects, cleanup campaigns, workshops and seminars, conferences, and training and public lectures. Many of the NGOs in the GCC region face problems, including lack of funds and volunteers, especially young volunteers. These obstacles hinder their abilities to carry out missions effectively and achieve their environmental goals. As such, environmental NGOs have not been very effective in lobbying for their causes.

NGOs can potentially play a very important role in new matters such as the CDM. In fact, supporting CDM programs can be one way NGOs can improve their image, spread their message, and attract funds and volunteers. This could include raising awareness (among individuals and in the public and private sectors); serving as watchdogs to monitor, foster, and propose CDM projects for different industries; and proposing ideas for clean projects to authorities and the private sector.

Renewable Energy and Climate Change

Renewable energy projects and other clean technologies for mitigating climate change will enable GCC countries to align their GHG reduction and human development efforts, and promote mitigation activities that accelerate rather than slow socioeconomic progress. The Arab region not only has a considerable supply of oil and natural gas, but also an ideal geographic positioning to receive maximum exposure to sunlight and, in many areas, wind, which would provide endless renewable energy. According to one regional expert, "The

region is exposed to direct sunlight, as well as a reduction in the percentage of clouds. The usual Direct Natural Exposure…in the Gulf region is about 1800 kilowatt/hours per every square meter, and this makes the adoption of solar energy in the region technically and economically feasible. Statistics show that both the Middle East and North of Africa are equipped to deal with this technology…"[8]

Wind-generated energy is the least costly among all sources, and it is abundant in the region. For example, wind speeds reach 8 to 11 meters per second in Oman. However, renewable energy is almost nonexistent in the Arab region, representing only around 0.1 percent of energy supplies and producing less than 0.3 percent of electricity. The few renewable energy projects in GCC countries include the following:

- There is a mobile reverse osmosis desalination unit in Bahrain operated by solar power with a capacity of 200 gallons per day, and a mobile generator operated by solar and wind power with a capacity of 1.5 kilowatts.
- Saudi Arabia has several solar cooking, solar desalination, thermal and solar electricity, and photovoltaic systems projects ongoing. These projects were implemented through the American Cooperation Program which carried out many R&D programs in the last two decades of the 20th century.
- A desalination project in Oman uses thermal and solar power established to produce a limited amount of drinking water. Photovoltaic systems with a capacity of 352 kilowatts were built for pumping water, lighting, and communications.
- Prior to the Gulf War in 1990, R&D projects were carried out in Kuwait on solar lakes, air conditioning, and photovoltaic systems.
- Some mini-solar projects were implemented in the UAE for different purposes, such as phone cabins and traffic signals.

The Masdar Initiative

In April 2007, the government of Abu Dhabi began construction on the carbon-free city Masdar. The Masdar Company intends to build a unique, integrated "green community." This green energy and technology campus will offer a sustainable living environment and state-of-the-art office and research facilities built with green construction that depends on desalination, biofuels, sustainable transport, water recycling, wastewater management, solar cooling, sustainable irrigation, and other renewable technologies.

Although difficult to measure precisely, the following direct results are expected from the project by 2015:

- 10,000 new high-quality jobs in the clean energy and sustainable technologies sector in Abu Dhabi

- 800 full-time master's degree and PhD students at the Masdar Institute specializing in clean energy and sustainable technologies
- A multibillion-dollar expansion of the Abu Dhabi non-oil economy
- The creation of a world-class scientific and research hub in the Gulf region, which can become the core of other knowledge-based activities and industries, in addition to clean energy

There is no doubt that the announcement of Masdar and the accompanying initiative is a step in the right direction. The most important direct benefit will be the ability to help cut emissions and therefore set an example. This will raise awareness and inspire others to follow up with similar initiatives.

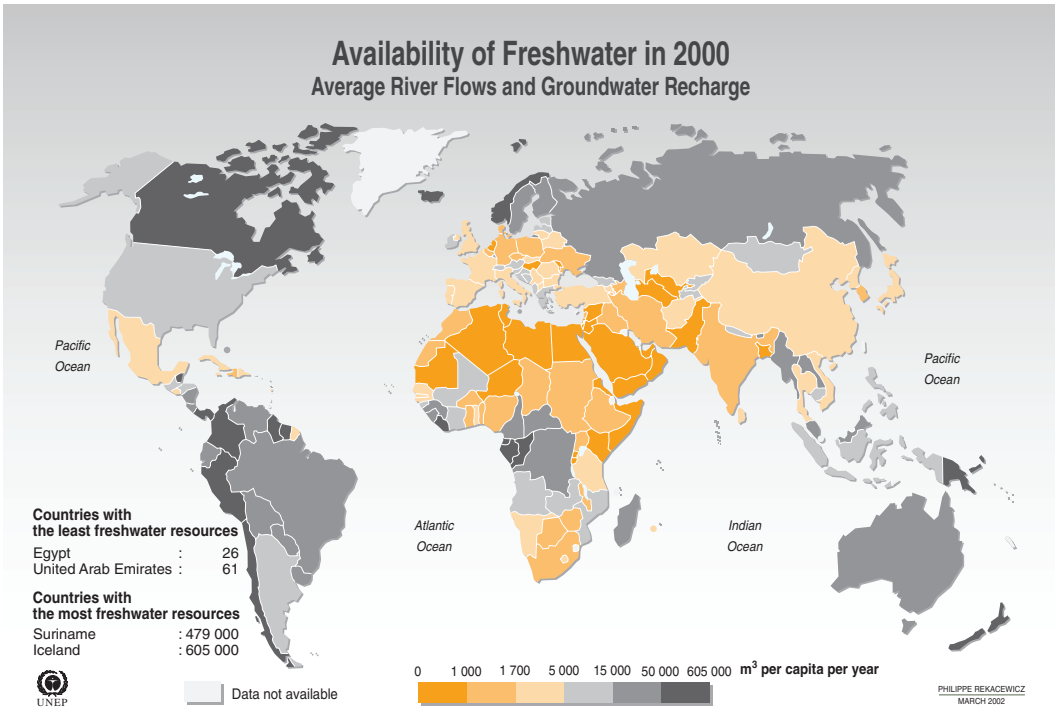
Conclusion

The Arab countries face numerous environmental challenges and have to reconcile many conflicting priorities, from promoting economic diversification, ensuring water supply and food security, and furthering environmental protection and conservation to adapting to the impacts of global warming.

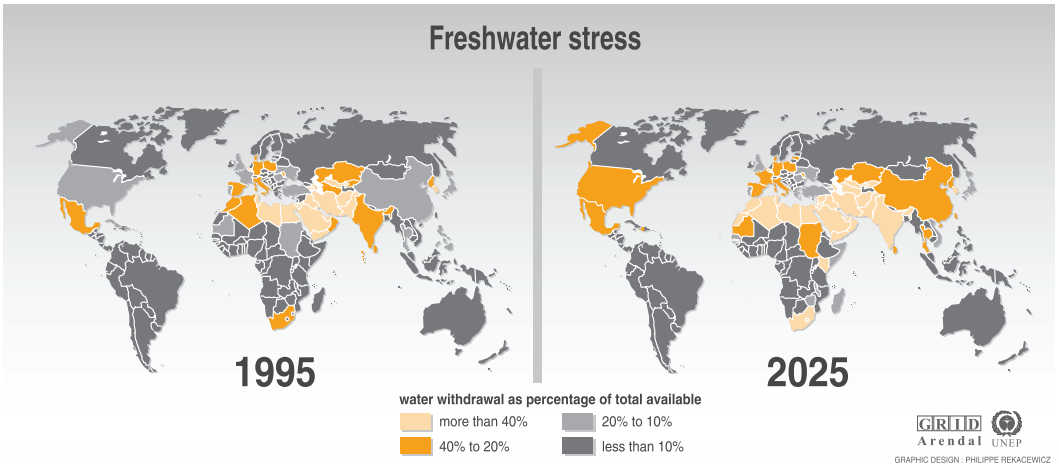
These countries play an increasingly important role in the climate change arena: they are at once producers and exporters as well as victims of global warming. Thus, they must be fully backed and supported by the international community. There is no room for unilateral efforts that ignore other players. Over the next two years, as negotiations on the Bali roadmap progress, there are opportunities for Arab countries to garner financial and technical support from the industrialized world to help them combat the negative impacts of desertification and climate change as well as make advances in the areas of green and sustainable technologies.

To be sure, the current policy engagement of the Arab countries is low. Cooperative projects and initiatives with the international community are few compared with other countries and regions. Inexperienced environmental authorities and lack of institutional capacity are a disadvantage. There is a definite need for better use of economic instruments in environmental policy to encourage environmental protection and promote clean technology that combats the negative effects of climate change. But many initiatives are in the pipeline to improve data and expertise, and to promote environmental awareness and protection. And there are many indicators that civil society will play an important role in general and especially in environmental issues in the near future. The Arab region's view of climate change, renewable energy, and traditional fossil energy sources has changed significantly in the last year. There is a shift toward energy diversification, with more research and initiatives in the field of renewable energy and a resolve to fight climate change and play a vital role in the emissions trading market. As one of the regions most vulnerable to global warming, the Arab countries will be increasingly likely to join the global effort to combat climate change.

Annex 1: Water Pressures through 2005



Source: World Resources Institute (WRI), *World Resources 2000–2001, People and Ecosystems: The Fraying Web of Life* (Washington, DC: WRI, 2000); map © 2002 Philippe Rekacewicz, UNEP/GRID-Arendal.



Source: United Nations Environment Programme (UNEP), *Global Environmental Outlook 2000* (London: Earthscan, 1999); map © 2000 Philippe Rekacewicz, UNEP/GRID-Arendal.

Annex 2: Per Capita Emissions Ranked by Country, 2000

Country	GHG(tCO_2e)	Rank	CO_2 only	Rank
Qatar	67.9	1	60.0	1
United Arab Emirates	36.1	2	25.2	3
Kuwait	31.6	3	26.8	2
Australia	25.6	4	17.3	7
Bahrain	24.8	5	20.6	4
United States	24.5	6	20.4	5
Canada	22.1	7	17.1	8
Brunei	21.7	8	13.7	10
Luxembourg	21.0	9	19.2	6
Trinidad & Tobago	19.3	10	16.7	9
New Zealand	18.9	11	8.6	32
Antigua & Barbuda	18.5	12	4.9	62
Ireland	17.3	13	10.9	18
Estonia	16.6	14	11.3	17
Saudi Arabia	16.4	15	13.4	11
Belgium	14.5	16	12.2	14
Czech Republic	13.9	17	12.1	15
Singapore	13.9	18	13.1	12
Turkmenistan	13.8	19	7.8	40
Netherlands	13.5	20	10.9	19
Finland	13.3	21	10.9	20
Russia	13.2	22	10.6	21
Palau	12.9	23	12.7	13
Nauru	12.8	24	11.4	16
Denmark	12.5	25	9.7	27
Germany	12.3	27	10.4	22
United Kingdom	11.1	32	9.4	30
South Korea	11.1	33	9.9	26
EU-25	10.5	37	8.5	34
Japan	10.4	39	9.5	29
Poland	9.8	43	7.8	41
Ukraine	9.7	44	6.3	47
South Africa	9.5	46	7.9	39
Spain	9.4	47	7.5	44
Italy	9.2	48	7.7	42
France	8.7	50	6.2	48
Argentina	8.1	52	3.9	70
Iran	7.5	60	5.3	56
Turkey	5.3	75	3.3	78
Mexico	5.2	76	3.9	71
Brazil	5.0	83	2.0	100
China	3.9	99	2.7	88
Indonesia	2.4	122	1.4	111
Pakistan	2.1	131	0.8	132
India	1.9	140	1.0	120
Developed world	14.1		11.4	
Developing world	3.3		2.1	
TOTAL WORLD	5.6		4	

Source: World Resources Institute 2007.

Note: Figures exclude CO_2 from international bunker fuels and land use change and forestry.

Interpreting the Trends

A Case for Integrating Groundwater and Surface Water Management

Kendra Patterson

Global water resources are increasingly threatened by overuse, pollution, and climate change. Concern is growing over how to ensure that the planet's endangered freshwater supplies are managed wisely and distributed equitably through space and time. One obstacle is that groundwater and surface water systems are typically viewed as disparate types of resources, and their study and management are often separated into tracks that rarely meet. Policy follows along these lines, with different ministries or departments charged with governance of one or the other. In countries that possess ground and surface water, this creates inefficiencies and makes sustainable use difficult. Groundwater is particularly vulnerable to overpumping, because it is an "invisible" resource and poorly understood.

Groundwater can be renewable or nonrenewable. Renewable aquifers are often connected to surface water systems, such as rivers or lakes, and water is transferred between them. However, the majority of the world's groundwater is confined in fossil water aquifers, which were filled thousands of years ago and are no longer replenished. These often vast natural underground reservoirs of ancient water could be called the last reserves of fresh water on the planet. They are gaining increasing attention as surface water resources become strained beyond capacity. It is of the utmost importance that they be managed carefully, because, as finite resources, they will eventually be tapped to exhaustion. River systems, and other types of surface water, are considered renewable, but they are equally vulnerable to overuse and can suffer seasonal exhaustion. Integrating groundwater and surface water management could enable more sustainable use of both.

Water management and governance are complicated by the fact that water resources often cross state borders and are the focus of competing national claims. This paper compares two cases of transnational water resources—the Nubian Sandstone Aquifer System (NSAS) in North Africa and the Ganges-Brahmaputra Delta in South Asia—to examine the common governance challenges of surface water and groundwater and the dangers of continuing to separate their management. The paper also suggests possible lessons each case holds for the other and their implications for integrating water management on a broader global scale.

Two Cases of Transboundary Water

Water management in the last century mostly consisted of large infrastructure projects such as dams and river diversions. Groundwater was equally exploited, and many countries, including Saudi Arabia and China, are now dealing with severe depletion. What defined the era of the "exploitation paradigm" was the implicit assumption that fresh water was nearly inexhaustible. Now that many countries are experiencing shortages, especially those in the Middle East and North Africa and other water-stressed regions, it is becoming clear that even renewable water resources cannot supply enough water if not managed carefully.

It is necessary to move beyond limiting perceptions of what constitutes "renewable" and "nonrenewable" resources. Equally important is the need to see water resources from a global perspective. Ramaswamy Iyer, former secretary of Water Resources for the government of India, points out that even considering water resources at the basin level is no longer enough, as it creates a "segregation of regions into 'hot spots'" that ignores water systems' global implications.[1] As the discussion of the two very different cases below demonstrates, groundwater and surface water share similar management challenges and goals. A better understanding of these commonalities is needed in order to facilitate their integration under one management scheme and to encourage more sustainable use.

The Nubian Sandstone Aquifer

The NSAS, the largest underground fossil water reservoir in the world, is shared by four states: Chad, Egypt, Libya, and Sudan. It occupies over 2 million square kilometers, underlying almost the whole of Egypt, half of Libya, the northeast corner of Chad, and the northwest portion of Sudan. With an estimated total volume of over 542,000 cubic kilometers (as a comparison, the Caspian Sea, the largest inland surface water body in the world, has a volume of 78,200 cubic kilometers), it has the potential, if tapped on a large scale, to turn an ostensibly water-scarce region into an oasis. In fact, Egypt has tapped the reservoir for decades to make the deserts bloom. Until 1984, when Libya began its ironically titled Man Made River project, a massive engineering feat that pumps the water to the surface and pipes it to the northern coastal cities, most wells that tapped the aquifer were local, village-level enterprises and small-scale projects in planned desert communities such as those in the New Valley, Egypt.[2]

Although scientists know the location of the aquifer underground and its estimated total volume, no one knows how much water is actually recoverable. This depends, among other things, on underground flow patterns, water depth, and the point at which deep wells are no longer economically efficient. With Libya now tapping it on a large scale, and other countries eyeing it as a potential source of copious and thus-far uncontested water, an urgency has been building to develop a better understanding of the aquifer's potential and its limitations. In the

last 20 years, several projects have sought both to create more scientific knowledge of the aquifer and to preempt political conflict by forming a commission of the four states that share it. The latest of these, the NSAS project, has the International Atomic Energy Agency (IAEA) as its executing agency and is funded by the Global Environment Facility.

As executing agency, the IAEA is directly involved with all four member countries and is the principle scientific and technical advisor. The IAEA might at first glance appear a curious choice to lead the project, but isotope hydrology, a technique in which the IAEA specializes, is the primary means of determining the age, origins, and movements of ancient underground water. Other parts of the project include establishing a database of shared information and a legal and institutional framework for joint management, with the ultimate objective of establishing "rational and equitable management of the NSAS for sustainable socioeconomic development and the protection of biodiversity and land resources."[3]

While an admirable goal, it remains to be seen whether conflict can be avoided if Chad, Egypt, and Sudan follow in Libya's footsteps and construct their own huge pumping projects. With no international laws or even substantial proposed frameworks for sharing underground water, and no indigenous common practices for doing so on a larger-than-village-level scale, there is the risk of a "race to the pumps"[4] situation if pressure on water resources continues to build. With water considered a national security issue throughout the region, it is unlikely that even with a joint management commission and a common informational database, these countries will readily share their future development plans with each other, much less submit them to joint decision making. Indeed, despite the aquifer's importance for future socioeconomic development, there is a deafening silence on the part of policymakers—with the exception of first-to-the-plate Libya—as to how it can or will be exploited.

The Ganges-Brahmaputra Delta

Water resources in South Asia, as in North Africa, are often seen as part of national security and are an extremely sensitive political issue. Unlike the case of the NSAS, however, there is already substantial tension between India and Bangladesh over the shared Ganges-Brahmaputra Delta. Bangladesh, the downstream riparian and politically and economically weaker of the two countries, generally feels it gets shortchanged when it comes to allocating the water.[5]

The Ganges and Brahmaputra, which originate in the Tibetan Himalayas, flow through India before entering Bangladesh from the north, and merge near the center of Bangladesh to form one river. This is joined south of Dhaka on its eastern side by the Meghna, which also flows in from India, and drains into the Bay of Bengal. With most of its land mass being either a floodplain or delta, Bangladesh is extremely vulnerable to fluctuations

in water supply. Consequently, Bangladeshis have become skilled at coping with moderate seasonal flooding and drought. However, Dhaka claims that modern infrastructure projects in India, such as the Farakka Barrage (dam) over the Ganges some 10 kilometers from the Bangladeshi border, have contributed to making conditions more unpredictable and extreme. India disputes that its dams have contributed to more severe flooding and droughts in its downstream neighbor.

The two countries have signed several treaties and memoranda of understanding over sharing the Ganges River, the most recent in 1996. Flow measurements used to determine each country's share are taken at Farakka,[6] so any water India may divert upstream is not taken into consideration. It is a constant complaint in Bangladesh that India does not share any information about river flow upstream of Farakka,[*] which is taken to be proof that India is diverting much of the water before it reaches the dam, thus "cheating" Bangladesh of its fair share. India, for its part, considered its disputes with Bangladesh to be resolved by the 1996 treaty.[7]

Bangladesh has never formally disputed the treaty, but often points out that India not sharing information about upstream flow conditions for the Ganges and other shared rivers makes it very difficult, if not impossible, for it to have enough advance warning of coming floods. India is mandated to share flow information only when the water level is 1 meter below the "danger" zone,[8] which gives Bangladesh an average lead time of three days at most. More advanced warning would make evacuations and other emergency preparations easier to mobilize in time. The lack of information sharing on the Ganges's and Brahmaputra's flows also occurs between other riparians upstream, and there is no regional mechanism for sharing data.

Perspectives on Groundwater and Surface Water

Internationally and nationally, groundwater and surface water are often separated into silos in the way they are perceived, studied, and managed. The most recent international consensus on the governance of shared water resources, the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses, mentions groundwater almost as an afterthought, and only deals with groundwater that is connected to surface water.[†] Considering the importance of groundwater to domestic water supplies in many countries,

[*] The Institute of Water Modeling, a trust established by the Bangladeshi government to do technical studies of water resources, is working with the Asian Disaster Preparedness Center in Thailand rather than its regional neighbors to develop a South Asian regional river basin model to assist in flood prediction.

[†] Article 2 of the convention is the one instance where groundwater is mentioned; it states: "'Watercourse' means a system of surface waters and groundwater constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus."

particularly for irrigation and drinking water in cities,[9] this is an astounding oversight. Groundwater is often taken for granted, and its physical characteristics and flow patterns are not well understood. Consequently, it is still predominantly the domain of scientists and engineers.

Because it is not a physical connection, the link between fossil water aquifers and surface water is less obvious than that between renewable aquifers and the surface water that replenishes them, as occurs in India and Bangladesh. In their most recent national water plans, both countries recognized the need to integrate surface and groundwater management,[10] but have yet to put this successfully into practice. Because Egypt and Libya are situated over vast reserves of nonrenewable water, groundwater and surface water policy are completely disconnected. In Egypt, the Groundwater Sector in the Ministry of Water Resources and Irrigation is located within the Irrigation Department, grouped with the Reservoirs and Grand Barrages Sector and other technical/engineering and irrigation-related departments. The Nile Water Sector is located within the "Headquarters," the central department. In Libya, all fossil groundwater is managed by the Great Man Made River Authority, the engineering body that oversaw the Man Made River project.

An argument can be made that the management of groundwater, especially the nonrenewable variety, should be separate from surface water. Indeed, in many ways it is such a special case that it deserves to be separated from surface water in the first instance, if only to encourage more study and understanding of it, as well the creation of an international consensus on its management and governance. The question of how to manage fossil water reserves sustainably is a challenge that will require some creative thinking and a reworking of the traditional "exploitation approach" to natural resources. But it is the very question of sustainability that ties the management of fossil groundwater to that of surface water and constitutes the most important lesson to be learned from examples such as the NSAS. As climate change affects the world's renewable water resources, changing what have come to be seen as their immutable qualities, there will be a need to reexamine the concepts of "renewable" and "nonrenewable."

The Ganges and Brahmaputra Rivers that flow into Bangladesh serve as an example of how water resources can be renewable in supply and yet limited in quantity, and can fall short of fulfilling a country's needs without being exhausted. Most people think of floods when Bangladesh's water challenges are mentioned. But despite being half delta and the final recipient of some of the world's largest river systems, the country is running out of water. Dhaka, which depends on aquifer water that is renewed by the rivers, suffers severe shortages because of declining groundwater tables. The northwest of the country has been experiencing desertification for some years. While drought is a seasonal phenomenon in Bangladesh, it is nonetheless a severe threat to the security of many of its people for much

of the year. India is also overpumping its aquifers,[11] and many wells on small-scale farms have dried up completely. Although the aquifers that underlie these two countries are considered renewable because they are nominally replenished by the Ganges and Brahmaputra Rivers, they are clearly as exhaustible as fossil water aquifers.

When the issue of renewable versus nonrenewable water is redefined as one of availability, of ultimately constrained water resources bounded by limited supply and rising demand, the similarities between the governance challenges faced by the NSAS and Ganges-Brahmaputra Delta are more apparent. First, like many large, transboundary water systems, both are shared by states that have considerable distrust and suspicion of each other. Both are in regions where water is considered to be a national security issue. Perhaps the greatest similarity, though, is the lack of information sharing among riparians. This is not always the fault of poor communication. In the case of the NSAS, the main problem is a lack of data.

The NSAS project has created a centralized database for sharing information about water quality, depth, flows, and other relevant data that could help the four riparian countries better understand the aquifer. The usefulness of this database is diminished by the fact that no one knows exactly how much water is there and what kind of future projects might be planned to exploit it. Estimates of how long the aquifer could last run anywhere from 20 to 200 years.* Growing demands on water and climate pressures will likely lead all four riparians to want to exploit it to the fullest extent possible, but when or how this will be done, and what kind of political, social, and economic situations will compound any conflicts that may arise, is something that needs more analysis.

In the case of the Ganges-Brahmaputra, where India and Bangladesh are already exploiting the water beyond its renewal capacity, the problems are both the withholding of important information and a lack of basin-level cooperation on data sharing. Bangladesh, as the direct downstream riparian of India, is reliant on its neighbor for information on upstream flow volumes in order to predict flooding and prepare for drought. While the two countries have data-sharing arrangements, these apply only when the water reaches a certain level (1 meter below the danger level). It has been suggested that there should be continual monitoring of water levels, with information transferred to Bangladesh at regular intervals.[12] Even this would not provide sufficiently complete information, because the rivers do not originate in India. A basin-level effort to coordinate monitoring of flow levels from the other riparians—Bhutan, China, and Nepal—would be necessary for this to occur. Currently, no such regional organization exists, and there are no plans to form one.

* The Man Made River was built to last of 50 years, a standard lifespan for this kind of infrastructure (Masahiro 1995).

While the lack of complete information and data-sharing cooperation are serious obstacles, the greatest governance challenge in the region is the lack of understanding of the global implications of water resources. A closer look at the NSAS demonstrates the dangers of ignoring the bigger picture.

What Is in Store for the Nubian Sandstone Aquifer?

The NSAS is like a shimmering underground oasis that is still relatively untapped and used nowhere near its projected potential. In a time when water scarcity has become an issue of global concern, its value is increasing. However, it does not garner much attention outside the small circles that specifically study groundwater, and very little information is available as to how and when its riparian countries plan to begin exploiting it on a large scale.

Its projected use may be estimated based on current developments in the region. The NSAS underlies four of the most water-challenged countries in the world. The International Water Management Institute estimates that by 2025 Egypt and Libya will suffer from physical water scarcity (when the water used in a country exceeds 60 percent of its usable supplies), and Chad and Sudan will have severe economic water scarcity (when there is enough water, but lack of capacity, infrastructure, and/or governance to deliver it equitably).[13] Two of these countries, Egypt and Sudan, also share the Nile. The original treaty governing the allocation of the Nile, which flows through 10 countries, states that the river belongs to its two most downstream riparians, Egypt and Sudan. For the past decade, the 10 riparian countries have been negotiating the Nile River Basin Cooperative Framework Agreement through the Nile Basin Initiative. These negotiations were recently concluded, but there are still disagreements among the states.[14] Egypt, in particular, is famously insecure about its water rights, to the point of positing its defense of these rights in the language of war.[15] Most famously, then-president Anwar Sadat said in 1979 that the only issue that would cause Egypt to go to war again was water.

While the nine upstream Nile Basin countries do not currently use enough of the river's water to threaten Egypt's downstream flow, fast-growing populations and increasing water scarcity could change this. The already contentious issue of the Nile could well become a source of conflict, even if the cooperative framework agreement proves fairer than the old treaty. Both Egypt and Sudan will most likely look to their copious underground water supplies to relieve some of the pressure of the situation. Chad, with its own growing population and scarce surface water supplies, will not be far behind.

There is another factor that will make the NSAS a very attractive option for its four riparian countries: the goal of agricultural self-sufficiency. Libya, subject to embargoes for decades, has made no secret of the fact that its Man Made River exists to help it grow enough food to eliminate dependence on imports. Choosing to exploit groundwater rather than build

desalination plants was also based on a desire for self-sufficiency, as desalination is reliant on foreign technology.[16] While experts in and out of Libya agree that agricultural self-sufficiency is not feasible, even if the Man Made River were run at full capacity, it remains the principle on which the country justifies the US$27 billion spent on an infrastructure project with an estimated lifespan of only 50 years.[17] Agricultural self-sufficiency is more than a matter of national and human security. Having the capacity to feed its citizens is widely perceived as a measure of a developed country. Sudan is currently working toward this still very far-off goal, and, like Libya, plans to make use of the NSAS to do it.[18]

Because no one knows how long the NSAS will last if all four riparian countries begin to exploit it on a large scale, and because of the lack of international consensus on how shared groundwater should be managed and governed, this is an insecure situation at best. However, even if the riparians continue to cooperate through a basin-level organization, there is an additional complicating factor. The NSAS demonstrates that fossil groundwater can be transnational in more than one way. Physically, it is shared by four countries. In terms of its possible uses and who will benefit from its water, it is shared on a global scale among countries that are not physical riparians.

Many countries around the world have given up on agricultural self-sufficiency because they lack either sufficient water or land and are looking to countries rich in both to feed their citizens. Sudan is large and could significantly increase its arable land if it exploited the NSAS.[19] Countries as diverse as Saudi Arabia and South Korea have been courting Sudan with an eye to exploiting its rich land and water resources.[20] Much as foreign companies gain rights to mine in countries with copious minerals, Saudi Arabia and others hope to develop wheat fields abroad and have control over the growing, harvesting, and export/import processes. Naturally, Sudan will benefit from the arrangement, and, for a cash-strapped, conflict-ridden country, the scenario probably has its attractions. Indeed, Sudan advertises opportunities for agricultural investment on its overseas embassy websites.[21]

This challenges the concept that agricultural self-sufficiency refers to food grown inside a state's sovereign boundaries, and brings up a host of legal and governance issues that will mean rethinking how shared water resources are viewed. Who "owns" the water that will be used to irrigate these fields? Does Saudi Arabia have an exclusive use right to the amount of water it needs, even to the detriment of Sudan's own citizens—or those of the other riparian countries? How will Chad, Egypt, and Libya react to Sudan exporting their shared fossil water in this way (crop exports/imports are often called "virtual water"), when there is no current treaty that specifies each country's share? Does the NSAS "belong" to its four riparian countries, or to any entity with the desire and means to exploit it?

These are only some of the questions in need of further exploration. They challenge deeply rooted conceptions of water resources that states are only beginning to examine through

practices such as integrated water resource management. Such practices go against the traditional water management paradigm that posits natural resources as a matter of sovereignty. However, the future of the NSAS itself is easy to predict. Eventually the water will run out. And long before that happens, dropping water levels will likely make mining it prohibitively expensive. Saudi Arabia, one of the countries now looking to exploit it, ironically offers the best example of how fossil water can disappear, and over a relatively short period of time. In the 1970s, Saudi Arabia also had a goal of wheat self-sufficiency, and mined its nonrenewable groundwater to create oases in the desert. By 1984 it had achieved its goal and was using groundwater to meet 75 percent of its water needs. In fact, for a while, it was one of the world's top wheat exporters.[22] Not 30 years later, much of its groundwater is gone or has become so polluted and salty from overpumping that it is no longer suitable for irrigation.[23] Now Saudi Arabia is looking beyond its boundaries for water, and is joined by a growing company of similarly land- and water-scarce states.

Toward an Integrated Understanding of Water Resources

The underlying themes of all water resource discussions, especially now that climate change is an accepted phenomenon, are scarcity and sustainability. As examined earlier, even so-called "renewable" water resources, such as the Ganges and Brahmaputra that flow into Bangladesh, are limited and do not always supply what is needed. It is necessary to begin considering all water as if it were nonrenewable and to adjust management strategies to encompass a more holistic view of water resources.

This will require integrating what are currently seen as separate types of water resources—surface and ground—under one water management scheme. Here India's and Bangladesh's national water plans, which stress the interconnectedness of the Ganges and Brahmaputra to underlying aquifers, are a good place to start. However, countries that have confined groundwater that is not physically connected to its surface water resources, such as Egypt and Sudan, also need to understand that these resources have interdependent uses. Although fossil water can never be used sustainably—even with careful management, it will not last forever—its life can be extended if used in tandem with surface water resources.

It is also necessary to recognize that water is no longer just a national or regional issue. As Saudi Arabia's and other countries' interest in the NSAS demonstrates, freshwater resources are of global interest, and should also be of global concern. This is the case for the Ganges-Brahmaputra Delta, whose headwaters are in Tibet. China, like Saudi Arabia, has overexploited its fossil water reserves, particularly the deep aquifer under the North China Plain. Pumps in the area must now drill down over half a mile to access water, a process that is too expensive for most farmers.[24] China is considering diverting water from the Brahmaputra River in the south to irrigate its northern farms.[25] If this plan is carried out, India's and Bangladesh's water supplies will be profoundly affected. Recognizing linkages

between water resources separated by thousands of miles and several sovereign borders—and particularly between fossil groundwater and surface water systems—is necessary to truly commit to sustainable practices.

Conclusion

Without understanding that groundwater is an integral part of the global water supply, there is a risk it will be exploited on a scale similar to rivers in the last century. The era of large, ecologically indifferent infrastructure to "push rivers around"[26] is indeed still alive and well in many parts of the world. Fossil groundwater, invisible, not well understood, and finite, is especially vulnerable to this exploitative paradigm.

Much research has been devoted to the concept of using water management as a way of encouraging cooperation among states. Indeed, it has been argued that states are much more likely to cooperate than fight over shared water resources.[27] While collaboration is encouraging, it is not enough to simply cooperate. The goal of sustainable use must define water management in the coming decades. It has been shown that sustainability can function as a framework within which cooperation is possible.[28] However, without moving beyond dichotomous concepts such as renewable versus nonrenewable, and surface water versus groundwater, managing for sustainability will be similarly constrained.

To an end user, it matters little whether the water comes from a surface source or from underground; the main concern is that it be plentiful and clean. All types of water in a given system, such as a country or region, form a totality of that system's water resources and should be managed together to ensure that use is equitable, ecologically responsible, and sustainable. Equally important is acknowledging the links among seemingly unconnected water resources. Recognizing the wide-ranging global implications of water use is the next step in creating wise governance of the planet's freshwater reserves.

A River Runs Through It: Climate Change, Security Challenges, and Shared Water Resources

David Michel

Global climate change threatens to significantly affect water resources worldwide. Continuing global warming will accelerate the Earth's hydrologic cycle, increasing both precipitation and evaporation and impinging on fundamental hydrometeorological mechanisms. Mounting global temperatures will augment melting of the polar and alpine glaciers that contain the bulk of the planet's fresh water. Elemental patterns and processes such as the seasonality of rainfall and snowfall, the onset of the monsoon, and the recurrence of El Niño–Southern Oscillation (ENSO) phenomena may shift or falter. Extreme climate events will increase in frequency and degree at both ends of the spectrum, with flash floods and deep droughts, intense storms, and searing heat waves becoming more numerous and more severe.

The world's river systems, crucial to global water supplies, will particularly bear the repercussions of growing climate pressures. Altered precipitation patterns and increased melting of mountain glaciers will disrupt the upstream sources that nourish river waters. Changing stream flows risk upsetting the timing, quantity, and quality of freshwater resources available to communities and ecosystems around the world. According to one recent study, by 2050, human-induced climate change will affect river discharge in every populated basin on the planet.[1] In much of the world, shifting freshwater availability will collide with increasing demand. The Organisation for Economic Co-operation and Development (OECD) calculates that by 2030 some 3.9 billion people—47 percent of the global population—will be living in areas with high water stress, mostly in developing countries.[2]

To many observers, such figures presage potentially serious shortfalls between rising demands and future water supplies, shortfalls that could spark dangerous conflicts. Water is life. It is essential for drinking and for growing food. If climate change alters the amount or distribution of this vital resource, water-dependent societies could suffer considerable consequences. Greenhouse-driven changes in river flows risk rippling through connected systems, touching farming, fisheries, and forestry, sanitation works, and hydropower generation.

Insufficient water supplies can impair agricultural production, endanger public health, strain established settlement patterns, and jeopardize livelihoods and social well-being. Where different countries (e.g., upstream and downstream) or different communities (e.g., rural and urban) share the same river, worsening climate pressures could engender sharpened competition or even violent confrontations to secure an increasingly scare resource. Policymakers, pundits, and the popular press alike have openly worried that the coming century could witness the eruption of outright "water wars."

Closer inspection of global hydropolitics, however, suggests that the more hyperbolic warnings of looming water wars are overblown. From local streams to international rivers, riparians seem more often to find opportunities for a cooperative *modus vivendi* than the seeds of a *casus belli* in shared water resources. No modern state has ever declared war on another solely over water. Indeed, by all historical accounts, the only such water war ever fought occurred over four millennia ago.

Nevertheless, open warfare between nation states is not the only threat to peace and prosperity posed by climate impacts on common waters. Rising stresses on freshwater supplies could fuel tensions within states as well as between them and will put new pressures on cooperative institutions from the local to the international. A reexamination of the human security issues arising at the intersection of global warming and global water can illuminate where the likely flashpoints lie and guide policymakers striving to keep the coming four millennia free of water wars.

Climate Impacts on River Systems

Climate-related changes in river flows stem principally from changes in the volume, timing, and form of precipitation (whether it falls as rain or snow). Globally, the Intergovernmental Panel on Climate Change (IPCC) projects that both annual mean precipitation and the number of heavy precipitation events will rise over the course of the 21st century. Glaciers and snow cover will contract as temperatures mount. Within these global tendencies, however, regional trends will vary considerably. Comparisons of multiple computer models suggest that precipitation will increase in the higher latitudes of both the northern and southern hemispheres, in Eastern Africa, and in much of Asia, but will decrease significantly across Central America and the Caribbean, as well as throughout the Mediterranean, Middle East, and North Africa. Even so, while precipitation will wax in some regions and wane in others, the total global land area subject to increasing water stress will double by midcentury. Extreme hydrological events, storms, floods, and droughts are also projected to increase. Ironically, because precipitation will be concentrated in more intense events, some basins could see both periods of heavy rainfall, high runoff, and increased flood risk interspersed with longer and more severe dry spells. Similarly, even where increased river

runoff from greater rainfalls or enhanced glacier melting will boost total water supply, the benefit may be offset by higher variability in seasonal availability and higher flood risks.[3]

The populations living along many major river systems in the developing world could prove especially vulnerable to such pressures on water supply. In the Nile Basin, Egypt receives 95 percent of its water resources from abroad and Sudan, 77 percent. Fully 86 percent of the Nile waters on which these countries rely originally flow from the Ethiopian Highlands, where the single June-to-September rainy season appears susceptible to potential changes in ENSO cycles. In South Asia, glacial melt from the Himalayan region comprises 9.1 percent of the Ganges river flow, 12.3 percent of the Brahmaputra, and 44.8 percent of the Indus. Himalayan glaciers, in turn, are retreating more rapidly than anywhere else in the world. Initially this melting will feed greater river runoff. As the glaciers recede, runoff will decline, with potentially dire consequences for riparians reliant on the previous levels of river flow. Around the world, major river deltas will be among the most exposed of all areas to climate change. Many exhibit high vulnerability both to river flooding and to sea-level rise and storm surges. Indeed, higher river flows can exacerbate the local impacts of sea-level rise and storm surges in the delta as incoming ocean water piles up over outflowing fresh water. By one calculation, perhaps 3 million people altogether could be displaced by climate-induced coastal flooding in the Nile, Ganges-Brahmaputra, and Mekong Deltas by 2050.[4]

Climate impacts on river basins will influence individual tributaries, communities, and water consumers at local scales as well. Within regions, climatic and geographic circumstance subject different countries along the same waterway to disparate hazards. One study prepared to inform preparation of India's national climate policy examined greenhouse scenarios for multiple subbasins of the Ganges River. It projected that precipitation might jump over 50 percent in some areas while falling 10 percent or more in neighboring zones. The number of anticipated drought events afflicting certain subbasins leapt fivefold in some places while plunging by the same order of magnitude in others.[5]

Even so, the specific ramifications of growing greenhouse warming for individual river basins remain difficult to discern. Existing studies concentrate heavily on North America, Europe, and Australasia. Only a handful of analyses have been brought to bear on key systems outside these regions such as the Mekong, the Ganges-Brahmaputra, the Indus, or the Nile. These efforts often deliver disparate results. An examination of the Nile Basin found that the present uncertainties surrounding future rainfall patterns and water management structures precluded any clear indication of climate change effects on Nile river flows. Similarly, current model forecasts of greenhouse repercussions for South Asian rivers disagree whether runoff will increase or decrease.[6] Uncertainty about future water resources as much as projections of potential variability and extremes complicate water managers' efforts to prepare for climate change.

Water Resources and Security Threats

Concerns that climate change could ultimately undermine global order have grown markedly in recent years, but they are not new. In the early 1970s, unusually difficult weather struck many parts of the globe. The Mediterranean Middle East suffered the severest drought of the century. In 1972 Moscow sweltered under its hottest summer ever recorded. As Russia's breadbasket east of the Urals struggled through the driest months in 100 years, the USSR bought 30 million tons of grain on the world markets, including 18 million tons from the United States, to make up the shortfalls. In Africa, 1973 delivered a fifth straight year of drought to the Sahel region, parching pasturelands, drying up rivers and wells, and leaving 100,000 dead.[7] This string of weather-related disasters raised fears that the world's food stocks could prove dangerously vulnerable to repeated climate catastrophes. A Central Intelligence Agency (CIA) analysis of the time suggested that, in the worst case, where climate change caused grave shortages of food despite US exports, hungry but militarily powerful nations could make desperate attempts to get more grain any way they could. Massive migration backed by force might spread, and nuclear blackmail was not inconceivable.[8]

Since that time, the worsening risk of global warming has engendered growing public and policy preoccupation with potential climate impacts on water security. In 1991, then–UN secretary general Boutros Boutros-Ghali famously pronounced that "the next war will be fought over water, not politics." His successors have evinced similar worries. In 2001, Kofi Annan warned that "fierce competition for fresh water may well become a source of conflict and wars in the future." And current secretary general Ban Ki-Moon has argued that the ongoing Darfur crisis "grew at least in part from desertification, ecological degradation, and a scarcity of resources, foremost among them water."[9] Accompanying this chorus of concern, numerous policy scholars as well have asserted that, as population growth and economic development raise pressures on demand and environmental pressures degrade supplies, resource scarcities could precipitate violent international conflicts, with shared rivers an especially dangerous flashpoint.[10]

From the speeches of international civil servants and the pages of academic journals, the argument that water and other resource conflicts, exacerbated by global warming, could undermine the international order has taken root in public policy and the public mind. The European Union explicitly invokes the danger that climate stresses could menace global security as a basis for European Community climate policies.[11] When the UN Security Council held its first-ever meeting on the greenhouse threat to international peace, 55 nations lined up to address the session.[12] Growing apprehension that unchecked global warming could potentially push environmental and social systems over a precipice is perhaps nowhere better illustrated than by the *Bulletin of the Atomic Scientists*. For six decades, throughout the Cold War and beyond, the bulletin's "Doomsday Clock" has served as an iconic indicator of modern society skirting the edge of momentous thresholds for global welfare.

Historically, it measured the danger of nuclear war. At the beginning of 2007, however, the clock advanced two minutes, closer to the fateful stroke of 12:00 than at any time since the height of the 1980s arms race, in large part due to the rising risk of climate change. In the eyes of the bulletin's directors and sponsors, including 18 Nobel laureates, it is now five minutes to midnight.[13]

Water Wars?

Responding to this rising tide of alarm, a number of water policy analysts have moved to evaluate the risk of prospective water wars against the historical evidence. Combing through data sets covering 124 countries and 122 of the world's 265 international river basins, a group of scholars surrounding Aaron Wolf at Oregon State University identified 1,831 interstate events between 1946 and 1999 that concerned water. Cooperation, they discovered, far outweighed confrontation, representing 67 percent of events. Of 507 incidents judged conflictual, 414 amounted to only rhetorical exchanges. In all, they found 37 instances of military or violent confrontation. In no case did disputes over water lead to formal declarations of war. On the contrary, riparians in transboundary basins signed fully 157 international freshwater treaties over the same period.[14]

In contrast to the often anecdotal or at best case study–based assertions advanced about impending international water conflict, Wolf et al. provide a more global and rigorously quantitative corrective. Their work is widely cited to deflate anxious claims that strains on water supplies will ignite future water wars and to highlight the predominantly collaborative character of interstate hydropolitics.[15] Yet, there are several reasons to fear that previous levels of international cooperation will not necessarily continue to prevail.

First, although when tallied as individual events, examples of cooperation considerably outnumber cases of conflict, this tote-board accounting may not accurately describe the dynamic degree of tension over water resources that riparians experience. In relations among nations, governments and publics may deem 1 exchange of gunshots much more telling than 10 exchanges of friendly communiqués. Indeed, that many hostile actions occurred in basins covered by official treaties bears out that even formal cooperative agreements by no means preclude states coming to blows. That no state formally declared war on another over water carries almost no probative value. The fact is that throughout the entire second half of the 20th century (1950–2000), there were only two formally declared wars for any reason anywhere in the world.[16] By the same token, security strategists and policy planners attempting to gauge the danger that rows about resources could escalate to war may judge the disclosure that water issues contributed to "only"[17] 37 violent incidents —including 21 examples of "Extensive war acts causing deaths, dislocation, or high strategic cost"[18]—to be less than reassuring. If this is already so, they might well wonder, what will happen if climate change aggravates existing strains on shared water supplies?

To be sure, students of water politics who emphasize the relative absence of violent encounters in the empirical record also clearly acknowledge that "The future of transboundary water conflict may not look like the past."[19] But there is also some question as to how much the past looks like the past. That is to say, the historical view recounted by Wolf and his colleagues may not fully reflect the role of water discord in interstate conflicts. Their assessment demonstrates that, across all water interactions among states inhabiting the same basin, cooperative instances predominated over clashes and riparians rattled sabers much more than they crossed swords. This approach shows states collaborate more *often* than they fight, but it does not address whether or not frictions over shared waters make the risk of violent confrontations more *likely*. Here, some other expeditions into the hydropolitical archives offer more troubling evidence. In an extensive statistical study, Gleditsch et al. examined every transboundary river in every one of the world's international river basins from 1880 to 2001. They determined that, even after accounting for other factors that trigger interstate conflict, countries that share a river face a higher probability of engaging in fatal military disputes. Though not conclusive, their results also suggested that competition stemming from water scarcity may help explain this propensity.[20] Similarly, Hensel and Brochmann reviewed the management of every shared river in the Americas, Western Europe, and the Middle East from 1900 to 2001. Their investigation indicated that growing water demands and greater scarcity both make explicit disagreements over rivers more likely and heighten the risk that these claims will become militarized.[21]

Other scholars have criticized historical arguments that divide transboundary water relations into so many discrete and static incidents, each instance then designated either collaborative or contentious. These analysts maintain that conflict and cooperation quite often coexist, embedded in more complex interactions. Qualifying international water politics by scoring events on a unidimensional conflict/cooperation axis misses the importance of this broader, multifaceted context. Crucially, it may obscure how many nominally collaborative acts can in fact serve to ignore, evade, exacerbate, or entrench contentious underlying issues. Rather than mitigate potential conflicts, such cooperation may sustain them. So, for example, focusing on small-bore scientific cooperation between Bangladesh and India sharing data on the Ganges masks the degree to which underpinning issues continue to fester unresolved, stoking enduring tensions. So too, formal legal instruments such as the 1929 and 1959 Nile Treaties represent the summit of international water cooperation. Yet those accords also enshrine an extraordinarily lopsided allocation of the river. Egypt and Sudan receive an absolute right to use 100 percent of the Nile waters, roughly 75 percent to Egypt and 25 percent to Sudan. The eight other basin states receive nothing, a distribution they increasingly contest.

"Not all cooperation is pretty" write Zeitoun and Mirumachi on the many visages of water politics.[22] Some is downright ugly. Some may affirm asymmetries of power among riparians. Some may codify coercion. Surveying the distribution of transboundary flows between

Israel and Palestine (giving 90 percent of the water to Israel), and the Israeli-Palestine Joint Water Committee procedures for licensing projects within Palestine (giving Israel an effective veto over works judged to threaten state interests), one observer labeled the arrangements not cooperation, but "domination dressed up as cooperation."[23] Hydropolitics is still politics. Thus, like all politics, it is, in the classic definition of Harold Lasswell, a question of who gets what, when, and how.[24] The simple quantity of transboundary water cooperation must not blind analysis to its quality, what exactly it entails, and how it comes about.

Civil War, Civic Unrest

Wolf and his fellows countered deterministic claims of impending water wars by delving into the chronicles of interstate hostilities. Many of the more recent analyses, concerned that climate pressures on water supplies and other resources could spark combustible conflicts among states, however, also worry that the same stresses could kindle potentially violent turmoil within them.[25] Civil conflicts can be as destructive as international ones. By one estimate, internal wars have killed three times more people than interstate conflict since World War II.[26] They are also far more common. By one count, 95 percent of all conflicts over the past decade have occurred within states, not between them.[27] And civil wars can be as destabilizing to global order as international ones. States racked by civil war are far more likely to become embroiled in militarized conflicts with their neighbors. Whether the fighting remains confined inside one state, the disruptive repercussions typically do not. All too often civil wars draw in combatants from surrounding countries to support one side or the other, protect endangered interests or compatriots, or take advantage of the neighbor's distress.[28]

Regrettably, swings in climatic conditions seem already to be contributing to such intrastate conflagrations. A 2004 study of 41 African nations determined that wherever drought precipitated a 5 percent drop in GDP growth one year, the likelihood that country would fall into civil war the next increased by more than half. Worrisomely, this relation held whether the countries in question were richer or poorer, democratically or undemocratically governed, ethnically divided or not.[29] More recently, an assessment of all civil wars since 1975 showed that, where rainfall deviates significantly below the normal in one year, the risk that a high-intensity internal war will break out the following year jumps substantially.[30]

Yet armed clashes to secure scarce resources, whether waged among states or between governments and insurgent groups, are not the only greenhouse threat to domestic order and international stability. Some climate impacts could kill or imperil large numbers of people, placing severe pressures on exposed populations and civil institutions. Droughts could weaken agricultural production, diminishing food supplies, raising prices, perhaps inciting hoarding or "bread" riots. Floods could destroy infrastructure and inundate settlements, depriving victims of sustenance, their homes, and their livelihoods. The weight of

such strains may exceed the ability of some societies to adapt, fostering civic disturbances and possible political unrest. "Many developing countries do not have the government and social infrastructures in place to cope with the types of stressors that could be brought on by climate change," concluded a review by former senior American military officers. And "When a government can no longer deliver services to its people…conditions are ripe for turmoil."[31] Here too, available evidence suggests the risks are real. A study of 187 states and territories covering the second half of the 20th century found that the danger of violent civil conflict increased markedly following climate-related disasters, the risk rising with the number of events suffered in a given year.[32]

In a globalizing world, such woes will not necessarily stay put. Potential climate catastrophes could both displace victims across borders and draw interventions from abroad. As the UN High Commissioner for Refugees points out, mobility and migration represent crucial coping and survival strategies for the victims of natural disasters and humanitarian crises.[33] On one oft-cited estimate, floods, droughts, and rising sea levels could generate 200 million climate refugees by 2050. At present, such projections represent no more than best-guess extrapolations, highly sensitive to underlying assumptions and classifications defining who counts as an "environmental" refugee. Multiple factors drive human migration, but empirical studies suggest climate pressures could play an increasing role. Fieldwork on flooding in the Mekong Delta, for instance, has found through questionnaires of Vietnamese migrants in Cambodia that half the respondents had decided to migrate in part because of environmental problems.[34]

While emigration may permit the victims some escape from environmental stresses, it can create new sources of conflict in the destination states.[35] Refugees displaced directly by environmental disaster can place heavy burdens on the natural resource base and the social and economic capacities of the host communities. Their presence may stir social tensions. In Bangladesh, for example, migrants from the flood-prone plains have been met by occasionally violent opposition both in the Chittagong Hill tracts and over the frontier in the northeast Indian region of Assam. Indeed, India continues to pursue a long-standing project of fencing off the border, erecting along the Brahmaputra a barrier itself constructed to withstand storms and floods.[36] Migrants dislocated by civil strife at home can pose additional challenges for receiving countries. Voluntarily or involuntarily, they may bring the conflict with them. They may be recruited into combatant factions; their settlements may become targets or bases for the contending parties.

While climate change may fire the engines of environmental migration, many outlets for such refugees are narrowing. As international migration of all kinds has surged in recent years, more than doubling from 75 million in 1960 to 191 million in 2005, governments around the world increasingly deem migration—particularly unauthorized or mass

population movements—a security issue. Many states now exhibit a growing willingness to "militarize" their responses, deploying military force to halt or control migratory flows.[37] Some analyses contend that developed countries may come under growing pressure to admit swelling numbers of environmental refugees. Most international refugees from natural disasters, though, move no further than neighboring countries. Developed countries worried about the potentially destabilizing effects of climate refugees, then, seem more likely to intervene with relief and reconstruction efforts on the ground than with asylum offered from afar. In the first instance, it will be the neighbors—the probable receiving states—and regional powers that will feel most compelled to step in to avert incipient humanitarian catastrophes or contain widening conflicts.

Unfortunately, ample indications testify to the social stresses global warming is already exerting. In the last 30 years, weather-related hydrometeorological disasters of all kinds—floods, droughts, windstorms, hurricanes, etc.—have quadrupled, surging from 428 in 1974–78, to 817 in 1984–88, to 1,707 in 1999–2003.[38] According to the reinsurance giant Munich Re, great natural catastrophes—those that overwhelm local recovery capacities, requiring interregional or international assistance—have almost tripled since the mid-20th century, jumping from 21 in 1950–59 to 57 in 1996–2005. Economic losses from these calamities have multiplied 12-fold, from US$48.1 billion (2005 values) in the 1950s to US$575.2 billion over the 10 years ending in 2005.[39] Worse has been the human toll. Between 1990 and 1999, an annual average of 188 million people worldwide lost their homes, livelihoods, health, crops, or livestock for some time due to natural disasters, six times the 31 million per year similarly harmed by armed conflicts.[40] In 1998 alone, the Red Cross calculates, 25 million people, or 58 percent of all the world's displaced persons, were refugees fleeing environmental catastrophes.[41]

Climate Pressures on Cooperative Water Management

History is filled with examples of water conflicts. Peter Gleick maintains a Water Conflict Chronology database detailing hundreds of incidents stretching back to 2500 BC.[42] Yet cooperation over shared water resources certainly holds an equally ancient pedigree. Though not traceable to Sumerian antiquity, the world's oldest international water agreement, a grant of freedom of navigation by Emperor Charlemagne to a monastery, appears to date from 805.[43] And where lethal clashes have occasionally erupted despite the existence of mutual agreements, cooperative relations have persisted even through open hostilities. India and Pakistan, for example, have fought two wars since concluding the Indus Waters Treaty in 1960, but have never once broken that accord.

Students of transboundary water resources have identified two key variables that define the likelihood and intensity of water conflict in a given river basin. The first is the amount

and rate of physical or institutional change in the water system covered. The second is the strength of the cooperative institutions linking the riparians.[44] Global warming will place unprecedented pressures on both.

Rising Physical Pressures

Climate change will contribute to dramatic alterations in the physical parameters of the water regime prevailing in many rivers. Almost a billion people now live in areas projected to experience a swing in river flow of 40 percent or more, and 365 million inhabit basins where river discharge could shift by upwards of 90 percent by midcentury.[45] Even where mean annual river flows remain closer to their current levels, seasonal variations could disrupt existing ecological patterns and upset socioeconomic structures reliant upon them. The Mekong River offers a case in point. Maximum monthly flows in the basin are expected to grow some 35 percent by 2038, while minimum monthly flows will shrink 17 percent. In other words, both flood risks in the wet season and water shortage in the dry season are projected to become more severe. One study of 16 large basins around the world found that, under one strong warming scenario, flood levels that previously occurred only once a century might recur as frequently as every two to five years. Droughts could similarly intensify. According to one model study, the proportion of the global land surface suffering extreme drought at any one time could jump 10- to 30-fold by 2090; the frequency of extreme drought events could double, and their mean duration increase sixfold. Another multimodel test projected that droughts in the mid-latitudes and northern subtropics could expand the land area experiencing extreme drought from 1 percent at any given time to 30 percent by 2100.

Climate pressures on water supplies may be even worse than projected. Forecast levels of water stress and water shortage build on projections of greenhouse gas (GHG) concentrations from greenhouse emissions and on calculations of the global warming that would then result. At present, the IPCC estimates that doubling the amount of carbon dioxide in the atmosphere—the customary yardstick for measuring climate sensitivity—would boost global average surface temperatures between 1.5°C and 4.5°C. If climate sensitivity to rising carbon dioxide levels is 1.5°C, then atmospheric carbon concentrations could almost double from today's amounts before global warming would cross 2°C above preindustrial levels, the threshold that many climatologists consider dangerous. But if climate sensitivity is 4.5°C, then carbon concentrations would have to be held to today's levels and all greenhouse emissions essentially eliminated by 2050 to keep humanity within the 2°C warming limit. Recent work, however, suggests the possibility that GHG concentrations could generate significantly more warming than previously believed. Although not likely, climate sensitivity may fall completely outside the IPCC estimate range and might reach as high as 10°C or more.[46] If so, the consequences for the global hydrological regime could

be catastrophic. Yet analyses of the emissions pathways that would be necessary to restrain GHG accumulations within the 2°C guardrail, even assuming lower climate sensitivity, show the increasing improbability of realizing such radical reductions in greenhouse pollution.[47]

Cooperative Institutions

By the same token, existing cooperative institutions may have difficulty grappling with the challenges posed by climate change. Addressing greenhouse pressures on common water resources, water policy experts commonly agree, calls for "integrated water management" techniques approaching river basins as a whole and encompassing all the demands on the river waters from human uses to maintaining natural ecosystems. Many current cooperative arrangements, however, are not particularly well adapted to such strategies. Policymakers must think across national and institutional boundaries if they are to think through growing relations of interdependence. Neither administrative jurisdictions nor bureaucratic remits correspond to ecological zones or environmental functions. Water policy in particular must appreciate that water resources are never fixed. Water is always part of the hydrological cycle and part of an ecosystem from which it is diverted or withdrawn. As such, policymakers must develop more holistic approaches to managing shared water resources, integrating the needs of different users—including ecosystems—evolving over time. This is now infrequently the case.

Decision-making power is asymmetric and information scattered among riparian states. Actions taken by countries upriver, such as constructing dams or drawing off water for irrigation, can hold significant ramifications for those downriver. Knowledge of water balances in specific tributaries or water demands in specific communities is spread unevenly among multiple entities across multiple countries. Within riparian states, responsibilities for different aspects of climate, water, and development policies are typically divided, with different institutions and authorities serving different constituencies and objectives. Different stakeholders perceive different problems and priorities.

Despite the possible rewards, international cooperation must surmount numerous political and institutional hurdles. Though transboundary water resource management offers positive cooperative opportunities, it also presents potential conflictual pitfalls. Collaboration aims to deliver mutual gains. A logic of "benefit sharing" could catalyze greater cooperation among riparian countries.[48] Many international agreements divide river waters into designated allotments for each party. As global warming threatens to upset transnational river flows, such quota systems risk spawning a zero-sum and potentially contentious dynamic. Benefit sharing strives to build cooperation around creating mutual advantages (e.g., food security, flood control, power generation) that profit all parties together or each in turn—sharing gains rather than sharing water. But most cooperative climate and water

policies necessitate substantial up-front costs that may only pay off over time. Before states can aspire to collective "benefit sharing" they must contrive to share out the price of collaboration that each will bear, a less appealing exercise.

The prospective fruits of cooperation can also prove problematic. Often, implicated stakeholders may feel that their interests do not figure in the ostensibly shared benefits. In the Mekong Basin, many riparian communities have long contested the construction of large dams intended to deliver the benefits of hydropower generation, arguing that the state pursues these projects without regard to the detrimental repercussions for the river environment and for their livelihoods.[49] Even the simple benefit of shared information can nurture mutual understanding, but it can also breed mutual antagonism. For downstream riparians, data detailing flows upriver can disclose how much water their more advantageously placed neighbors are diverting for their own use. Revealingly, while the ministries of the South Asian Association for Regional Cooperation (SAARC) recently agreed to share meteorological information, they declined to share hydrological data.

Intergovernmental organizations can bring shortcomings of their own to cooperative endeavors. Bilateral and multilateral institutions established to further cooperation can perpetuate the ingrained controversies and power imbalances that characterize their member states. The 1929 Nile Treaty which still governs aspects of water use in the Nile Basin is a colonial artifact dating from a period when Britain ruled most of the upstream riparians.[50] While river basin or regional associations may aspire to play the honest broker, ultimately they can only achieve as much or as little as their members allow. The existence of multiple institutional arenas can complicate as well as facilitate concerted policy formation. Domestically, different ministries often compete to take the lead on climate policy development in different international settings, hampering national coordination. Internationally, significant actors are often absent from important institutions. Though it is the upstream riparian, China holds only observer status in the Mekong River Commission. In the SAARC, foreign ministries overshadow generally feeble environmental agencies. To date, declarations, not deeds, dominate the association's environmental accomplishments. Institutional cultures as well as institutional structures may advance or confound international cooperation. Institutions have their own agendas, audiences, and objectives. They may succumb to bureaucratic overreach or bureaucratic inertia. They are not mere automata blankly awaiting government instruction.

Climate Security as Policy Outlook

Policy communities in the developed and developing nations alike perceive climate change as a prospective security threat. Yet developing country experts conceive the nature of this threat quite differently. Developed country policy analyses typically cast climate security as a question of *international* stability. In this view, greenhouse impacts striking one

country may spread risks to others, generating political frictions and possibly violent confrontation. Thus, global warming could diminish water supplies or food production, sharpening competition for scarce natural resources. Or refugees fleeing flooding or drought might spill into neighboring states, straining local capacities and sparking civil strife. Other countries might be drawn in, looking to avert destabilizing humanitarian catastrophes or contain widening conflicts.

For many developing states, however, climate change imperils their *national* security, even their national survival. Rather than reverberating from abroad, greenhouse impacts directly endanger their societies at home, threatening loss of life, loss of livelihoods, loss of property, and loss of territory (to sea-level rise). Serious climate security risks do not just emanate *from* developing countries, they happen *to* developing countries. Developed nations frame climate insecurity as a potential hazard exported from the developing world. In marked contrast, developing nations see climate insecurity as a present danger imposed upon them by decades of unabated greenhouse emissions in the developed world.

Similarly, focusing on the potential "hard" security threats posed by climate change detracts attention from the ongoing threat to "human" security experienced by millions of the poorest and most vulnerable in the developing world who lack adequate water supplies. Insufficient quantity and quality of freshwater resources strike much harder at the lives and livelihoods of developing country populations than any security reverberations from water wars that are likely to hit their developed neighbors. An estimated 2.6 billion people worldwide still lack improved sanitation facilities. And 3 million people in developing countries die each year from waterborne diseases, most of them children.[51] Climate change pressures on water supplies may make cutting these figures more difficult. Yet these very real water supply issues certainly pose a greater threat to the safety and well-being of more people than the as-yet-unrealized risk of future water wars.

Nevertheless, as a matter of political motivation, growing recognition of the potential security challenges presented by unchecked global warming gives policymakers powerful additional reason to enact effective greenhouse mitigation measures. Yet framing climate change as a looming risk to international stability holds important hazards of its own. First among these is the danger that focusing states' attention on the climate security risks to themselves could deflect energy and resources away from necessary cooperation with others. Countries concerned that climate stresses could ignite domestic strife may hoard relief supplies rather than assist stricken neighbors. States worried that climate migrants from abroad could cause civil turmoil at home may close their borders to refugees fleeing greenhouse impacts. Nations anxious that global warming could trigger struggles over scarce natural resources may move preemptively to control their supply. "How people define a problem," former diplomat Harold Saunders points out, "begins to determine what

they will do about it."[52] Without due care, emphasizing the very real security risks raised by climate change could lead fearful governments to take adversarial actions that would aggravate the very international antagonisms that both greenhouse and security policymakers hope to avoid.

Less likely but no less troublingly, excessive focus on climate security risks deforming not only the effective content of countries' particular policies but the very nature of some governments' response to the greenhouse problem. Numerous analyses of the climate security threat have noted the danger that global warming's impacts could simply overwhelm the coping abilities of many states. Dissatisfaction with government responses or disputes over distribution of disaster assistance could then spark potentially violent confrontations. For many of the most vulnerable states, the possible consequences for national stability could prove calamitous. At the same time, many of the countries most vulnerable to climate impacts have weak or troubled state and civil institutions. As a practical matter, these nations cannot rapidly or readily improve their governing capacities to deal with extreme climate stresses. Should they come to view global warming primarily through a security lens, when greenhouse impacts strike, these states may feel compelled first to deploy their military and security apparatus to head off dangerous civil conflict. The problem risks being all the more acute in ethnically or religiously divided societies where a drought, flood, or other natural disaster may afflict one group more than another. By the same token, these same considerations may lead neighboring countries to look upon these more greenhouse-vulnerable states principally as sources of regional instability—and so as candidates for military intervention or quarantine as much or more than for disaster relief and reconstruction. The increasing awareness of global warming's global security implications can provide a strong incentive for international cooperation to meet the climate change threat. But these issues must be carefully and collaboratively addressed if they are not to furnish instead a new inducement to international conflict.

Conclusion

Global climate change will significantly affect the hydrological cycles that nourish the world's major river systems. Potential shifts in the availability and distribution of shared freshwater supplies could engender conflicts among countries and communities over the management of this essential resource. Contrary to the claims of some commentators, these disputes will not likely spark open warfare over water. Rather than engage in battle to secure water sources, states have far more often engaged in negotiations to hash out cooperative agreements for managing common water supplies. Global warming heightens the need for such cooperation. Climate pressures ignore borders. In a warming world, water managers must similarly formulate integrated policies at ecosystemic and river basin levels that cross political boundaries.

Many water experts have rightly argued that riparian nations have very largely succeeded in controlling competition and conflict over shared resources by establishing cooperative international institutions. These institutions have already prevented or defused many potential water conflicts in transboundary basins. Many have survived and perhaps even helped alleviate extreme interstate hostilities. Yet as climate change renders basin-level water management increasingly important, many transboundary river systems lack the necessary institutional structures. In some cases, some riparians do not participate in the relevant accords. In others, some nations are reluctant to relinquish national policy prerogatives to "integrated" management. And some basins have no cooperative institutional mechanisms in place at all.

Identifying and acknowledging the wealth and resilience of cooperative arrangements governing transboundary rivers furnishes a valuable counterweight to undue apprehensions about looming water wars. Recognizing these successes, however, must not keep policymakers from identifying and acknowledging the potential dangers to international stability that climate-fueled pressures on water supplies still pose. These include natural catastrophes and civil conflicts within states that could both displace refugees into surrounding countries or draw in neighbors, or regional or global powers seeking to avert humanitarian disaster or contain conflict and prevent unrest from spreading.

Assessing the prospective security risks raised by climate change requires gauging the balance between cooperative opportunities and possible drivers of conflict. The potential stakes for global security could be considerable. The need to reach these judgments, however, must not push decision makers to overprivilege security concerns in formulating climate strategies or water policies. Just as transboundary water resource management increasingly requires holistic strategies, integrating competing demands across contending uses, so crafting effective climate policy will require broad collaboration engaging multiple parties in reconciling myriad pressures and perspectives for global greenhouse governance.

Appendix 1: Author Biographies

Ashok Jaitly is a Distinguished Fellow with The Energy and Resources Institute (TERI) in Delhi. With over 35 years of experience in the prestigious Indian Administrative Service at senior policy and management levels, Mr. Jaitly held several important positions in various central and state government departments. He was Principal Advisor to the Chief Minister of Jammu and Kashmir; Chief Secretary of Jammu and Kashmir state; Additional Secretary, Ministry of Rural Development, in which capacity he supervised a very substantial Rural Drinking Water Supply program; and Director General of the Council for Advancement of People's Action and Rural Technology. As Director General, Mr. Jaitly was actively involved in appraisal of project proposals and in the monitoring and evaluation of projects at various stages in the areas of sustainable, social, and economic development, as well as also providing support and facilitation for poverty alleviation, rural development, appropriate technology, and community participation in development. Mr. Jaitly holds an MA (economics) and a diploma in development studies, both from the University of Cambridge, UK. He also holds responsibility as Chairperson-India WASH Forum of the Water Supply and Sanitation Collaborative Council, a UN-sponsored body based in Geneva. As Director of the Water Resources Policy and Management Division at TERI, Mr. Jaitly is presently engaged in work on policy and governance issues of sustainable development including natural resource management, water issues, rural energy, and decentralized governance.

Mohamed Abdel Raouf Abdel Hamid is a Senior Environment Researcher at the Gulf Research Center (GRC) in Dubai, United Arab Emirates. Dr. Raouf has been a lecturer in environmental accounting and economics, as well as a consultant for the World Bank, the Ministry of Industry in Egypt, the Ministry of Planning in Yemen, and Badr Petroleum Company. He was a member of the Bapetco-Shell Egypt Sustainable Development team in 2000. Dr. Raouf authored a book in 2007 titled *Economic Instruments as an Environmental Policy Tool: The Case of GCC Countries*, published by the GRC, and wrote a policy paper in 2008 titled "Climate Change Threats, Opportunities, and the GCC Countries." He was part of the project team that prepared the *Green Gulf Report* (2006). He received his PhD in environmental sciences from Ain Shams University in Egypt and has taken advanced coursework in environmental management at Augsburg University, Germany.

David Michel is a Research Fellow with the *Regional Voices: Transnational Challenges* project at the Stimson Center where his research focuses on the human security and international governance issues raised by global warming. He previously served as Senior Associate with the Center for Transatlantic Relations at the Johns Hopkins University's Paul H. Nitze School of Advanced International Studies (SAIS) in Washington, DC, where he specialized in international climate policy. Educated at Yale University, the École des Hautes Études en Sciences Sociales, Paris, and Johns Hopkins (SAIS), he has written widely on the challenges presented by global environmental change and has consulted with several NGOs participating in the climate regime negotiating process.

Sreeja Nair is a Research Associate with the Center for Global Environment Research at The Energy and Resources Institute in India since 2005. With an interdisciplinary educational background of a BS in biomedical sciences and a MS in environmental studies, her research has been on policy analysis related to the impacts of climate variability and change on natural ecosystems and society. In particular, she has worked extensively on assessing the impact of climatic and developmental stressors on populations, with a major focus on the agriculture and water sectors. Currently, she is pursuing her MA in climate and society at Columbia University.

Kendra Patterson is a Research Associate with the *Regional Voices: Transnational Challenges* project at the Stimson Center. Her current areas of research include hydropolitics and security, and the management and governance of transboundary water resources. Prior to joining Stimson, her primary research interests were constructions of gender in China and Japan, the role of national identity in international relations, and East Asian security. Ms. Patterson earned her BA from Global College (Long Island University) while studying at Zhejiang University in Hangzhou, China, and the Japan Center in Kyoto. She was awarded the Heiwa Nakajima Scholarship to study at the Tokyo University of Foreign Studies in 2002 and received her MA from the Australian National University in 2004.

Khairulmaini Osman Salleh is a Professor of Geography at the University of Malaya (UM), where his research focuses on river basin geomorphology, environmental hazard studies, environmental resources development planning, and climate change. He is currently involved in ongoing research analyzing regional environmental security issues and challenges in Southeast Asia for the Climate Affairs Capacity Development Programme for the UM-National Center for Atmospheric Research. Current projects include Flood Hazards: A Study of Their Types, Causes, Impacts, and Management Policies and Their Implementation; and Dam Break Studies—Impact on the Hydroelectric Energy Development in Malaysia. He has edited and coauthored several books on the impacts of globalization on Southeast Asia and Malaysia, and is widely published on environmental management and natural hazards in international journals. He received his PhD from the University of Sheffield, UK.

Jayashree Vivekanandan is a Research Associate with the Resources and Global Security Division at The Energy and Resources Institute in Delhi. At TERI, she studies the governance dimensions of transnational issues such as climate change and water resource management. Her other research interests include prospects for ecological democracy, the political and ecological aspects of water resource management, and risk assessments of emerging technologies. She recently authored a book chapter advocating a layered understanding of transnational governance issues, which will appear in a forthcoming volume, *Challenges to Sustainable Governance*, published by TERI and AFD, France. She holds a PhD in international relations and a master's in political science from Jawaharlal Nehru University.

Appendix 2:
Experts Consulted

Delhi Meeting Participants

Shihab Najib Al-Beiruti, Inter-Islamic Network on Water Resources, Development and Management (INWRDAM), Jordan
Hamed Assaf, Issam Fares Institute for Public Policy and International Affairs, Lebanon
Mihir Bhatt, All India Disaster Mitigation Institute (AIDMI), India
Dia El Din El Quosy, Water Resources and Irrigation Committee, Academy of Scientific Research and Technology (ASRT), Egypt
Mats Eriksson, International Centre for Integrated Mountain Development (ICIMOD), Nepal
A. K. Gosain, Indian Institute of Technology Delhi, India
Mohamed Abdel Raouf Abdel Hamid, The Gulf Research Center (GRC), Dubai
Syed Iqbal Hasnain, The Energy and Resources Institute (TERI), India
Ramaswamy Iyer, Centre for Policy Research, India
Ashok Jaitly, The Energy and Resources Institute (TERI), India
Shafqat Kakakhel, Sustainable Development Policy Institute (SDPI), Pakistan
Shaheen Rafi Khan, Sustainable Development Policy Institute (SDPI), Pakistan
Nimmi Kurian, Centre for Policy Research, India
Chandan Mahanta, Indian Institute of Technology Guwahati, India
Ainun Nishat, International Union for Conservation of Nature (IUCN), Bangladesh
Nguyen Huu Ninh, Center for Environment Research, Education and Development (CERED), Vietnam
Ligia Noronha, The Energy and Resources Institute (TERI), India
Suresh Prabhu, Member of Parliament, India
Khairulmaini Osman Salleh, University of Malaya, Malaysia
Anond Snidvongs, Southeast Asia START Global Change Regional Center, Thailand
Jayashree Vivekanandan, The Energy and Resources Institute (TERI), India

Regional Experts Interviewed

Bahrain

Waleed K. Al-Zubari, Arabian Gulf University

Bangladesh

Emaduddin Ahmad, Institute of Water Modelling (IWM)

Raquibul Amin, Programme Coordinator, IUCN
Giasuddin Ahmed Choudhury, Center for Environmental and Geographic Information Services (CEGIS)
Malik Fida A. Khan, Center for Environmental and Geographic Information Services (CEGIS)
Tauhidul Anwar Khan, Bangladesh Joint Rivers Commission
Sharmind Neelormi, Centre for Global Change (CGC)
Reba Paul, Bangladesh Water Partnership (BWP)
Atiq Rahman, Bangladesh Centre for Advanced Studies (BCAS)
Waliur Rahman, Bangladesh Institute of Law and International Affairs (BILIA)
Quamrul Islam Siddique, Bangladesh Water Partnership

Cambodia

Tep Bunnarith, Culture and Environment Preservation Association

Indonesia

Istiqlal Amien, Agroclimatology and Hydrology Research Institute
Robert Delinom, Indonesian Institute of Sciences – LIPI
Asclepias Rachmi S. Indriyanto, Indonesian Institute for Energy Economics
Agus P. Sari, PT EcoSecurities Indonesia
I. Nyoman Suryadiputra, Wetlands International Indonesia Programme

Philippines

Rex Victor O. Cruz, College of Forestry and Natural Resources, University of the Philippines Los Baños
Angela Consuelo S. Ibay, Manila Observatory
Rodel D. Lasco, World Agroforestry Centre
Antonia Yulo Loyzaga, Manila Observatory
Deanna Marie P. Olaguer, Manila Observatory
Juan Pulhin, College of Forestry and Natural Resources, University of the Philippines Los Baños Ramon Faustino M. Sales, Jr., Philippine Rural Reconstruction Movement

Thailand

Sanit Aksornkoae, Thailand Environment Institute
Vute Wangwacharukul, Kasetsart University
Phansiri Winichagoon, United Nations Development Programme

US Experts Consulted

Edward Cameron, World Bank
Ambika Chawla, Worldwatch Institute
Neil Leary, Dickinson College
Heather McGray, World Resources Institute
Melanie Nakagawa, Natural Resources Defense Council
Sarah Papineau, Altura Advisors
Namrata Patodia, Pew Center on Global Climate Change

Appendix 3:
Partner Institutions

Middle East

Gulf Research Center (GRC). Based in Dubai, United Arab Emirates, the Gulf Research Center is a privately funded, nonpartisan think tank, education provider, and consultancy specializing in the Gulf region (the six Gulf Cooperation Council countries, and Iran, Iraq, and Yemen). Established in 2000, the Center conducts research on political, social, economic, security, and environmental issues from a Gulf perspective, redressing the current imbalance in Gulf area studies, where regional opinions and interests are underrepresented. With "Knowledge for All" as its motto, the GRC strives to promote different aspects of development and facilitate reforms in the region in order to secure a better future for its citizens.

Issam Fares Institute for Public Policy and International Affairs (IFI). The Issam Fares Institute for Public Policy and International Affairs at the American University of Beirut (AUB) was inaugurated in 2006 to harness the policy-related research of AUB's internationally respected faculty and other scholars in order to contribute positively to Arab policymaking and international relations. In the established tradition of AUB, IFI is a neutral, dynamic, civil, and open space where people representing all viewpoints in society can gather and discuss significant issues of the day, anchored in a long-standing commitment to mutual understanding and high-quality research. The main goals of IFI are to raise the quality of public policy–related debate and decision making in the Arab world and abroad; to enhance the Arab world's input in international affairs; and to enrich the quality of interaction among scholars, officials, and civil society actors in the Middle East and abroad. It operates research-to-policy programs in the areas of climate change and environment, Palestinian refugee camps, youth-related issues, and think tanks and public policymaking in the Arab world.

South Asia

Asia Foundation, Sri Lanka. Recognizing that a sustainable peace is tied to overcoming deeper problems of a weakened democracy, lack of justice, and human rights violations,

the Asia Foundation's program in Sri Lanka seeks to identify and support organizations and institutions that promote democratic governance and the rule of law as essential for lasting peace and prosperity. The Asia Foundation programs in Sri Lanka date back to 1954. The Foundation has been a pioneer in strengthening community-based legal services and mediation for the poor in Sri Lanka. The Foundation supported a definitive study on the relationship between aid, conflict, and peace-building in Sri Lanka, and a follow-up study on the US involvement in the country's peace process. The Foundation distributes some 80,000 new English-language publications a year to libraries throughout Sri Lanka.

Institute of Peace Studies and Conflict Resolution (IPSCR). The Institute of Peace Studies and Conflict Resolution was established in January 2007 under the aegis of the Centre for Study of Society and Secularism, Mumbai. The overarching goal of the Institute is to create enabling conditions for peace and security by creating awareness in the society of factors affecting peace; addressing myths attributed to religious teachings; research and study into communal and sectarian conflicts; capacity building and peace advocacy, especially among youth; and supporting women's empowerment. IPSCR collaborates with other institutions, including the Tata Institute of Social Science Research, and the Department of Civics and Politics and the Department of Sociology, University of Mumbai.

Institute of Policy Studies (IPS). The Institute of Policy Studies based in Islamabad and founded in 1979 is an autonomous, nonprofit, civil society organization, dedicated to promoting policy-oriented research on Pakistan affairs, international relations, and religion and faith. IPS provides a forum for informed discussion and dialogue on national and international issues; formulates viable plans; and presents key initiatives and policy measures to policymakers, analysts, political leaders, legislators, researchers, academia, civil society organizations, media, and other stakeholders. Periodicals and publications, interaction, dialogue, thematic research, and capacity-building programs are instrumental in its research endeavors. IPS garners collaboration as well as extends its active cooperation to other organizations in one or more areas of research.

Pakistan Institute of Legislative Development and Transparency (PILDAT). The Pakistan Institute of Legislative Development and Transparency is an indigenous, independent, and nonpartisan research and training institution committed to strengthening democracy and democratic institutions. PILDAT works to increase the legislative capabilities of elected officials, carries out in-depth analysis of the democratic developments of the country, provides performance reviews of the Parliament and provincial assemblies, and encourages the culture and value of democracy in youth through the first-ever Youth Parliament of Pakistan. The Institute also facilitates the formulation of issue-based caucuses across party lines, including the Young Parliamentarians' Forum, the Parliamentary Consultative Group on Women's Issues, and the Parliamentary Group on Inter-Faith Relations. PILDAT also facilitates non-Parliamentary groups of leading intellectuals and thinkers for

discourse on issues such as free and fair elections, the electoral process, youth and politics, and dialogue between Muslims and the West.

Regional Center for Strategic Studies (RCSS). Based in Colombo, the Regional Center for Strategic Studies is an independent, nonprofit, and nongovernmental organization that fosters collaborative research, networking, and interaction on strategic and international issues pertaining to South Asia. RCSS coordinates research on strategic and security-related issues; promotes interaction among scholars and other professionals in and outside the region who are engaged in South Asian strategic and international studies; and fosters relationships and collaboration among institutions studying issues related to conflict, conflict resolution, cooperation, stability, and security in South Asia.

Sustainable Development Policy Institute (SDPI). The Sustainable Development Policy Institute, based in Islamabad, was founded in 1992 as an independent, nonprofit organization which would serve as a source of expertise on socioeconomic development and environmental issues in Pakistan. The Institute works to conduct policy-oriented research and advocacy from a broad multidisciplinary approach; promote the implementation of policies, programs, laws, and regulations of sustainable development; strengthen civil society through collaboration with other organizations; disseminate research findings through media, conferences, lectures, publications, and curricula development; and contribute to building up national research capacity and infrastructure. The Institute acts as both a generator of original research on sustainable development issues and as an information resource for concerned individuals and institutions. SDPI's function is thus twofold: an advisory role fulfilled through research, policy advice, and advocacy; and an enabling role realized through providing other individuals and organizations with resource materials and training.

The Energy and Resources Institute (TERI). The Energy and Resources Institute was formally established in 1974 in New Delhi with the purpose of tackling the acute problems that mankind is likely to face in the years ahead resulting from the depletion of the earth's energy resources and the pollution their unsustainable use causes. The Institute works to provide environment-friendly solutions to rural energy problems, tackle global climate change issues across continents, advance solutions to the growing urban transport and air pollution, and promote energy efficiency in the Indian industry. TERI is the largest developing country institution devoted to finding innovative solutions toward a sustainable future. TERI has established affiliate institutes abroad: TERI-NA (North America) in Washington, DC; TERI-Europe in London, UK; and has a presence in Japan and Malaysia.

Southeast Asia

Centre for Strategic and International Studies, Jakarta (CSIS). The Centre for Strategic and International Studies based in Jakarta and established in 1971, is an independent,

nonprofit organization focusing on policy-oriented studies on domestic and international issues. Its mission is to contribute to improved policymaking through research, dialogue, and public debate. CSIS believes that long-term planning and vision for Indonesia and the region must be based on an in-depth understanding of economic, political, and social issues including regional and international developments. In the area of foreign policy, the Center's research is complemented and strengthened by its relations with an extensive network of research, academic, and other organizations worldwide. CSIS's research is used by government, universities, research institutions, civil society organizations, media, and businesses.

S. Rajaratnam School of International Studies (RSIS). Based in Singapore, the S. Rajaratnam School of International Studies was established in January 2007 as an autonomous school within the Nanyang Technological University. RSIS is a leading research and graduate teaching institution in strategic international affairs in the Asia-Pacific region. Its name honors the contributions of Mr. S. Rajaratnam, who was one of Singapore's founding fathers and a well-respected visionary diplomat and strategic thinker. RSIS includes the International Centre for Political Violence and Terrorism Research, the Centre of Excellence for National Security, the Centre for Non-Traditional Security Studies, and the Consortium of Non-Traditional Security Studies in Asia. The focus of research is on issues relating to the security and stability of the Asia-Pacific region and their implications for Singapore and other countries in the region.

Singapore Institute of International Affairs (SIIA). The Singapore Institute of International Affairs is a nonprofit, nongovernmental organization dedicated to the research, analysis, and discussion of regional and international issues. Founded in 1961 and registered as a membership-based society, SIIA is Singapore's oldest think tank. Its mission is to make Singapore a more cosmopolitan society that better understands the international affairs of its region and the world.

Notes

Climate Change and Water: Examining the Interlinkages

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