



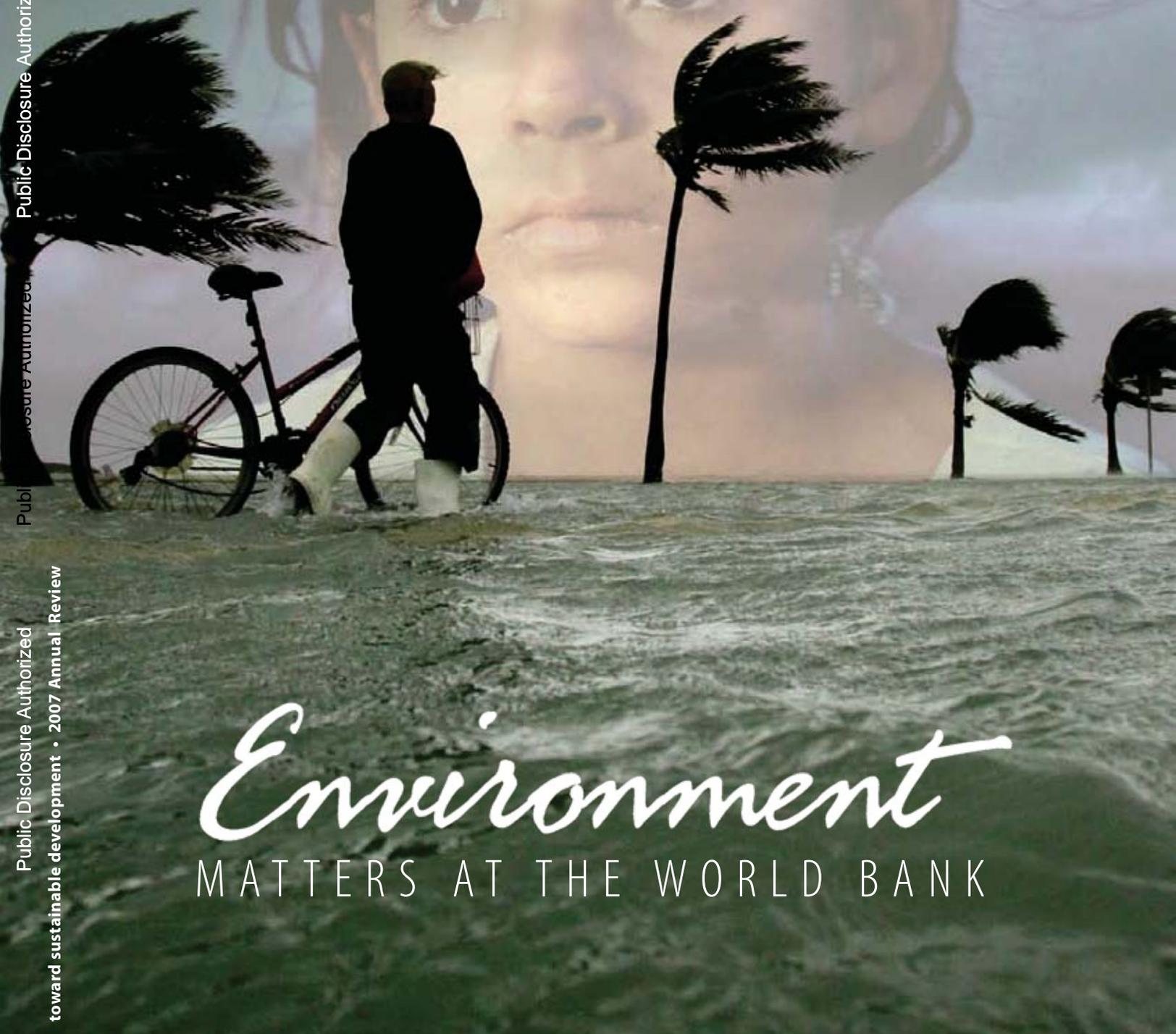
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Environment

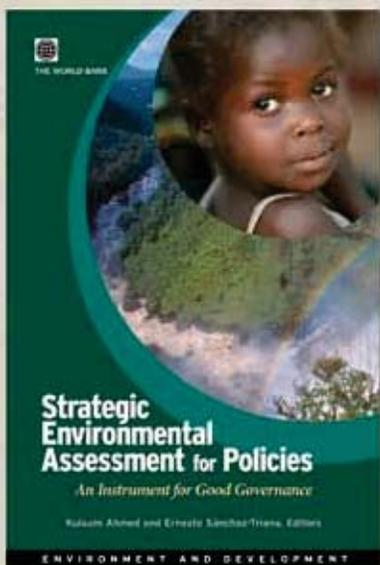
MATTERS AT THE WORLD BANK



Climate Change and Adaptation

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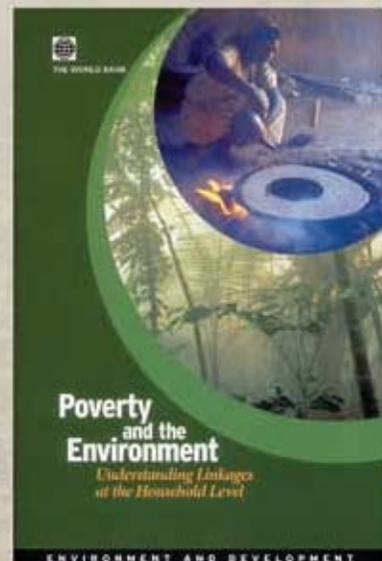
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LETTER FROM KATHERINE SIERRA

VICE PRESIDENT, SUSTAINABLE DEVELOPMENT



This edition of *Environment Matters* arrives just as the international community embarks on a two-year process to secure a new global framework to limit the amounts of greenhouse gases (GHGs) entering the atmosphere and devise ways to help developing countries adapt to and prepare themselves for the effects of climate change. At the World Bank, we believe that climate change—and developing countries' adaptation to it—is a critical challenge of our time that must be integrated into core development strategies.

The past year has been rich in prominent, authoritative, but increasingly alarming reports, each pointing to the unequivocal link between human activity and global warming. Even if a new emissions control framework is put in place after 2012, and even if efforts to reduce GHG emissions are successful, we are already facing some degree of global warming and climate change—and therefore some degree of disruption.

Changes in temperatures and weather patterns will affect the frequency and severity of rainfall, droughts, floods, access to water, flood protection, health, and the use of land. These impacts will not be evenly distributed. The poorest countries and people, those least responsible for climate change and least able to cope with it, will suffer earliest and most due to their geographical location, low incomes, and low institutional capacity, as well as their greater reliance on climate-sensitive sectors like agriculture.

This is why building up resilience to increasing climate variability is the most significant climate challenge facing many developing countries. But we believe that adaptation, while necessary in and of itself, can also serve to meet the development objectives of countries. Many appropriate adaptive measures are consistent with good development practice. They can improve the local environment, increase resilience to current and future climate variability and to natural disasters, and ease the dissemination of innovative technologies. They can also reduce resource scarcity within specific social groups or regions—thereby addressing some of the principal causes of social unrest and violent strife. In other words, climate action is development action.

While much of the adaptation effort will occur autonomously—as individuals, households, and businesses respond to the changing climate—or through government-led investments, the international community can provide the policies, knowledge, infrastructure, and markets to make it happen in the most cost-effective way.

This implies increased international cooperation among all actors concerned with development. The World Bank has a role to play and we intend to do so. This issue of *Environment Matters* lays out some of the challenges we face and offers some of the proposals for progress that we are considering. Anyone interested in adaptation to climate change will find a wealth of material in these pages.




Katherine Sierra

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Welcome to *Environment matters...*

This year's theme on climate change and adaptation is timely. In the last two years, several major new studies have been released, including the Stern Review in 2006 and the latest IPCC reports in 2007. With these reports, the world community has become increasingly cognizant of the urgency of this issue.

At the World Bank Group, climate change and adaptation are under intense scrutiny. Currently, the various departments of the Bank are engaged in over 100 analytical, technical assistance, and knowledge products on this subject—setting the stage for the Bank's Strategic Framework on Climate Change, which will be presented later in 2008.

In their messages, Sustainable Development Vice President Kathy Sierra and Environment Department Director James Warren Evans highlight some of this work and the challenges ahead.

Outside Viewpoints span a range of stakeholders. Colin Chartres, of the International Water Management Institute in Sri Lanka, describes challenges to the Consultative Group on International Agricultural Research and other research institutions. Atiq Rahman, of the Bangladesh Centre for Advanced Studies, presents the views of a major NGO in Bangladesh. Maarten van Aalst, of the Red Cross/Red Crescent Climate Centre, links the disaster preparedness and development agendas. Luis Mejia, of the National Institute of Health in Colombia, emphasizes the need for urgent action on a range of waterborne diseases.

Feature articles highlight a number of key adaptation challenges and opportunities. The Bank's Ian Noble discusses what we know about climate change, what we will never know, and how to plan and deal with uncertainty. Muthukumara Mani assesses various estimates of the costs of adaptation and financing options. A team from the SDV anchor and the Tyndall Center collaborated to discuss a range of social dimensions of vulnerability and resilience to climate change. Finally, several special features describe some innovative thinking in the Bank's adaptation work in the areas of water security, biodiversity, and index-based risk insurance.

Regional reviews—the core of the magazine, as in all previous years—describe the issues and actions highlighted by the different regions. These articles are a reflection of the different impacts of climate change on regions, subregions, and even within countries.

In last year's *Environment Matters* reader survey, many readers requested more individual case studies and examples of best practice, as well as more access to graphs and sources of information. In response, we are also glad to present a consolidated assessment by various World Bank departments of the challenges of climate change with the simultaneous launch of WBI's Development Outreach: Special Report on Climate Change, Low Carbon Economies, and Resilient Societies. This publication presents client case studies in response to climate change. Both magazines provide a complementary view of current experiences within and outside the Bank.

Astrid Hillers

Senior Environmental Specialist
Environment Department



COVER IMAGES

Young girl: © CORBIS

Man with bicycle: © CORBIS

CIRCULAR IMAGES FROM LEFT TO RIGHT:

Digging for water, Kenya: Frank Sperling, World Bank

Mountains, Nepal: Will Davies

Crane, Ethiopia: Will Davies

Rain forest butterfly, Sumatra: Kathy MacKinnon, World Bank

Corn, Kenya: Frank Sperling, World Bank

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CLIMATE CHANGE IS A DEVELOPMENT ISSUE

TOWARD CLIMATE-RESILIENT DEVELOPMENT

DIRECTOR'S OVERVIEW

Frank Sperling

— JAMES WARREN EVANS
ENVIRONMENT DEPARTMENT

Climate change is a development, economic, and investment challenge. It offers an opportunity for economic and social transformation that can lead to an inclusive and sustainable globalization. That is why addressing climate change is a critical pillar of the development agenda.

— Robert Zoellick
World Bank Group President,
at the United Nations Climate
Change Conference in Bali, Indonesia
December 2007

When Robert Zoellick in Bali described climate change as “a critical pillar of the development agenda,” he was setting the vision for our emerging strategy on climate change. Even though we have been active in this area for some time now, there will be a significant step-up in our work on climate change in the months and years ahead, given its crucial importance to the poorest people in the world’s poorest countries.

Sustainable Development Vice President Kathy Sierra, in her message in *Environment Matters*, noted that it is the poor who will suffer the earliest and the most from climate change. As the world’s premier development organization, we

owe it to those in developing countries to take actions that will do two things as soon and as effectively as possible: mitigate the increase in greenhouse gas emissions and help developing countries adapt to the already inevitable effects of climate change.

Stepping Up Action for Lasting Change

Realizing the urgency of both addressing climate change while assuring increased energy access to poor countries, the Bank Group formulated the Clean Energy Investment Framework and Action Plan in 2006/2007. This Framework focuses on three areas of our work:

1. Energy for growth, with a particular emphasis on access to energy in Sub-Saharan Africa;
2. The transition to a low-carbon development trajectory; and
3. Adaptation to the effects of climate change.

We realize that scaling up our actions in these areas will require significant additional financial resources and that these resources must not compete with

achieving the Millennium Development Goals. On the other hand, if climate risk is not fully integrated into core development strategies and investment design, poverty reduction goals will be jeopardized. The recent replenishment of IDA15 was increased by 42 percent to \$14 billion per year. This was partly in response to the Bank’s submission that climate change will increase the resources needed to maintain levels of benefits from IDA by \$0.6 billion to \$1.9 billion per year. Comprehensive climate risk management in IDA projects will likely be the largest source of funding for adaptation in least developed countries in the immediate future.

We still have a lot to learn about fully integrating adaptation into national development planning. We need to accelerate our collaborative efforts with other multilateral development banks, GEF, and other development partners to assist immediately vulnerable countries in putting this challenge into practice.

During the financial year ending in July 2007, the World Bank made real progress in mainstreaming climate vulnerability and risk management into country dialogue and into work-



ing with client countries. We did this through a range of instruments that:

- Deepened analytical work. Much better understanding of country-specific adaptation challenges, supported by strong analytical work has contributed to up-streaming vulnerability to climate change in country and sector development plans. GEF and donor support has been effectively leveraged to scale up this analytical work.
- Achieved greater inclusion of adaptation in Country Assistance Strategies (CASs). In FY07, 32 percent of CASs acknowledged concerns about climate impacts on water resources, agriculture, land, disasters, the spread of vector-borne diseases, and infrastructure sustainability.
- Launched a “Screening Tool” to help identify climate risks. This is being expanded into a comprehensive climate data portal to facilitate access to core climate information.
- Applied innovative climate risk insurance pilots on a project level.
- Worked with the Global Facility for Disaster Risk Reduction and Recovery to integrate climate change.

The World Bank has started to gain important experience in climate risk assessment, forecasting and communi-

cation, and on-the-ground adaptation activities. In the Indian State of Andhra Pradesh, for example, a promising pilot project aims to promote comprehensive drought resilience through innovative techniques and management approaches in agriculture, natural resource management, and the strengthening of institutions. In Malawi, mainstreaming disaster and climate risk management into country planning processes, strengthening meteorological services, and piloting index insurance schemes help to achieve greater disaster preparedness and, therefore, decrease vulnerability.

Many countries are already facing decreases in available surface water. In Morocco, the Bank is working with farmers and the government to design ways to make irrigation more efficient and reliable while taking account of water’s limited availability. Overall, creating greater water security is an important focus of the Bank’s support to client countries.

Impacts of climate change on biodiversity and ecosystem services (terrestrial and marine) is a major concern. Amazon dieback, losses of forests from land conversion, coral bleaching, the decline and shift of fish stocks, and the increased invasion of non-native species are of concern in many areas, especially in fragile tropical and subtropical ecosystems. There are activities in the Caribbean, the Andes region, and Mexico to protect and sustainably manage ecosystems in the face of climate change.

Climate change also has a real impact on health, social development, and poverty reduction outcomes—including an increased risk of conflicts and migration through pressure on land and water resources. A collaborative effort by environment, social, and poverty specialists in the Bank is under way to identify options to minimize these impacts.

Challenges Ahead

While this issue of *Environment Matters* places its emphasis on adaptation to climate change, adaptation and mitigation are integrally linked. Future adaptation costs will dramatically increase if effective mitigation measures are not taken on a global scale.

Opportunities arise from mitigation–adaptation synergies. In Bali, for example, the World Bank, with strong support from donor countries and The Nature Conservancy, was proud to launch the new Forest Carbon Partnership Facility. We were also pleased to receive assistance from the UN Permanent Forum on Indigenous People in designing a carbon fund that will pilot reduced emissions from deforestation and forest degradation, while at the same time improving (a) the livelihoods of forest communities, (b) forest ecosystem services, and (c) forest biodiversity.

Furthermore, climate change will provide opportunities to revisit current practices. With the provision of additional resources, climate change, as discussed throughout this publication, can be a stimulus to assist the transition to improved practices in land management, energy production, coastal protection, and so on, especially in the poorest countries.

The Bank Group is currently developing a Strategic Framework for Climate Change, to be presented to the Development Committee at the Annual Meetings in October 2008. The Bank is also committed to reducing the carbon footprint of its own operations through the use of energy efficiency measures, renewable energy, and carbon offsets. Working with its partners, clients, and all sectors of society to turn the challenge of climate change into an opportunity for development leading to an inclusive and sustainable globalization is the exciting and challenging task ahead.

CLIMATE CHANGE ADAPTATION FOR AGRICULTURE AND AGRO-ECOSYSTEMS



Colin Chartres
Director General
CGIAR International Water Management Institute
Sri Lanka



The Critical Role of Water

It has been said that climate change mitigation is about gases and that adaptation is about water. In a world where 70 percent of water withdrawals are used for agriculture, it is important that we develop adaptation strategies to manage the impacts of climate change on water availability, agriculture, and the environment. Adapting to changes in water availability and seasonal distribution is possible, but we need to know the direction and magnitude of these potential changes and their degree of certainty. Given the likelihood of increasing water scarcity and variability, especially in the world's poorest countries, we have to ask whether we are saddled with outdated 20th century paradigms on how we manage water supplies that are fit for agricultural production, as well as domestic, industrial, and environmental uses.

Here are the relevant facts: (a) population is expected to increase by 2 billion in the next 20 years; (b) climate change, particularly in the tropics/subtropics, where most of the poor live, is likely to impact both total rainfall and seasonal distribution; (c) burgeoning urbanization and concomitant demand for water means productive land will be lost to degradation and other nonagricultural uses; (d) increasing acreage will be devoted to plants grown for biofuel production; and (e) there will be increasing demands for environmental water for wetlands and environmental flows that support valuable ecosystem services. All of these trends are going to put existing water, land, and agricultural resources under significant pressure.

A key feature of future water management will involve adaptation to changing conditions associated with competing demand and

variability in supply. Recently, provision of supply to those without clean water and sanitation was recognized as a key Millennium Development Goal. In some countries, particularly in Africa and South America, lack of finance—termed economic water scarcity—has been the key impediment to the expansion of access to clean water and adequate sanitation. In many countries in the Middle East and Asia (for example, China and India), however, the new challenge is how to manage growing demand for water in the face of supplies that are effectively fully allocated or utilized. This can be described as physical water scarcity. Increasing physical water scarcity means that real trade-offs among irrigation, other beneficial water uses, and the environment are inevitable and will require new sets of biophysical and socioeconomic tools to determine the most appropriate strategies. Climate change will undoubtedly put water users in many countries under more pressure.

As the new Director General of the International Water Management Institute (IWMI), my job is to focus IWMI's limited resources on assisting the poor in improving and retaining access to diminishing water supplies, as well as improving the productivity of their share of the resource. The good news is that a recent comprehensive assessment of water management in agriculture (Molden 2007), prepared with input from over 700 scientists, provides us with some clear directions as to what has to be done if the challenges of coping with competition for reducing water supplies are to be met in a future of climate change and population growth. The assessment asks a key question: "Is there enough land, water, and human capacity to produce food for a growing population over the next 50 years?" It concludes that

while it may be possible to produce the food, it is probable that today's food production and environmental trends, if continued, will lead to crises in many parts of the world.

The assessment details seven policy actions that must be taken to deal with the challenge (see *Box*, below). They indicate that we must rethink the old paradigms about water in order to successfully manage adaptation to climate change and other risks to our water resources, food production, and environment.

If we are to adapt to climate change, we will need to (a) think creatively about water storage systems, including groundwater storage and reuse; (b) improve basin management and water allocation processes; and (c) develop drought response strategies, including early drought warning systems, crop insurance, changing land use and cropping patterns, and increasing water productivity. All of these will have to be embraced by policy makers, governance and institutional processes, water managers, and water users. In the environmental area, adaptation will require improved understanding of ways in which agriculture and wetlands can coexist, as well as better communication to communities and politicians regarding the value of ecosystem services provided by the environment.

The conclusions of the comprehensive assessment resonate with me, especially given that I have just spent two years helping the Australian government develop strategies to deal with the worst drought since European settlement. The lessons emerging from Australia are that individual projects aimed at fixing part of the system are often useless, or even create new difficulties in the face of systemic natural resource changes. The approach has to be scientifically holistic and embrace profound reform. From a scientific perspective, this means understanding the regional drivers of water availability (for example,

KEY POLICY ACTIONS FOR WATER MANAGEMENT IN AGRICULTURE

1. Change the way we think about water and agriculture
2. Fight poverty by improving access to agricultural water and its use
3. Manage water to enhance ecosystem services
4. Increase the productivity of water
5. Upgrade rainfed systems—a little water can go a long way
6. Reform the reform process—targeting state institutions
7. Deal with trade-offs and making difficult choices.

Source: Molden 2007.

climate variability and change, land use change, etc.), modeling how these changes affect water availability, and analyzing what this means for water entitlement holders and their annual allocations. From there, it is possible to determine how these will impact food production, urban and industrial supplies, and the environment. The challenge is then to develop socially equitable means of sharing the diminished supply between beneficial users and the environment. Policy reform, in order to address the complex inter-sectoral and compounding effects of climate change, has to take such an evidence-based approach in order to be effective.

I expect that the above model will apply in most countries. However, it requires the water management community to start to look at the big picture and to be far more holistic and integrative than we have been in the past. It also requires donors and researchers to complement on-the-ground work with greater use of interdisciplinary teams to define the issues and develop strategic policy, institutional, and governance reforms. A key issue will be identifying how the environment can be used to provide ecosystem services that are valued by water users. It means looking at wastewater as a resource, as opposed to something to jettison into the ocean. It means developing a better understanding of how wetlands and other ecosystems provide clean water and food supply via ecosystem service functions. Above all, it means using scientific, social, and economic evidence to guide the reform process.

The CGIAR is gearing up to these challenges via a new Climate Change Challenge Program with a focus on diagnosing vulnerability of agricultural systems to climate change and development of adaptation pathways for affected systems. This will be complemented at IWMI and other centers by additional work on innovative scientific approaches, including improved prediction of climate change impacts on water availability, better ways to retain and store water to supplement diminishing rainfall and shorter wet seasons, and the development of more drought-resistant crops and improved biofuels. However, a critical need in many developing countries will continue to be for the CGIAR to assist agricultural and water management agencies to build scientific capacity and to implement policy and institutional reform to facilitate the adoption of improved responses to climate change threats. IWMI is somewhat daunted by the magnitude of these challenges, but also excited at the prospect of tackling many of them in partnership with other agencies and national land and water managers across the globe.

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CLIMATE CHANGE AND DISASTER RISK REDUCTION



Maarten van Aalst
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Climate change is no longer a long-term environmental issue. The first impacts are already with us, and bound to get worse. In terms of natural hazards, this includes increases in heat waves, floods, droughts, and in the intensity of tropical cyclones, as well as higher sea levels. Developing countries, and particularly the poorest people, are most affected.

We are already witnessing an increase in the number of natural disasters, from around 200 annually in the period 1987–97 to about double that in the first seven years of the 21st century. This rise is caused almost entirely by an increase in weather-related disasters. Floods, for instance, are not just occurring more often, but also damage greater areas than they did two decades ago. And these increases are accompanied by a rapid increase in socioeconomic losses and in the number of people affected.

Mega-disasters also are occurring more often; examples include the European heat wave of 2003, which killed over 35,000 people; Hurricane Katrina in the United States, which caused over \$125 billion in damage; and the massive flooding during the Asian monsoon of 2007. However, the statistics also show a particular increase in smaller disasters. These events do not make it onto the headlines, but do have tremendous impacts on lives and livelihoods, particularly of the poor.

The disaster statistics primarily reflect a growing vulnerability to natural hazards that are intimately tied to development patterns, notably

unsound environmental practices, population growth, urbanization, poverty, and economic shortsightedness. And there is the risk that disasters themselves trap people in vicious circles: the most vulnerable become even more vulnerable to new disasters.

Climate change brings an additional challenge, and is likely already a factor in the increase in disasters. It aggravates the intensity and frequency of many hazards, but it also creates surprises, such as hazards occurring in succession, or in places where they had never been experienced before. In terms of planning, past experience no longer guides what we can expect in the future. Those who depend on natural resources for their livelihoods are hit worst. Many are also finding it harder to rely on seasonal climate patterns; for example, changes in the timing and intensity of rainfall affect decisions about what and when to plant and harvest. One of the few assets of poor farmers, traditional knowledge about their environment, is no longer reliable.

Unfortunately, disaster impacts and the accompanying humanitarian response have often been seen in isolation from broader development patterns. Efforts to integrate disaster risk reduction into development planning are only gradually capturing more attention. And something similar applies to climate change. Despite overwhelming evidence about its potential impacts on development and poverty reduction, climate change has long been restricted to the corner of environmental issues, to be dealt with in terms of greenhouse gas emissions reductions, and primarily by environment ministries.

Studies of the extent to which climate risks are factored into development plans and projects (for example, Burton and van Aalst 1999; van Aalst, Agrawala, and Moehner 2005) found that little attention was paid to changes in risks, but also that little attention was paid to current climate-related hazards, even in countries and sectors that are highly vulnerable. World Bank project documents typically include due diligence on robustness in the light of currency fluctuations, changing market conditions, political unrest, and other factors, but not on the risk that the investment could be hit by a flood or storm. As shown by an IEG evaluation entitled *Hazards of Nature, Risks to Development*, countries affected by disaster, as well as the Bank and other donors that try to help them, have generally treated disasters as interruptions in development rather than as a risk that is integral to development assistance (IEG 2006).

To that end, disaster management and climate change adaptation cannot be tackled by stand-alone projects or by specific agencies with client-country governments. Instead, they require an integrated approach as part and parcel of regular development planning and project preparation. Such planning should be based on an analysis of risks facing a country or sector and the specific program—including direct risk, the risk of underperformance, and the risk that the project could trigger broader vulnerabilities, such as when new infrastructure fosters population growth in unsuitable areas. Rather than another burden on project planners, such risk management is actually an opportunity to enhance the robustness of programs and to achieve more effective and efficient poverty reduction.

Besides a responsibility for the effectiveness of its own investments, the World Bank also has a comparative advantage in helping client countries tackle these challenges by (a) engaging finance and planning agencies in debates about climate and disaster risk reduction; (b) integrating risk reduction into sectoral programs, with spin-offs in terms of capacity building on risk reduction within sectoral agencies; and (c) streamlining and enhancing the effectiveness of existing coordination mechanisms, such as the national climate change focal points and disaster management agencies, which often lack political clout in terms of pushing adaptation and risk reduction in major line agencies.



Rough terrain and a lack of paved roads make access difficult for Red Cross vehicles trying to reach remote villages in Marsabit, Kenya.

Innovative projects such as the Kiribati Adaptation Program, now in its pilot implementation phase, demonstrate such integrated climate risk management, ranging from national budgets and planning in all key ministries to consultation with local communities and NGOs. This engagement with stakeholders is a key element. In the end, a lot of climate risk management can and must be done by people, communities, civil society (including humanitarian organizations such as the Red Cross/Red Crescent), and the private sector. Their role is not just to disseminate climate risk information to the local level, but also to foster dialogue, trigger action, and provide feedback on priorities and the effectiveness of interventions.

Within the Red Cross/Red Crescent, we have been mapping out the consequences of climate change for our humanitarian work in a growing number of developing countries. Red Cross/Red Crescent volunteers and staff all around the world are getting a close-up look at the impact of changing climate risks, and realize they need to enhance their assistance to the most vulnerable. They also realize that relief and reconstruction are not enough and are helping vulnerable communities to adapt to the changing risks. As demonstrated by these experiences, integrating climate change into their humanitarian work is not rocket science, but it is not business as usual either—changes are needed. And partnerships are key—among various government departments, the private sector, individuals, communities, civil society, and national and international providers of scientific information.

Climate change is a very serious challenge for development. While funding for climate risk management is expanding, it does not come close to what is needed to fully address the rising risks, so we have to be smart and efficient. Precisely in that sense, however, climate change also brings opportunities to enhance development by integrating risks that have been neglected for too long and to engage a broad array of actors, foster enhanced coordination, and strengthen partnerships at all levels.

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ADVANCING CLIMATE CHANGE ADAPTATION THROUGH GREATER COLLECTIVE ACTIONS



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Climate change is a global process, but it has serious and devastating local impacts that are felt unevenly across the world. The poor in developing countries, who are likely to suffer the most from the effects of climate change, have over many generations developed coping strategies to deal with natural disasters and variability in weather and climate. But these strategies are not likely to be effective in dealing with the devastating long-term impacts of climate change. Vulnerable communities now need more planned and informed adaptation strategies to protect their lives, livelihoods, wealth, and well-being from climatic disasters. Scientists, policy and decision makers, and development partners must work together to understand adaptation needs and develop appropriate and effective approaches for advancing community, local, regional, and sectoral adaptations.

The United Nations Framework Convention on Climate Change (UNFCCC) has provided the moral, ethical, and scientific basis—as well as structure—for advancing adaptation. The convention urges all the parties to cooperate in preparation for adaptation to impacts of climate change and develop appropriate and integrated plans for coastal zone management, water resources, and agriculture, as well as to minimize adverse effects of climate change on economic growth, public health, and environmental quality. It calls for urgent actions and resources from developed countries to assist the developing country parties that are vulnerable to the adverse effects of climate change.

Progress and Barriers to Adaptation. The 2007 Intergovernmental Panel on Climate Change (IPCC) report identified a number of

barriers to adaptation, including physical and ecological barriers; financial, institutional, and technological barriers; and information and cognitive barriers.

To address some of these limitations, we must build greater awareness among vulnerable communities about climate change, as well as harmonize data and information about climate change and its impacts. The UNFCCC supports information exchange and awareness building, but this has not been adequately put into practice in sufficient scale. With the support of the World Bank, UN agencies, and others, local governments and competent NGOs should be engaged in awareness and capacity building initiatives. It would be appropriate to incorporate this into a broader framework of disaster risk reduction.

As for technology and resource mobilization, an inventory of adaptation technology—including indigenous practices and eco-specific interventions—could be adapted and modified to address climate change impacts at the local and regional scales. Developed countries and institutions must provide support for a technology inventory and innovation for adaptation and disaster risk reduction in the developing world. Efforts must be made to ensure the transfer of these technologies and to monitor the appropriateness, efficacy, social acceptance, market access, and replicability of these technologies and practices. The World Bank can play a key role in initiating and furthering this process in collaboration with appropriate research, policy, and extension organizations.

UNFCCC Efforts on the Adaptation Front. The UNFCCC's Nairobi Work Programme (NWP) on impacts, vulnerability, and adaptation to climate change aims to assist countries—particularly developing countries, including the least-developed countries and small-island states—to improve their understanding and actions in relation to impacts, vulnerability, and adaptation. The NWP is structured around nine areas of work, focusing mainly on assessment, capacity building, and informed decision making through research, development of approaches, planning, and advocacy.

The NWP offers a significant opportunity for advancing these concepts to the planning stage. To ensure a significant number of activities on the ground, we must build local adaptation capacity. The tools developed in NWP can be utilized, but they must be sensitive to the practices that communities have developed through their own knowledge systems and cultural sensitivity. Research and implementing organizations, preferably from the South, could be used as intermediaries for hastening the process of innovative adaptation projects and programs.

Linking Mitigation and Adaptation. The UNFCCC, Kyoto Protocol, and NWP have suggested simultaneous actions by various actors on mitigation, adaptation, and technology innovation. Many scientists feel that mitigation is the best form of adaptation. Mitigation measures—such as measures to reduce emissions of greenhouse gases and to adopt a low-carbon development path—implemented now will reduce climate impacts and adaptation costs in future. Though mitigation has been stumbling somewhat, there has been some progress in adaptation efforts, particularly in the developing countries. Many developing countries recognize that adaptation has a direct and reinforcing relationship with poverty, food security and health, livelihood promotion of the poor, disaster risk, and sustainable development.

Helping Least-Developed Countries Adapt. Many of the least-developed countries have formulated National Adaptation Plans of Action, or NAPAs. The Global Environment Facility has supported the formulation of NAPAs, but developing countries need resources and technology from developed countries and multilateral and bilateral development agencies like the World Bank to implement the adaptation activities identified in NAPAs.

The development of NAPAs also could be improved in various ways. For example, they should adopt a holistic and livelihood approach instead of a sectoral approach. The NAPA process, in both planning and implementation, should ensure the integration of indigenous

knowledge and practices in advancing adaptation. Finally, NAPA activities should consider short-, medium-, and long-term climatic variability and impacts. Measures to help the poorest sectors of society should be the first priority.

Involving NGOs and Communities. The Bangladesh Centre for Advanced Studies (BCAS), an independent research and policy institute in Dhaka, has a strong interest in understanding adaptation needs and approaches. BCAS also seeks to promote climate change adaptation with various stakeholders and actors, including governments, development agencies, and communities. In association with the International Institute for Environment and Development and development partners, BCAS organized an international Community-Based Adaptation (CBA) Workshop in Dhaka in 2007 to enhance understanding among scientists and practitioners about approaches to adaptation and the integration of adaptation into sustainable development. Working with partners under the South-South-North initiative, BCAS is also advancing community adaptation projects in drought- and salinity-affected areas of Bangladesh. Project activities may include both adaptation and mitigation measures, such as irrigation with solar energy, afforestation, water security, and livelihood promotion.

A Greater Need for Partnerships. Southern NGOs can play a key role in mainstreaming adaptation in development such as through disaster risk reduction and other approaches, as well as assist in achieving MDGs such as promoting water and sanitation, poverty reduction, and enhancing nutrition for the poor. An interesting example is a gradual change in the profile of adaptation activities in Bangladesh. A Climate Development Forum has been formed in which leading climate organizations are working closely with leading development agencies. This process is generating a gradual mainstreaming of climate adaptation in the development process, but it is only a beginning.

Greater Equity and Collective Action. Climate change will increase inequity and social conflict in the coming decades if we don't take urgent actions now before it goes beyond our control. The southern and developing countries have very little capacity—both economically and politically—to influence global decision making. The UN Conference of Parties and related global decision-making processes must create greater scope and structure for effective participation and contribution from the South to reverse current practices. To build a better and just world, we have to ensure equity and justice in mitigation, adaptation, technology generation and transfer, and resource allocation to save the planet, people, and ecosystems from the emerging danger of climate change.

IMPACTS ON HEALTH



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Climate change is a threat to the health of the Colombian people. Several of the expected impacts will have a direct or indirect impact on human health. Take, for example, the disappearance or reduction of ecosystems such as the páramos of Colombia; one might think this has no relation to or impact on human health. However, this disappearance or reduction may restrict access to water, with all the effects on health that this may cause.

Although there still is uncertainty about the magnitude of the global impact of climate change on human health, there is no question that negative local effects may be significant. This represents a challenge for the health systems of all countries, especially for those with greater vulnerability to climate change. These countries generally happen to be those that have contributed the least to greenhouse gas emissions, such as Colombia.

Therefore, we must begin a process of adaptation in health systems that will allow us to foresee and whenever possible limit the negative impacts of climate change on human health. We cannot afford to wait until all necessary evidence is available before beginning this process. In fact, Colombia already has evidence of the possible impacts of climate change on diseases such as malaria. Work performed by renowned universities, research groups, and institutions revealed a four- to eightfold increase in malaria transmission in Pacific coastal areas during the El Niño phenomena of 1994–95 and 1998. This increase in transmission during El Niño makes it possible to estimate the possible effects of this disease under a climate change scenario.

Increases in incidence are already being observed. In Colombia, malaria incidence during epidemic years increased from less than 15

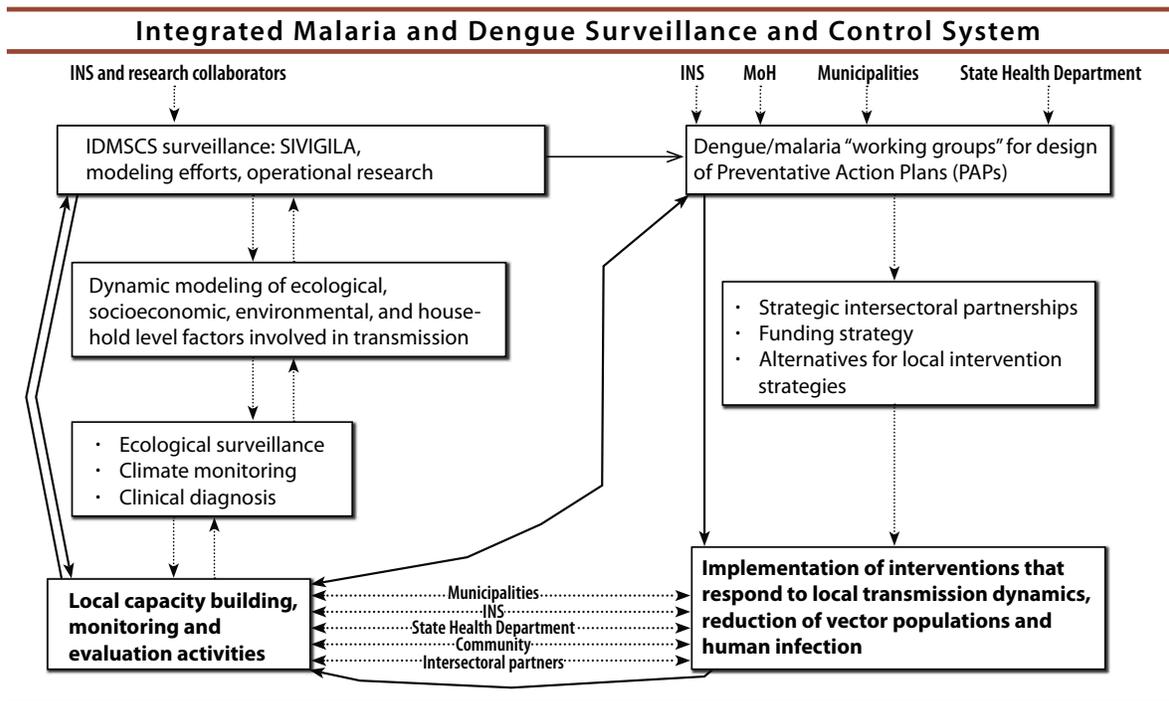
per 10,000 inhabitants in 1964 to 58 per 10,000 in 1983 and almost 156 per 10,000 inhabitants in 1998. The rate of dengue transmission has also shown an increasing trend, with a four-fold increase in cases from 1997 to 2002. In 2002, 81,831 Colombians fell ill to dengue and dengue hemorrhagic fever.

An adaptation measure that would provide great benefit and allow us to address, and in some cases prevent, the effects of climate change on human health is the strengthening of the public health surveillance and control system. In Colombia our aim is to incorporate system tools in public health surveillance that will allow us to determine thresholds of temperature or precipitation on which increases in the transmission of malaria and dengue are observed. With such tools, such as statistical modeling, we would be able to launch an early warning system based on climate variables. This would allow us to anticipate the occurrence of epidemics or outbreaks and to formulate preventive action plans, rather than contingency plans as currently occurs in most cases. Through the health component of the Integrated National Adaptation Project (INAP), we are piloting this approach in several Colombian municipalities (see *Box*, at right).

The task is a difficult one, because it requires important changes in the institutional schemes of the health sector and of other sectors involved and in the way in which the public health surveillance and control system is operated. However, Colombia is making headway in this direction. The challenge ahead is to expand the INAP to a national scale. It is also important for us to engage in joint research with other countries in order to determine with greater precision the effects of climate change on human health, thus decreasing uncertainty and enabling the identification of specific adaptation measures.

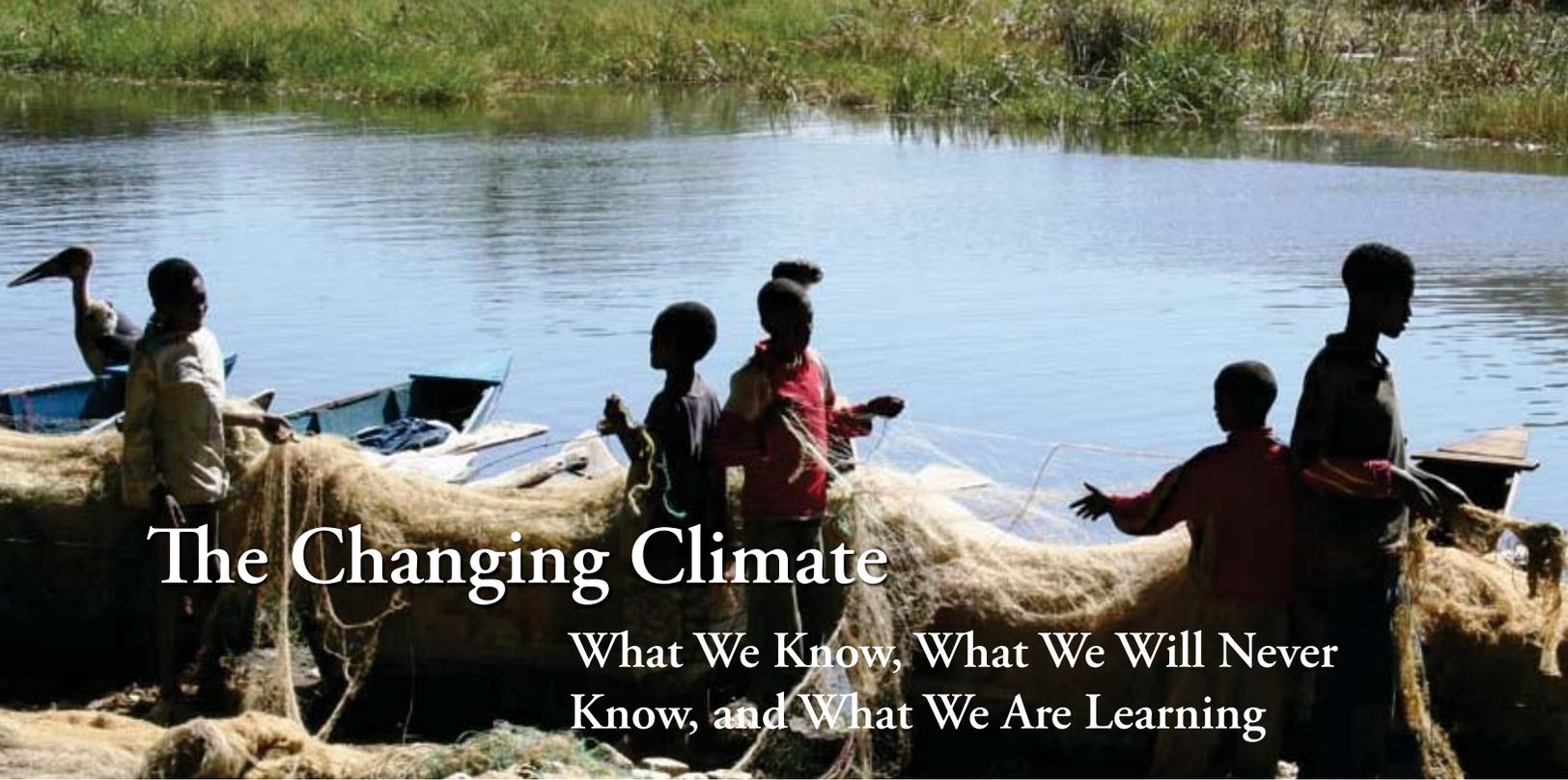
ADAPTING TO THE IMPACTS OF CLIMATE CHANGE ON HEALTH VIA THE INTEGRATED NATIONAL ADAPTATION PROJECT

Colombia's public health institutions have begun a strategic change to better cope with key threats related to the added risk from climate change. Colombia has adopted, with the support of the INAP project, a comprehensive effort to address the consequences of increased risks from dengue and malaria. The approach taken is summarized in the *Figure* below. The National Institute of Health (INS) is working toward the implementation of interventions that respond to local transmission dynamics, reduction of vector populations, and human infection. To such end INS, under the leadership of the Ministry of Health and in partnership with state and municipal health agencies, has developed working groups to design and implement pilot "Preventive Actions Plans." These actions plans are supported by: (a) applied research-oriented activities; (b) implementation of an integrated surveillance program encompassing ecological, climate, and clinical data; (c) design of an innovative and tailor-made early warning system to better focus scarce resources; (d) exploration of targeted actions in response to early warning signs; and (e) enhanced local capacity to include the community in response to warning events.



Some early successes have been achieved. The following preliminary results are here highlighted as they point out the validity of the approach taken and its potential to guide other countries and regions.

1. Identification of key epidemic amplification neighborhoods/areas in each pilot municipality will allow focusing mosquito control in small areas, increasing the effectiveness of the control measures, reducing resources, and increasing attention to surveillance.
2. Applied research activities will allow a better understanding of the many factors affecting the effectiveness of public health delivery systems. Such knowledge allows health managers to guide resources toward preventing actions that are not possible without specific local knowledge.
3. Well-defined experimental exercises are required to assess the effectiveness of new approaches to health delivery systems. Although efforts in Colombia to counter the negative impacts of climate change in malaria and dengue have produced very encouraging early results, it is too early to assess the new level of effectiveness achieved.
4. The challenge of implementing an applied research approach increases the commitment of those participating. Good communication of the project objective and its design among all participants has created a new sense of purpose, with an increased level of satisfaction among all involved. Only anecdotal evidence is available, but it is noticeable to those managing the program.



The Changing Climate

What We Know, What We Will Never Know, and What We Are Learning

A common concern of many people when they first take up the additional challenge of dealing with adaptation to climate change along with the multitude of other challenges in their day-by-day tasks is that “there is so much uncertainty.” It is true that there is uncertainty, but in this article I seek to at least categorize and bound some of those uncertainties to help guide us in our work. I will deal with some of the important things that we do know, then some of the things we are never likely to know, and finally some of the things we are learning and where we might be able to make a difference.

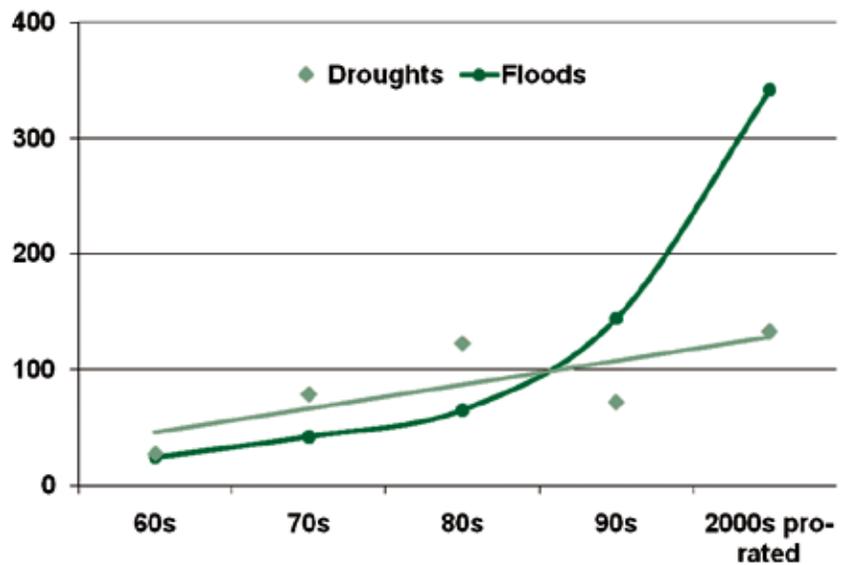
What We Know

The most important thing we know is that the Earth is warming. Observational evidence, complex modeling, and simple physics all confirm this. The warming may not go on forever, but the Earth has warmed consistently and unusually over the past few decades in a manner that can be explained only when a greenhouse process is overlaid on orbital variation, solar variation, volcano

eruptions, etc. The best models available, and simple physics, suggest that warming will continue, especially while we continue putting more greenhouse gases into the atmosphere. Estimates of the temperature rise over this century vary, but most fall within the range of 1.5 to 4 degrees Celsius tem-

perature increase over this century for mid-range assumptions about mitigation efforts. By 2050 most models predict that surface temperatures will have warmed by about 1 to 2 degrees over 1970s’ temperatures. We might think of this as that every location in temperate zones will be effectively 200

The frequency of both droughts and floods is increasing in Africa. While both are damaging to livelihoods, floods are especially problematic, as they destroy productive infrastructure. Many regions are now experiencing flooding at a far higher frequency and intensity than ever before.



Source: Author's analysis.



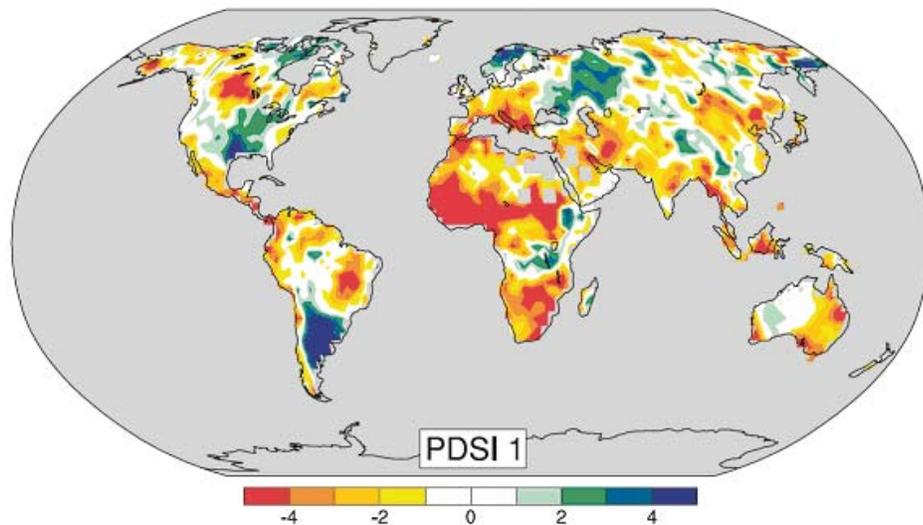
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to 300 kilometers closer to the equator, although the actual change is more complex, with summer temperatures often affected more than winter and more subtle changes in precipitation. Another comparison is that the unusually warm weather that has affected so much of the world over the past decade is only about half a degree above the temperatures of the 1970s.

We also know that the atmosphere is getting wetter as higher temperatures lead to more evaporation from both land and ocean. More moisture in the atmosphere has led to a modest few percent increase in global precipitation over the past century, but atmospheric models and basic physics suggest that this will continue as higher temperatures lead to more evaporation and thus even more moisture in the atmosphere. But there will be large spatial variability in changes in precipitation. Some regions, such as the Mediterranean basin, are projected to have significantly less rainfall. More important, rainfall events are changing, and observations and modeling both confirm that rain is tending to come in fewer intense events with longer dry spells between them. This is leading to more dry spells and more flood-

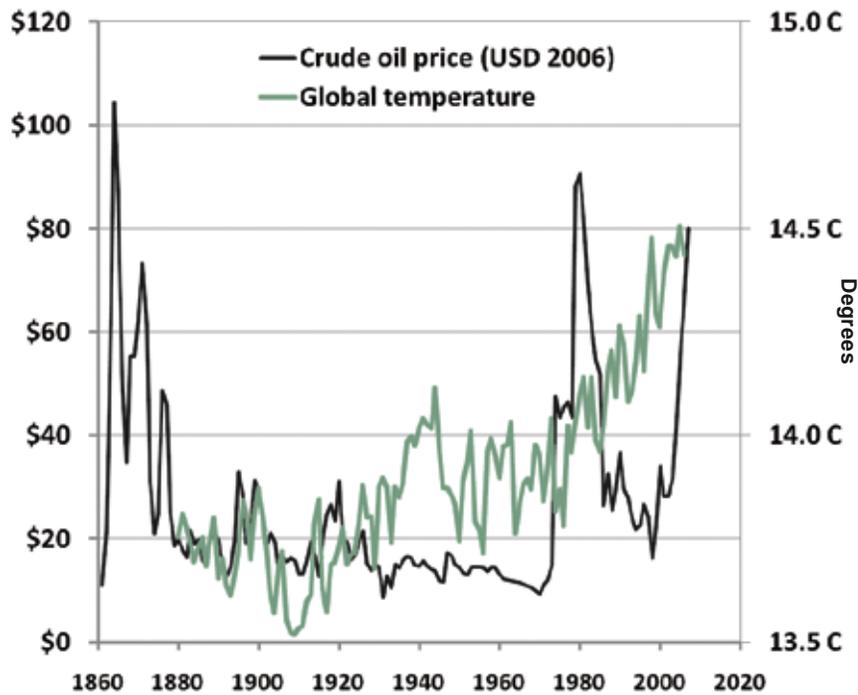
ing in many parts of the world. Flooding is a particular problem in regions that have rarely experienced floods in the past, as floods tend to have a long-term impact on infrastructure, livelihoods, and economic development (see *Figure*, previous page). Also, the combined effect of warming and the slight increase in rainfall in many regions of the world is going to be a drier climate, as potential evaporation increases by the equivalent of about 50 millimeters of rainfall per year per degree Celsius temperature increase. Thus, increased evaporation from higher temperatures will outstrip modest increases in rainfall in most regions. This can be best summarized using a drought index that balances precipitation and evaporation. The *Figure* below, from the recent IPCC Fourth Assessment Report, shows a distinct drying trend during the 20th century over most of the globe and in particular over some of the world's major food bowls—the Mediterranean basin, southern Africa, Australian cereal belt, northeast China, and much of South and Southeast Asia.

Changes in the Palmer Drought Index since the 1980s (red-yellow more droughts; blue-green fewer). Despite a small increase in global precipitation, most of the land surface, including many important food-producing areas, is experiencing increased drought conditions. The impact of these droughts can be reduced by adapting agricultural practices; this remains a core challenge to both developed and developing countries.



Source: Trenberth, K.E., P.D. Jones, P. Ambenje, R. Bojariu, D. Easterling, A. Klein Tank, D. Parker, F. Rahimzadeh, J.A. Renwick, M. Rusticucci, B. Soden, and P. Zhai. 2007. "Observations: Surface and Atmospheric Climate Change." In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds., *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom, and New York: Cambridge University Press.

Variation in global mean temperature and oil prices. There are many sources of uncertainty in development planning.



Source: Author's analysis.

climate-related trends and variability. This is why access to recent climate records (e.g., the past 30 years) is just as important as access to various climate change projections. In dealing with climate variability we must now also look ahead to how climate is projected to change and whether the selected actions are compatible with such a change. In some cases this step may suggest further analysis and this can usually be done by extending analyses of current climate variability with some simple climate scenarios.

What We Will Never Know

Now, a few things we are never likely to know—at least in our and possibly our grandchildren's lifetimes. Weather forecasting has improved enormously in my lifetime, with 10-day forecasts now having some real information content for planning

activities, but we cannot know the weather more than a few weeks ahead. The Earth's atmosphere is chaotic, and weather-related early warning systems that extend beyond a few weeks will always be probabilistic. This means, for example, we can say at the time of selecting a crop variety to plant that, based on current conditions, El Niño, and recent trends, weather conditions in 60 days time during the critical seed-set phase of your crop are 30 percent more likely to be damagingly dry. But we cannot forecast that they will be dry.

Also, there will always remain difficulty in estimating the climate for more than a few decades ahead. This is partly because the climate models are inadequate, but largely because societal behavior is even more difficult to predict. Most of the uncertainty in the IPCC temperature projections for the end of the century arises from the uncertainty about which emissions path we will choose to follow. The IPCC scenarios that have been the basis for so much work on climate

change are likely to be replaced by a radically differently designed set over the next few years. The different socioeconomic scenarios will be replaced by four representative concentration pathways: a "without-action scenario," in which greenhouse gas concentrations continue to increase through 2100, and three scenarios in which greenhouse gas concentrations are stabilized at different levels during this century. This will allow greater focus in doing the expensive climate simulations. During 2010, new simulation results will become available; these will include multiple runs to get better estimates of projected variability. For the period to 2035, there will be a series of high-resolution runs that will give us a much better estimate of possible near-term climates. Meanwhile new socioeconomic scenarios of our response to climate change are being developed; by using statistical techniques based on the suite of climate simulations described above, the consequences for climate change can be estimated.

On top of this, there are still huge uncertainties about whether some thresholds might be exceeded. A decade ago the scientific community was confident that the Greenland and Antarctic ice sheets would show little melting this century. Now, with distinct signs of rapid melting and the discovery of new melting processes, this is recognized as too cautious a conclusion. Other uncertainties include dramatic changes in ocean currents; interactions between higher temperatures, drying, and fires, leading to greatly increased emissions in tropical and boreal forests; and the rapid melting of permafrost and associated methane emissions. These sorts of high impact but low probability uncertainties will always remain. We must continue to monitor the changing understanding of these phenomena, but they are no reason to delay acting on the threats we are much more certain about.

What We Are Learning

Finally, in which areas are we learning? Climate modeling is continuing to improve. Higher resolution global circulation models (GCMs) will provide better projections at a regional level and, most important, a better description of rainfall events, as the model resolution allows better tracking of cloud formation and major storm paths (see *Figure*, below). This is why several groups in the Bank are using the results of the Japanese Agency for Marine-Earth Science and Technology's Earth Simulator, which covers the globe with a 20-km grid rather than the more usual 200- to 500-km grid of most GCMs. The challenge will be to translate these better projections into better estimates of the impacts in terms of flooding patterns, crop growth, etc. An even harder task will be translating the biophysical impacts into impacts on livelihoods, human behavior, and national economies. Better climate projections will certainly become available in the future, but it is important to start to develop models and other methods

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to translate climate projections into impacts right now.

However, the most important lesson that we are all struggling to learn is how to factor climate change into the wider development agenda. Adaptation to climate change should not be treated as a stand-alone issue. We have until now dealt rather poorly with current climate variability; now we have to do much better, and with a changing and apparently more variable climate. The place

to start, of course, is with current climate variability, observed trends, and the current coping strategies of communities and institutions. However, coping strategies of the past may no longer be suitable—not only because of the effects of climate change, but also because changing social and trade patterns may exceed the range that traditional coping measures are able to address. Effective strategies may already be known elsewhere, but this knowledge has to be transmitted and in many cases new knowledge, new technology, and new crop varieties developed. In some cases, current livelihoods may no longer be viable. These strategies may have to be supported and bolstered, but in some cases new strategies may have to be found, especially if climate projections are adverse to current strategies. In this sense, climate change will provide opportunities for revisiting current practices. With the provision of additional resources, as discussed in other chapters, climate change can be a stimulus to assist the transition to improved practices of land management, energy production, coastal protection, and so on, especially in the poorest countries.

Higher resolution in a global circulation model can make huge improvements in modeling storms and precipitation patterns. The image on the left is a snapshot of a model run using a coarse resolution (c. 320 km), while the image on the right is a similar point in the model run at a higher resolution (20km).



Source: Shapiro, Melvyn, and others. 2007. *The Socioeconomic and Environmental Benefits of a Revolution in Weather, Climate, and Earth-System Analysis and Prediction*. A Weather, Climate and Earth-System Prediction Project for the 21st Century. Picture courtesy of Takeshi Enomoto, Earth Simulator Center/JAMTEC.

This article was prepared by Ian Noble, inoble@worldbank.org, of the Environment Department. ENV website: www.worldbank.org/environment/climatechange.



Beyond the Sea Walls

Financing Adaptation Needs in Developing Countries

The policy response to global warming has focused on the steps that industrial and developing nations should take to mitigate greenhouse gas emissions (GHGs). Far less attention has been paid to what developing countries should do to adapt to the consequences of foreseeable climate change in the coming decades. Climate change adaptation encompasses more than structural measures—sea walls, land use planning, and building code—and also more than better sectoral policies for agriculture, water, forestry, and human health. It also requires ensuring that countries' legal and economic structures and price signals encourage adaptation.

Developing countries, particularly the poorest countries, will be the ones most vulnerable to climate change and increasing climate variability because they have the least capacity to adapt. Excessive floods, droughts, heat waves, and rising sea levels will amplify the already existing challenges posed by tropical geography, a heavy dependence on rainfed agriculture, rapid population growth, poverty, and a limited capacity to cope with an uncertain climate.

The consequences of extreme events are already being disproportionately felt in developing countries. For low-income countries, major natural disasters today cost an average of 5 percent of GDP. Water stress is increasing in Africa; by 2020, between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change. Food security, health, and agricultural incomes will be under particular threat from climate change in many of the poorest countries, including in South Asia and Sub-Saharan Africa. According to a recent Bank study, a 1° C increase in temperature will lead to a 10 percent loss in average net revenues per hectare in Africa (Kurukulasuriya and others, 2006).

Most studies have focused on physical and social disruption associated with climate variability. Much less attention has been paid to the less quantifiable and indirect effects on widening of trade or government deficits, unemployment, or the increasing scale and depth of poverty. Even more so, climate change as a source of economic vulnerability has often been overlooked in discussions about achieving and sustaining progress with the Millennium Development

Goals (MDGs). World Bank estimates suggest that, if countries improve their policies and institutions, the MDG targets can be reached by 2015 with additional resources of \$40–60 billion a year. However, ongoing climate change ultimately will affect efforts and resources needed to reduce global poverty.

How can developing countries and their development partners improve their capacity to cope with and adapt to climate change? While sustained economic growth might eventually equip countries with the resources necessary to expand their adaptive capacities, on various other fronts—such as adjusting the macro- and sectoral policy environment—a more proactive stance is needed to minimize these impacts.

Coping with the Structural Impacts

High dependence on sectors that are sensitive to changes in climate—such as agriculture, water resources, energy, forestry, and



Will Davies

fisheries—increases the economic vulnerability of poorer countries to the adverse effects of climate change. Increased climate variability is expected to reduce agricultural productivity, potentially increase malnutrition, decrease water availability in many areas of the subtropics, and increase the incidence of many diseases. Rising sea level could displace tens of millions of people in deltaic areas and small island states.

In the short term, a number of structural adaptation measures can reduce the costs associated with climatic variability. These include (a) land use planning to reduce or adapt construction on coastal regions subject to storm damage and river shorelines subject to frequent floods; (b) building standards aimed at ensuring some level of robustness against hurricanes and other extreme events; (c) engineering interventions, such as creation of reservoirs for flood control, irrigation, and hydropower; (d) dikes to reroute flood waters; and (e) seawalls to break storm surges. One of the most significant impacts of climate change is likely to be on the hydrological system. This will be particularly true in arid and semi-arid areas, where water scarcity will

put additional pressure on water allocation mechanisms, creating the potential for new water use conflicts between different users and regions.

While these refer mostly to costs of physical investments, a much longer-term planning and resource allocation effort will be necessary in many other areas such as agriculture, water resources, and health. In agriculture, this will entail promoting farming practices that withstand climate variability. Water supply infrastructure will need to anticipate possible climate effects. Serious environmental and health risks might necessitate a significant restructuring of resources directed toward strengthening public health interventions.

These will entail integrating adaptation within national development policies, plans, and programs. But this is bound to generate some form of additional costs, so decision makers would need to identify the most efficient measures that generate the highest social and economic returns in the face of risk and uncertainty. A more accurate understanding and quantification is urgently needed to help demonstrate why and how governments can approach adaptation.

Policy Approaches

Unlike greenhouse gas mitigation, which has to be coordinated internationally, incentives for adaptation to climate change are essentially local, national, or in some cases regional issues. While renewed attention to mitigation based on new information is important, the inevitable consequences of climate change should not be ignored. It is therefore in the interest of governments in developing countries to proactively create the right incentives and institutions, provide more information to the private sector, and develop basic knowledge on adaptive technologies. Key sectors (especially agri-

culture and water) in many countries are not well adapted to current climate variability and extreme events. If these countries could—through policy reforms, institutional development, and improved access and use of available technologies—become less vulnerable to current climate variability, they would almost certainly reduce their vulnerability to long-term human-induced climate change.

Further, in many countries the insurance sector is only at a nascent stage of development. To a large extent, it does not have the capacity or ability to optimize risk coverage and premium terms.

Financing for Adaptation

While incentives may often be created by governments, most actual adaptation measures will be autonomous and taken by individuals and the private sector. However, adaptation measures that require an extensive capital investment will require direct public intervention. The additional costs of making new infrastructure and buildings resilient to climate change in OECD countries is estimated to range from \$15–150 billion



Klas Sanders

GLOBAL STUDY ON ECONOMICS OF ADAPTATION

This multidonor research study aims to assess the resource implications and eventual tradeoffs for developing countries to adapt to different scenarios of climate change as they continue to advance their development and poverty reduction agendas.

The specific objectives are to (a) develop sectoral and global cost estimates of adaptation and (b) develop and transfer to developing countries a working methodology to assess adaptation costs and improve these estimates as more data and analyses become available.

The methodology would include (a) identification and quantification of damage costs of climate change without planned adaptation; (b) development of cost-benefit analyses of adaptation actions based on the identification and costing of a range of such actions (from policy and regulatory changes, when more readily quantifiable, to investment decisions); (c) consideration of different time horizons, discounting, and climate scenarios; and (d) integration of the regional and sector analyses with national and global computable general equilibrium models.

each year (0.05–0.5 percent of GDP), with higher costs reflecting the prospects of higher temperatures in the future (Stern 2006). For example, the cost of building infrastructure that offers protection against future storm surges and floods has been estimated in the United Kingdom at \$18–56 million annually for the next 80 years (Hallegatte 2006). These estimates assume increased frequency of these events due to climate variability. Similar estimates for developing countries are not currently available. To fill this gap, the World Bank, in partnership with the governments of the UK and the Netherlands, is leading a global program of research on the economics of adaptation in developing countries that was launched in Bali in December 2007 (see *Box*, above).

Meanwhile, the World Bank has broadly calculated a global estimate based on investment flows—both international and domestic—in developing countries and calculated how much of these investments are likely to be sensitive to climate impact and how much more investment would be needed to make the investments more resilient to the changes. The figures are in the range of \$10–40 billion a year for the developing countries alone, or 1 percent of

GDP annually, as noted in the Stern Review (see *Box*, below). More recent estimates by the UNFCCC Secretariat are in the range of \$28–67 billion. These estimates are broadly consistent with the Bank estimates (UNFCCC 2007).

A recent World Bank study looked at how much International Development Association (IDA) commitments would need to increase in order to maintain a constant level of net benefits to client countries after accounting for climate change impacts. The results are presented in the *Table* (top of next page), for three different levels of climate change impacts as derived from the Stern Review. The low estimate assumes market impacts only, the medium estimate assumes a higher sensitivity of global climate to GHG emissions, while the high estimate includes both higher climate sensitivity and non-market impacts in the form of damage to human health. The table derived from simulations suggests that countries receiving about \$9 billion in IDA credits in fiscal 2006 would need an increment in commitments of between \$0.6 billion and \$1.9 billion in order to offset the effects of climate change and to provide the

ESTIMATING THE COSTS OF ADAPTATION

During the preparation of the Clean Energy Investment Framework, some preliminary estimates of the costs of adaptation were calculated. These continue to be the first global estimates of adaptation from a developing-country perspective. The approach used examined the core flows of development finance, estimated the proportion of investment that is sensitive to climate risk, and then calculated the additional cost to reduce risk to account for climate change. According to the estimate, ODA and concessional finance have the most climate-sensitive component, with relatively less in private and government investment as the financing shifts from high-risk development spending in poverty reduction to commercial investment. While the estimated cost of adaptation of 10 to 20 percent is an assumption that is debatable, it draws on the Bank's experience in project preparation and financing (see *Table*, below). It is likely that in most activities, only certain components will need to be modified, often at relatively low cost and sometimes no additional cost. Nonetheless, these estimates provide a reasonable basis for addressing costs and ways of financing adaptation in developing countries.

Item	Amount per year (in billions of \$)	Estimated portion climate-sensitive (%)	Estimates costs of adaptation (%)	Total per year (in billions of 2000\$)
ODA and Concessional Finance	100	40	10–20	4–8
FDI	160	10	10–20	2–3
Gross Domestic Investment	1,500	2–10	10–20	3–30
Total International Finance				6–11
Total Adaptation Finance				9–41
Cost of Additional Impacts				40

Source: World Bank 2006.

Incremental IDA Requirements to Cope with Climate Change

Current IDA credits: \$9.00 billion (FY06)	Stern Review Damage Estimates		
	Low	Medium	High
Increase in IDA credits to offset projected benefit losses caused by climate damages (\$ bn)	\$0.58	\$1.36	\$1.89
Percent increase in IDA credits (%)	6	15	21

Source: World Bank 2007.

additional finance to avoid resources being diverted from achieving the MDGs.

The international community—including GEF, the World Bank Group, the regional development banks, and bilaterals—has already been an important contributor to the mobilization of resources in this direction. The successful replenishment of IDA provides a strong platform for integrating adaptation into development programs in poor countries. Financial instruments for adaptation—existing and new—are described in the *Box* below.

In conclusion, governments face the challenge of helping the private sector and communities adapt to increasing temperatures and climate variability by ensuring that their

countries' legal and economic structures and price signals encourage adaptation. The costs are substantial and cannot be borne by developing countries alone. The international community should support these efforts by enhancing cooperation in mitigating GHG emissions, stimulating the development of new technologies, and helping to identify, develop, and finance a comprehensive set of cost-effective adaptation measures. Support needs to be provided to address the need to transform the way adaptation is approached and financed—from often being stand-alone to an approach that assures that adaptation is fully integrated in national and sectoral development planning and budgeting. Only if this is done across economic sectors and levels of governance can government agencies make choices about the most cost-

effective mix of responses—ranging from policy measures to shift incentives to investment adjustments, extension of services, and improved contingency planning. Failure to do so could undercut the global community's efforts to cut poverty in half worldwide by 2015 and make further progress with the attainment of the MDGs.

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FINANCING MECHANISMS FOR ADAPTATION

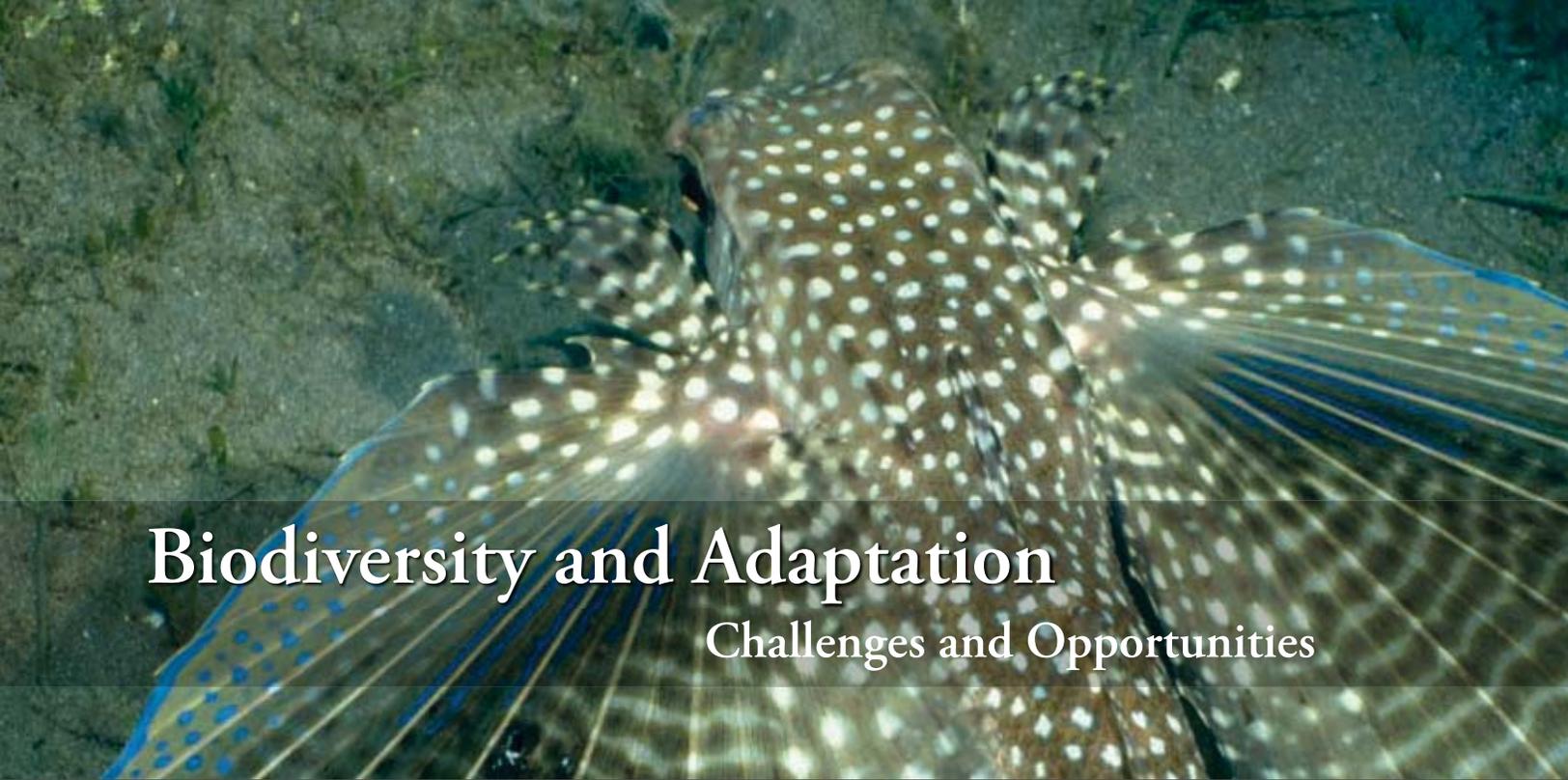
Creation of a new adaptation fund was announced at the recent UNFCCC Conference of Parties meeting held in Bali (Indonesia). It has been proposed that the fund is to be initially administered by the Global Environment Facility, with the World Bank to act as a trustee. Funding will mainly come from a 2 percent levy on revenues generated by the Clean Development Mechanism. This fund will also receive funds from other sources. It will finance implementation of concrete adaptation projects in developing countries, including activities aimed at avoiding forest degradation and combating land degradation and desertification.

Two other adaptation funds, the Special Climate Change Fund and the Least Developed Countries Fund, are already operational. The Special Climate Change Fund supports adaptation projects in all developing countries. The Least Developed Countries Fund helps in the preparation and implementation of national adaptation programs of action in the least-developed countries. Furthermore, the Strategic Priority to Pilot an Operational Approach on Adaptation is a funding allocation within the GEF Trust Fund whose objective is to support pilot and demonstration projects that address local adaptation needs and generate global environmental benefits in all GEF focal areas.

Contributions from all these adaptation funds are expected to be between \$150 million and \$400 million a year, which is far less than the anticipated needs to face climate variability in developing countries.

The recent IDA replenishment recognizes the need for increased resources to assist countries to adapt within their development framework. The World Bank also continues to work with countries in directing financing for adaptation through its various projects and programs.

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Biodiversity and Adaptation

Challenges and Opportunities

The Millennium Ecosystem Assessment showed that over the past 50 years human activities have changed ecosystems more rapidly and extensively than at any comparable period in our history. These changes have contributed to many net gains, but at growing environmental costs: biodiversity loss, land degradation, and reduced access to natural resources for many of the world's poorest people. Habitat loss and fragmentation, overexploitation, pollution, the impact of invasive alien species, and, increasingly, climate change all threaten global biodiversity. Many of these factors are interlinked. Thus the warming of coastal waters and coral die-off impacts coastal fisheries due to loss of fish habitats and breeding grounds. Similarly, degradation and disturbance in terrestrial and aquatic ecosystems generate niches that can be exploited by invasive exotic species.

This biodiversity loss matters because species and habitats are the building blocks on which human livelihoods depend—the foundation for productive forests, fisheries, and agricultural crops. Biological resources provide the raw materials for livelihoods,

sustenance, trade, medicines, tourism, and industry. Natural ecosystems provide a whole range of services, often unrecognized in national economic accounts, but vital to human welfare: regulating water flows, flood control, decontamination, and carbon sequestration, as well as providing nursery grounds for many species and products on which human communities depend. Enhanced protection and management of biological resources will also contribute to solutions as nations and communities strive to adapt to climate change.

New initiatives under the climate change agenda provide both opportunities and challenges for biodiversity conservation. Bio-energy plantations can substitute for fossil fuels and may also provide benefits to small farmers engaged in their production. However, without careful planning, biofuel production could lead to further clearance of natural habitats, either for biofuels themselves or for new agricultural land to replace converted crop lands. Similarly, wind, hydropower, and wave energy solutions require careful site selection and evaluation of likely impacts on habitats and wildlife, especially rare species.

How can improved biodiversity management enhance resilience to climate change and adaptation strategies? The Bank is already a major global funder of biodiversity initiatives, including support to more than 500 projects in over 100 countries during the last 15 years. Many of those projects are promoting sound natural resource management that could contribute to adaptation through maintaining and restoring native ecosystems and protecting large blocks of natural habitats across altitudinal gradients. Projects in the MesoAmerican Biological Corridor, support to the mosaic of state and indigenous reserves in the Amazon rain forests and the South African megareserves in the Cape Floral Kingdom, and maintaining corridors from the mountains to the coast all protect important ecosystems and species refuges. The large rain forest blocks in the Amazon notably influence global and local climates and rainfall patterns. Other projects are focusing on strengthened resource management to cope with greater climatic fluctuations, such as improved fire management in dryland and Mediterranean habitats and the Russian boreal forests.

It has been estimated globally that land and forest conversion contributes up to 18 per-



CORAL

cent of greenhouse gas emissions annually. Emerging from the United Nations climate conference held in Bali in December 2007, calls for greater action on avoided deforestation could provide new opportunities for rewarding nations and communities for improved forest protection and management. The Bank has been a leader in promoting incentives for protecting ecosystem services for carbon sequestration and biodiversity benefits. New initiatives, such as the Forest Carbon Partnership Fund, afford opportunities to protect forests for carbon sequestration and other multiple benefits, including conservation of biologically rich habitats and greater community benefits from native forest management and watershed protection.

In aquatic systems, the global Coral Reef Targeted Research project provides the scientific underpinning for management practices to adapt reef and fisheries management to address the threats arising from global warming. Elsewhere, projects in Central America, Tanzania, Indonesia, and Vietnam focus on integrated coastal zone management, enhancing protection of mangroves, coastal wetlands, and off-shore reefs, which helps sustain local fisheries and thriving

tourism industries, but also offers increased protection from sea level rise and extreme weather events.

The Bank's emphasis on biodiversity conservation, both as a global public good and a means of adaptation, will be an important part of the new Climate Change Strategic Framework. Agricultural programs, for instance, will need to take account of climate change and changing rainfall patterns. An emphasis on community-driven development is encouraging more sustainable agriculture, avoiding overgrazing and land degradation, and developing new agroforestry systems and multi-species cropping. Increased attention is also being paid to conserving agrobiodiversity in crop gene banks and traditional agricultural practices to maintain diversity of varieties and crops for food security (see, e.g., *Box* on "Agriculture and Adaptation to a Changing Climate in Yemen," page 50).

On the other hand, the introduction of new and adaptable exotic species for agriculture, biofuels, mariculture, aquaculture, and reforestation presents a particular challenge. Many of the attributes that make species useful for introduction (fast-growing, adaptable, tolerant of disturbance, and able to thrive in a wide variety of conditions) are exactly the same characteristics that can enable a species to become invasive. Invasive alien species (IAS) are a threat to both biodiversity and economic development, reducing crop and fisheries yields, choking irrigation canals, blocking hydroelectric dams, and reducing the lifespan of development investments. The economic impacts of IAS are expensive, an estimated \$140 billion annually in the United States alone. The Bank is beginning to take action to address this much-neglected threat through a global partnership with the Global Invasive Species Programme. Assisting clients, especially the LDCs and Small Island Developing States, to better understand and manage IAS problems will be an important part of the adaptation and development agenda.

In response to climate change, many countries are likely to invest in more infrastructure to address energy needs, irrigation, and flood control. Such strategies are rational and needed responses, but could further threaten biodiversity if new development leads to unmitigated destruction of natural habitats through creation of dams, sea walls, and flood canals. Increasingly in the infrastructure sector, however, the Bank can draw on some good conservation experience. For example, protection of the forests around the Nam Theun2 Dam in Laos, and a 30-year conservation fund to manage the watershed, is a critical factor in extending the lifespan of the hydropower generation facility. Rehabilitation of upland watersheds and wetlands contributes to regulating water flow, regulating floods and sedimentation, reducing vulnerability, and improving water quality for downstream communities. This has already been shown on a large scale in the China Loess Plateau project through its positive impact on local agricultural productivity, household incomes, and biodiversity, as well as downstream sediment reduction.

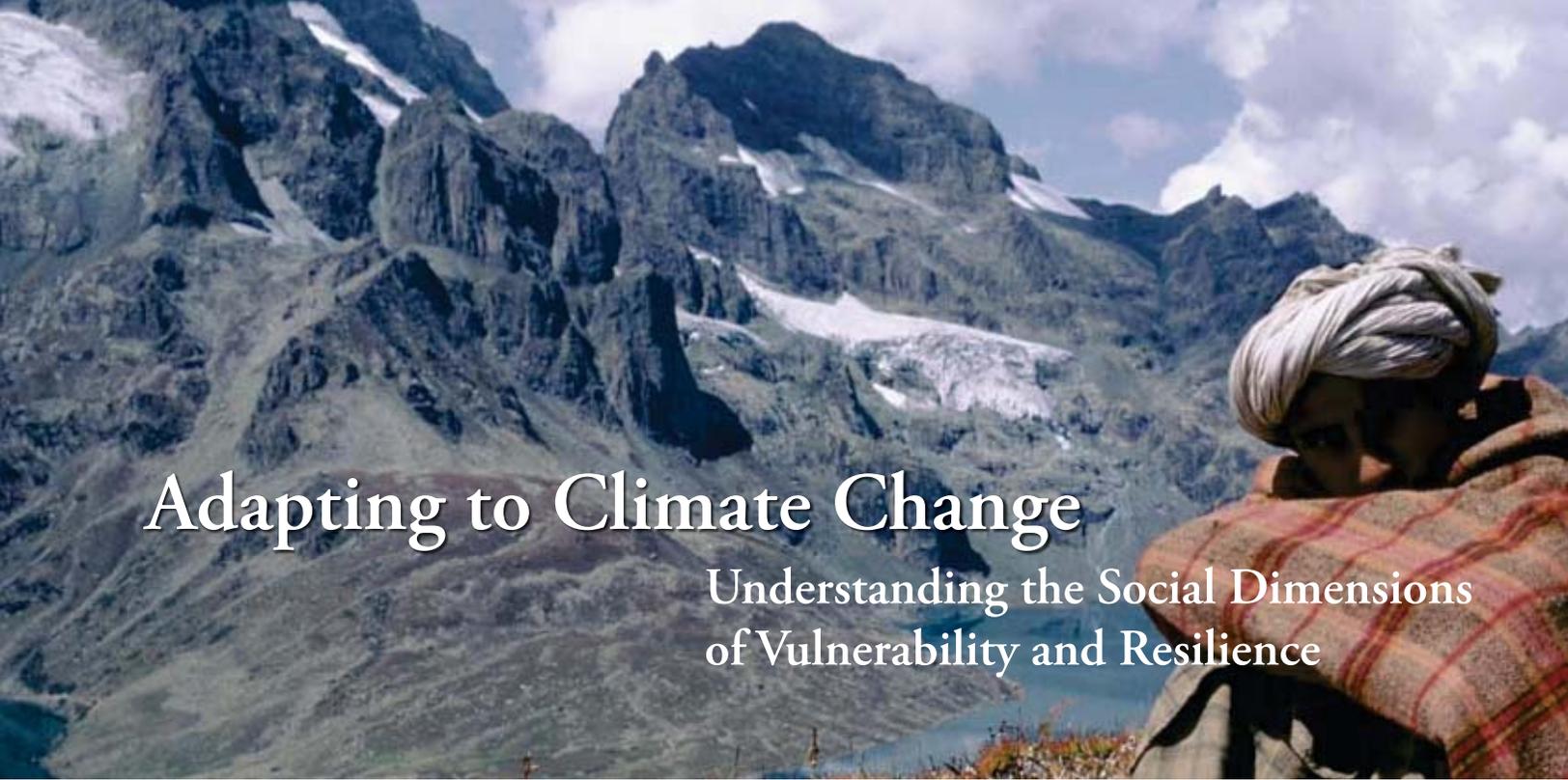
Adaptation will increasingly become and has to be central to the development agenda. Enhanced protection and management of natural ecosystems and more sustainable management of natural resources and agricultural crops is a critical part of sustainable adaptation strategies. Biodiversity conservation can play an important, cost-effective, and efficient role in reducing vulnerability to climate change.

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A photograph of a person wearing a white turban and a patterned shawl, looking out over a vast, rugged mountain range with patches of snow and glaciers under a blue sky with light clouds.

Adapting to Climate Change

Understanding the Social Dimensions of Vulnerability and Resilience

The consequences of climate change will not be distributed equally. While some scientific uncertainties remain about the character, magnitude, and rates of future climate change, there is widespread consensus in scientific and policy communities that planetary warming will have significant impacts on sea levels, weather systems, ecosystems, public health, and economic development. Less well understood are the likely impacts on human societies. Who will bear the direct costs of climate change? Who will bear the costs of adapting to climate change or of working to prevent it? How will societies and communities organize themselves to cope with risks and manage the social changes associated with climate change?

Typically, the biophysical and economic causes of vulnerability to climate change receive the greatest attention, yet social dynamics can be decisive in determining the susceptibility to harm and level of resilience of different social groups. This article argues that effectively managing the effects of climate change means confronting and integrating these social dimensions into adaptation planning.

Vulnerability to Climate Change

Climate-related hazards do not automatically translate into disasters. It is the overall vulnerability and capacity for resilience that will determine if a society can absorb climate impacts and positively respond or is unable to do so and therefore suffers the losses associated with disaster. If vulnerability therefore marks the threshold between successfully adapting to climate events and not being able to do so, then what comprises vulnerability and how can it be managed?

In the development literature, vulnerability has two dimensions: (1) an external side consisting of the risks, shocks, and stresses to which people are subject, and (2) an internal side encompassing the means to withstand or adjust to damaging loss. The biophysical perspective on vulnerability in the context of climate change is largely about the degree of human exposure to threats provoked by climate change and is therefore primarily external, comprising the amount of potential damage caused to a system by shocks (such as sudden climatic

events like hurricanes) or trends (such as environmental degradation over time). On the other hand, social dimensions of vulnerability to climate change are predominantly about the internal side—that is, what assets, institutions, and relationships do people have to deal with these external threats, and how in turn will their social organization be affected? Social vulnerability is assessed at the level of individuals, households, or groups, but incorporates factors that exist at local, regional, national, and sometimes global scales. The concept therefore relates to the ability of individuals or groups to act within the social, political, and environmental contexts in which they live.

Resilience—the Flip Side of Vulnerability

If vulnerability determines the extent to which individuals or a community will potentially suffer from climate-related events, then resilience is the ability to manage and adapt. It incorporates the notions of self-organization and the ability to learn,



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for possible population relocations, and efforts to address other key health and livelihood impacts.

Building Community Capacity for Resilience

Given the inability of climate models to identify precise risks in different locations and within social groups, and given the variability between these models, the aspiration to have precise top-down planning for local-level adaptation is clearly wishful thinking. It therefore makes sense to focus the adaptation agenda for climate change on reducing vulnerability by improving the adaptive capacity and resilience of the poorest and most marginalized groups. Strategies

are needed that look at the social processes that drive households into vulnerable conditions and at structural inequalities that are often at the root of social-environmental vulnerabilities, while at the same time realizing the potential of the coping strategies in the historical record of communities and social groups. The *Box* below provides an example from northeastern Brazil of reducing vulnerability and enhancing resilience in the face of recurrent drought that may worsen with climate change.

While some adaptation responses are only easily realizable by the state or the international community (i.e., provision of large-scale infrastructure and large-scale social transfer in the wake of major shocks affecting large areas), top-down planning approaches alone will not be sufficient to respond to climate-change-related impacts.

cope, and maintain future options. Rather than a concern about how to stop, change or minimize impacts, resilience is the ability to manage change. People's resilience or capacity to manage and adapt to change is determined by both their assets—including the amount and quality of knowledge and labor, physical and financial capital, and social relations and networks—and the services they can access—such as transport and communication, access to credit, markets, and emergency relief and recovery systems.

A grasp of the social factors that contribute to a population's vulnerability and resilience strengthens the capability of governments and aid agencies to develop effective preparatory measures to prevent and minimize climate change consequences. This knowledge contributes to a more precise understanding of who is vulnerable and how and why they are vulnerable or resilient, which is critical if public policy and development strategies are to foster sustainable adaptation to climate change. In the Maldives, for example, the government's framework for adaptation includes attention to building the capacity of farming households to adapt to climate change, long-term participatory planning

VULNERABILITY EXPOSED—ADAPTING TO RECURRENT DROUGHT IN NORTHEASTERN BRAZIL

Drought in northeast Brazil regularly exposes the underlying vulnerabilities confronting the rural population. Although drought events no longer cause significant mortality, they still contribute to human suffering, deprivation, and poverty. There has been growing concern that climate change will exacerbate current vulnerabilities.

There have been two major reasons why the majority of communities and residents live in conditions highly vulnerable to drought. First, they depend on rainfed agriculture. There is limited access to climate-neutral employment, and efforts to encourage industry to reduce this dependency have provided only minimal relief. Second, interventions have consisted of post-drought social security and welfare payments with little investment in capacity building for community preparedness. While these transfer payments are important for recovery because they protect families from being overwhelmed by drought, the measure also maintains the patron-client relationship with government instead of developing the capacity of communities to respond to and recover from events. While government assistance will always be critical, neglecting the communities' capacity contributes to persistent vulnerabilities.

This perspective is gradually changing. Instead of only focusing on government-led recovery, there is now increased investment in developing capacities at the community and individual level. The Ceará state government, for example, is providing institutional support to a community-driven development initiative that uses participatory GIS (geographic information systems) to draw on local understanding of local problems and potential solutions. The methodology is largely based on understanding drought not only as a biophysical but also a socioeconomic problem and to enhance preparedness by identifying and strengthening existing sources of resilience in order to live in, and adapt to, a semi-arid environment.

Source: D. Nelson and T. Finan. Forthcoming. "Weak Winters: Dynamic Decision Making and Extended Drought in Ceará, Northeast Brazil." In E.C. Jones and A.D. Murphy, eds., *The Political Economy of Hazards and Disasters*. Walnut Creek, CA: AltaMira Press.

If state responses are to be as effective as possible, the capacity of those at risk to make claims on public institutions for support is critical to ensure that a public response to such events will benefit the most vulnerable. For example, the capacity of poor people to cope with famine has been shown to depend on their communities' ability to make claims on various sources of support. Therefore, understanding the capacity of vulnerable communities to have agency as well as how their voices can be strengthened becomes critical for assuring effective public action.

Based on the assets they possess and services they can access, communities and social groups independently develop different adaptation strategies for climate-related challenges. These techniques come out of firsthand experience confronting actual climatic variability and natural disasters and therefore offer an important source of learning and knowledge.

One important asset that can prevent households from becoming more vulnerable is the ability to act collectively through strong community networks, known as social capital. The strength or weakness of social networks affects how a community collectively manages natural resources and systems, resolves disputes, distributes benefits, and takes advantage of new opportunities. Therefore, the presence or lack of social capital influences a community's ability to confront poverty and vulnerability. Strong social capital can potentially enhance the resilience of both social and natural systems.

The Bank's Role

In order to stem the threats from climate change, the international adaptation agenda needs to prioritize reducing social vulnerabilities and enhancing social resilience. To this end, the World Bank's Social

Development Department is advancing a work program focusing on the following four themes:

- ◆ *Supporting effective adaptation to climate change through understanding poverty and social impacts.* A variety of factors make poor people more vulnerable to the impacts of climate change, including (a) being dependent on fragile natural resources for livelihoods, (b) inhabiting areas of less productive potential and greater environment risk, and (c) lacking assets and capabilities, which enable effective adaptation.
- ◆ *Helping communities and households to manage risk, adapt to adverse impacts, and participate in actions to mitigate climate change.* Successful adaptation to climate change will require local-level institutions that foster collective action on a range of key tasks, such as managing natural resources, mediating competition over scarce resources to prevent insecurity and conflict, mutual



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aid, and community-based infrastructure development and maintenance.

- ◆ *Ensuring that actions to mitigate climate change benefit poor people.* An explicit consideration of the likely poverty and social impacts of mitigation measures will be critical to ensuring that key investments include and benefit the poor rather than eroding their livelihoods.
- ◆ *Understanding the political economy of climate action.* Accountability and public debate over climate action are important for developing responses that include vulnerable populations. A focus on understanding power dynamics and a concern for social justice and equity will help to ensure that poor people have voice and agency in decision making for climate change planning.

The Social Development Department's efforts on the social dimensions of climate change include the following main elements: (a) stocktaking in areas where substantial existing bodies of work exist to bring the Bank up to speed on existing knowledge; (b) new research and knowledge generation to deepen understanding of the social dimensions of climate change in key areas for policy and program action; (c) broader corporate policy development to integrate a concern for the social dimensions into the Bank's key policy and strategy processes at both the central and regional levels; and (d) development of policy and operational approaches to climate action that include poor and vulnerable populations.

Moving Forward

The social dimensions of climate change are about the implications for human well-being, human agency, social organization, and social justice. Confronting the social dimensions of vulnerability to climate change will be critical for effective and sustainable

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adaptation planning. It is important that efforts be focused on not only determining who will be most vulnerable to what events and what exacerbates that vulnerability, but what policies will best strengthen their capacity to adapt positively. In that light, it is critical that international development agencies pursue strategies that link global efforts for climate change mitigation with local efforts that strengthen the capacity of vulnerable communities to adapt to climate-change effects.

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Water Security

An Adaptation Imperative

Why does climate change worry us? With regard to water, we fear a world of droughts and floods endangering populations and economies and of rainfall so unpredictable that our knowledge and institutions, watersheds, reservoirs, and distribution systems will be inadequate to ensure the regulation and delivery of water when it is needed. We worry about the health impacts associated with this inability to manage water and the ecosystem impacts of managing water resources (to the extent we are able to do so at all) reactively rather than holistically.

Climate change may bring back these challenges to countries that for a hundred years have enjoyed robust water security, with reliable water supplies and few, if any, water shocks.

These challenges are already the reality, however, for many of the poorest countries that have always faced significant hydrological variability and have not yet achieved water security. Climate change will further increase the complexity and cost of water security in these nations.

Water and Growth

Most industrialized nations enjoy an “easy” hydrology of moderate, predictable rainfall and long ago achieved water security (see *Box*, below). Many of the poorest countries are characterized by a “difficult” hydrology—high inter- and intra-annual variability and extremes of rainfall—and, perhaps as a consequence, have not achieved water security.

They have remained poor in part because it has never been possible for them to make the comparatively large investments needed to achieve water security, investments that can only be funded from the growth that water insecurity itself constrains. They are therefore in a low-level equilibrium trap.

Ethiopia, for example, experiences highly variable rainfall and devastating droughts

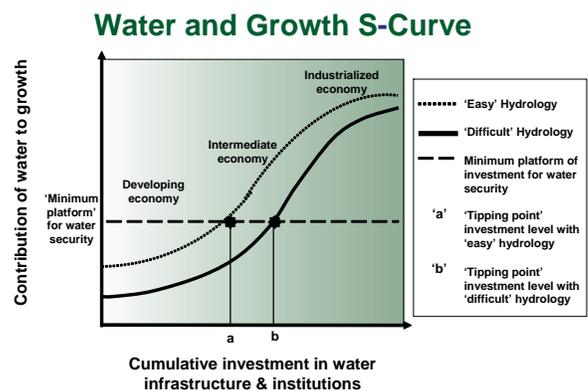
CREATING WATER SECURITY

Water security can be defined as the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies.

Water security in turn requires a minimum platform of institutions (i.e., human capacity, organizations, information, regulations, and incentives) and infrastructure (i.e., natural and man-made, large and small) to manage and deliver water.

The magnitude and mixture of investments needed to achieve water security will depend upon a country's hydrology and the vulnerability of its economy and people, such as its dependence on rainfed agriculture or the location of cities and assets in floodplains.

Source: Grey and Sadoff 2007.

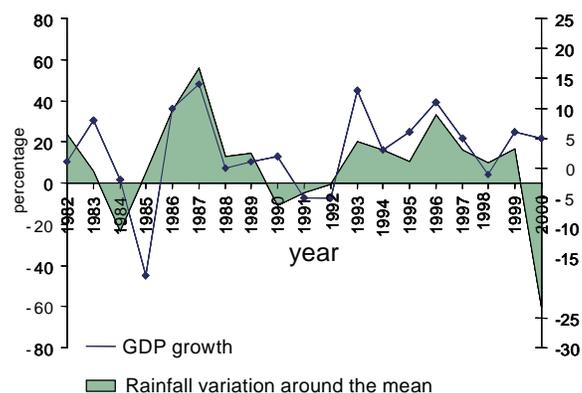




Yahid Alavian

whose effects ripple through the economy (see *Figure*, below). Hydrological variability was estimated to cost the Ethiopian economy over one-third of its growth potential (World Bank 2006). The very structure of the economy, with its heavy reliance on rainfed subsistence agriculture, makes it particularly vulnerable. Extremely low levels of hydraulic infrastructure and limited management capacity undermine attempts to manage variability. These circumstances leave Ethiopia's economy virtually hostage to its hydrology.

Rainfall Variability and GDP Growth in Ethiopia



Source: World Bank 2006.

In India, the economic impact of the seasonal monsoon has lessened as the economy has diversified. But in poor, water-insecure states like Bihar, the monsoon can still shock the state economy by about 15 percent. In 2007, flooding in Bihar affected 20 million people in 11,000 villages. Rapidly melting glaciers in the regional headwaters and increases in monsoon extremes predicted as a consequence of climate change will intensify the impacts of climate variability.

This link between hydrological variability and growth holds globally—greater rainfall variability is associated with lower per capita GDP (Brown and Lall 2006). The wealthiest countries in the world typically experience low levels of intra-annual and inter-annual rainfall variability, while the poorest countries have the highest.

Water Security—The First Step in Adaptation

Water is the primary medium through which climate change will impact people, economies, and ecosystems. Today's hydrological variability is already a fundamental development challenge in many poor countries. Achieving water security is therefore a first and necessary step toward climate adaptation, and an investment that will deliver important growth and poverty gains independent of climate change outcomes.

The climate change “adaptation deficit” in many of the world's poorest countries builds on a legacy of water insecurity. Seen another way, the intractable water security challenge in many poor countries will be compounded by climate change, which will increase the complexity and cost of ensuring water security.

Those countries expected to see the greatest increases in hydrological variability (and hence in adaptation deficits) will be those already experiencing the greatest variability and vulnerability—and generally those that lack the institutions and infrastructure to manage their water resources.

Ironically, those hardest hit are also likely to be the countries that have contributed the least to the drivers of global climate change.

Water Security in an Age of Climate Change

In all countries, adaptive capacity—both social and physical—will need to be enhanced to protect the poorest and most vulnerable populations and ecosystems. In some countries, adaptation may even call for structural changes to vulnerable economies. Whatever the route, achieving water security is imperative for poverty reduction and a fundamental adaptation strategy for the water-insecure poor in an age of climate change.

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Insuring Against Risks

In general, communities that have the capacity to take adaptive measures in response to climate change are less likely to suffer from potentially adverse impacts. However, at times the impacts may exceed their ability to cope. Being able to put in place a sustainable system to help them recover from such situations can avert utter ruin of community livelihoods or government budgets. Insurance is a mechanism with such potential. The World Bank and other agencies are gaining experience in working with a diverse array of insurance projects that span different regions and climatic hazards, different scales (community-level; multi-country) and vary in terms of the index used to make payments. Below are two examples of climate-hazard-related insurance schemes under way that look promising: (a) the index-based livestock insurance in Mongolia and (b) the Caribbean Catastrophic Risk Insurance Facility. In addition, other index-based insurance schemes are under implementation, such as a scheme to hedge drought risk in agricultural production for smallholder farmers in Malawi. Weather index insurance offers promise, but mainly if focused on selected hazards like deficient rainfall (drought) or excess rainfall.

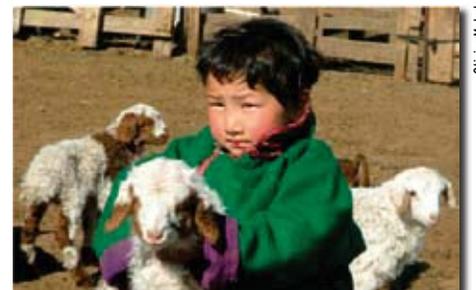
Piloting Index-Based Livestock Insurance in Mongolia

The Mongolian countryside remains a herder-based economy, with livestock husbandry supporting half of the population and contributing to nearly one-third of the national GDP. Major livestock losses are common; during *dzuds* (Mongolia's harsh winters), high levels of livestock mortality are often unavoidable. From 2000–02, one-third of Mongolia's livestock (11 million animals) perished due to harsh winters.

A promising approach to provide herder households with liquidity in the aftermath of a disaster is an index-based insurance product to indemnify herders based on the mortality rate of adult animals in a given area. The index-based livestock insurance policy pays indemnities whenever the adult mortality rate exceeds a specific threshold for a localized region (e.g., the *soum* in Mongolia). It provides incentives for good management; if a better herder has no losses when his neighbors have had large losses, the better herder is rewarded for the extra

effort by receiving a payment based on the area losses.

In 2006, the government of Mongolia decided to begin a three-year pilot program designed by the World Bank in three provinces of Mongolia (Bayankhongor, Uvs, and Khenti). This program combines self-insurance, market-based insurance, and social insurance. Herders retain small losses that do not affect the viability of their business, while larger losses are transferred to the private insurance industry. Participating insurers share underwriting gains and losses in the livestock insurance indemnity pool, which is a syndicated pooling arrangement. The government of Mongolia fully covers the final layer of catastrophic losses—insured losses beyond the reserves of the pool—through an unlimited (stop-loss)



Oliver Mahul



Yasar Arif Heretkar

reinsurance treaty, backed by a World Bank contingent credit facility.

The livestock insurance indemnity pool has several major advantages: (a) it fully protects other lines of insurance, as the insurance industry in Mongolia is still under-developed; (b) it fully protects the indemnities needed to pay for losses under the pool, thus eliminating any risk of default on payments; (c) it allows the insurance companies to pool their livestock insurance portfolio in different regions; and (d) it facilitates collaboration among the insurance companies selling the commercial product. After two sales seasons, 13 percent of the eligible herders purchased the insurance product from four local insurance companies, protecting almost 600,000 animals.

The pilot program has a strong outreach component to inform herders about the attributes of the index insurance product. Radio campaigns, local presentations, newsletters, press releases, and a wide array of other activities are planned.

This program paves the way for the development of financially sustainable agriculture

insurance programs for the poor. It supports a public-private partnership that aims (a) to offer insurance coverage that is attractive to herders, (b) to involve the domestic insurance market while protecting it against catastrophic losses, and (c) to limit the fiscal exposure of the government.

The project is also complementary to the ongoing IDA-funded Sustainable Livelihoods Project, which encompasses a package of initiatives, including participatory grazing and pasture management and support to the hay and fodder enterprise development.

Helping the Caribbean Cope with Hurricane and Earthquake Damages

Caribbean states are highly vulnerable to natural disasters and have limited financial options to respond. On average, a major hurricane affects a country in the region every two years. The Caribbean Catastrophe Risk Insurance Facility (CCRIF), which was launched on June 2007, is the first regional catastrophe insurance facility in the world. It provides 16 participating governments from the Caribbean region with immediate liquidity in the aftermath of a natural disaster. By pooling their risks together, participant countries save approximately 40 percent over individual premiums. Participating governments are Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Trinidad & Tobago, and the Turks and Caicos Islands.

CCRIF's reserves come from participating countries and donors. Its capacity to service claims is based on its own reserves combined

with the financial capacity of the international financial markets. This allows CCRIF to respond to events that may occur only once every 1,000 years or more, achieving a higher level of resiliency than international standards. CCRIF was able to secure \$110 million of claims-paying capacity on the international reinsurance and capital markets. Work is also being considered to expand the scope of the coverage provided by CCRIF to other natural hazards such as floods and tsunamis, as well as to other Caribbean territories.

From June 1 to December 31, 2007, five earthquake events and two hurricanes were reported by CCRIF participants. Hurricane Dean, which passed through the Caribbean Basin on August 18–20, 2007, was the most significant of these events for CCRIF participants. Even though this hurricane event generated losses on several islands, these losses remained below the attachment point of the policies purchased by the affected countries. This event was a good test of the CCRIF operational mechanisms. The facility operated as planned, with all affected countries informed within 24 hours of the interim payout calculations resulting from the passage of the storm.

In the light of Hurricane Dean and following inputs from different stakeholders, CCRIF has reviewed some of its operational procedures. The events following Hurricane Dean demonstrated the need for improved communication regarding the coverage provided and the operating mechanisms of the facility. Caribbean public relations expertise has been retained by CCRIF for this purpose, and CCRIF is working on a comprehensive communications strategy for the facility.

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Sub-Saharan Africa Region



IBRD 31567R JANUARY 2008



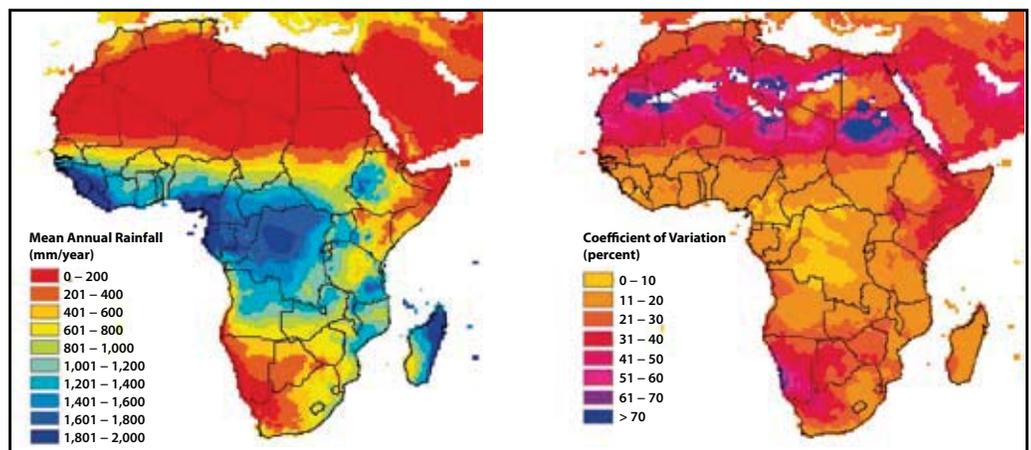
KENYA

Frank Sperling

In the climate change debate, long-term change often gets all the attention. As a result, the role of current climate in influencing development processes can be overlooked. This applies in particular to Africa. Africa is the only continent that resides almost exclusively within tropical latitudes. Two-thirds of its land surface can be classified as dryland. Moving from

the equator either south or north, there is a steep decline in average annual rainfall accompanied by an increase in variability (see Figure below). This broad picture is somewhat modulated by the influence of larger-scale atmospheric circulation and topography. For example, the western equatorial regions are wetter than the eastern.

Average annual precipitation [mm/year] (left) and coefficient of variation [%] (right) over Africa derived from UEA-CRU 1951–2000 monthly time series. While agriculture is often the mainstay of economies in Africa, the figures illustrate that for large parts of the continent marginal climates for natural-resource-based activities, characterized by high degrees of rainfall variability, predominate.



Source: A. Lotsch, 2007, Pers. Communication.

The Ethiopian highlands experience a cooler and wetter climate than the surrounding lowlands.

Over the past century, the average surface temperature over the African continent has increased by about 0.5° C (for example, Hulme, Doherty, and Ngara 2001). The warming trend is becoming more pronounced; by the end of this century, the median increase in temperature is projected to be 3 to 4° C higher than present-day conditions (IPCC 2007).

The projected changes in rainfall suggest that the existing differences in water availability across the continent will be exacerbated. This generally means already wet areas will receive more rainfall, while already dry areas will receive even less.

Rising temperatures will also increase evaporation rates. A recent analysis of the combined effects of changes in temperature and precipitation suggests that the length of the growing period tends to decrease for large parts of Sub-Saharan Africa, with the most notable exceptions being highland areas (Thornton and others 2006).

Aside from changes in average conditions, the effects of climate change on climate variability and the exposure to extreme events are a grave concern. There is growing evidence for shifts and changes in the characteristics of the rainy season.

Key Vulnerabilities

The frequent and increasing occurrence of climate-related disasters, particularly droughts and floods, underscores that the region's adaptive capacities are often already overwhelmed under current climatic conditions (OFDA/CRED database).

Livelihoods and economic activities are heavily dependent on natural resources and ecosystem services. In Sub-Saharan Africa,

the livelihoods of over 420 million people, almost 60 percent of the region's population, are centered on agriculture, hunting, fishing, or forestry (FAO 2004). For most African countries, agriculture continues to be the main pillar of the economy in terms of employment and contribution to GDP. With limited access to irrigation, livelihood activities are highly vulnerable to variations in rainfall. For example, agricultural growth for Ethiopia closely follows variations in annual rainfall (see Sadoff and Grey, pages 28–29). For the large number of subsistence-based livelihoods, however, it is particularly the impact on nonmonetary assets that reinforces conditions of food insecurity and poverty.

Among other factors, climate-related vulnerabilities are affected by land use change and environmental degradation and demographic trends. Agricultural growth has been largely achieved through expansion of cultivated areas and not productivity gains (IEG 2007). By 2030, every third person born in the world will live in Sub-Saharan Africa.

In light of the existing vulnerabilities, the impact of climate change on natural resources and ecosystem services and the associated implications for food security and agricultural productivity represent key concerns. Climate change lends further urgency to the sustainable management of land and water resources and the reduction of environmental degradation.

Other key vulnerabilities that need to be considered include the effect of climate change on the disease burden in humans and livestock, given the prevalence of water- and vector-borne diseases. Another grave concern is the loss of housing and infrastructure due to floods and coastal erosion processes, which is already well documented for a number of African countries, such as Mozambique and South Africa (IPCC 2007). Inadequate roads also hamper efficient emergency relief and access to markets when it is most needed. Changes in extremes and run-off also will

have implications for energy infrastructure in African countries.

Adaptation to Climate Change—Climate Risk Management

Adaptation to climate change should be viewed as part of a continuous process of managing climate risks. Risk mitigation strategies need to take into account the time horizon and scope of development activities. At the local level, practical interventions will be predominantly focused on reducing vulnerabilities to current climate variability and climatic changes, which are already visible. At the district and national level, it is important that, first, an enabling environment is established to manage existing climate risks and, second, programs (for example, education, incentives for economic diversification) are initiated that will help reduce vulnerabilities to medium- to long-term risks associated with climate change. The latter implies assessing the implications of climate change for the viability of livelihoods, development strategies, and long-term structural investments.

Climate change also requires regional dialogue and cooperation. Sixty-seven main water courses are shared by 47 countries. There is a need for knowledge partnership and joint capacity development in order to address and respond to changes in water and natural resources efficiently and effectively and defuse conflict potential. Tackling resource management—especially water resources management at the basin level—and fostering transboundary cooperation is one response that the Bank has supported in several major basins in Africa.

At the country level, coordination mechanisms on climate change need to be strengthened and embedded in existing country partnership strategies. Uganda re-

ceives about 630 new donor projects and activities per year, Tanzania 700, Ethiopia 790, and Mozambique 845 (Paris 2006). Client countries often participate in a broad range of multilateral agreements. In light of these complexities, it is important that there is clear communication between client countries and donors on key vulnerabilities and ways to address them.

World Bank Activities

The overarching objective is to make more development processes more resilient to climatic risks to ensure their sustainability. A growing number of World Bank IDA projects include adaptation components, recognizing climate change rarely can be addressed through stand-alone projects but rather has to be viewed in terms of its effects on the achievement of core development objectives. Integrating climate risk management perspectives into IDA investments represents the key entry point for reducing vulnerabilities. In addition to directly addressing climate risks in IDA projects, the World Bank is using supplemental grant finances from the Global Environment Facility, the Global Facility of Disaster Risk Reduction, and various trust funds (TFESSD, BNPP). These resources are also underpinning a range of analytical and capacity building activities (for example, see pages 58–61) that seek to inform development investments about climate impacts, vulnerabilities, and adaptation options. Some examples follow:

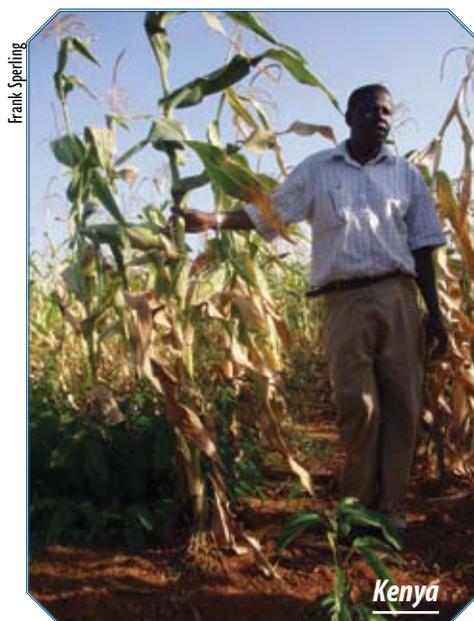
Cross-regional and multicountry. The World Bank is engaged in the multi-stakeholder TerrAfrica partnership, which aims to harmonize and scale-up sustainable land management investments. The program recognizes climate risk management as an integral component of its activities, which include coalition building at the global, regional and national level, knowledge development and management, and investments.

Regional, river-basin specific. The Bank is also engaged in mainstreaming climate risk

management at the basin level. For example, in the Nile Basin, such activities include consideration of climate change scenarios in the Strategic Social and Environmental Assessment for the Nile Equatorial Lakes Region. In addition, climate information and scenarios are being factored into both the Nile Decision Support System and the Eastern Nile Planning Model, which are intended to help identify future investments and improve cooperative basin management.

Kenya. A range of project activities in Western Kenya and the country's arid and semi-arid lands address climate-related vulnerabilities. These include knowledge development; providing investments for watershed, drought and flood management; strengthening early warning systems; promoting community-driven development efforts focused on improving local capacities to manage near-term risks; and supporting capacities at the district and national level to manage medium- and long-term risks associate with climate change.

Madagascar. The World Bank provides technical assistance on the linkage between hazard management and adaptation, exploring in particular the evolution of cyclone and drought risk. Working with the government, this analytical work guides the identi-



fication of risk management and risk transfer schemes.

Malawi. Activities are focused on mainstreaming disaster and climate risk management into country planning processes, strengthening meteorological services, contingency planning, piloting index insurance schemes, and development of cyclone-resistant building codes for housing, roads, and other infrastructure.

Burkina Faso. The World Bank is engaged in community-based activities focused on sustainable management of natural resources, which includes managing current and future climate risks within the broader project context.

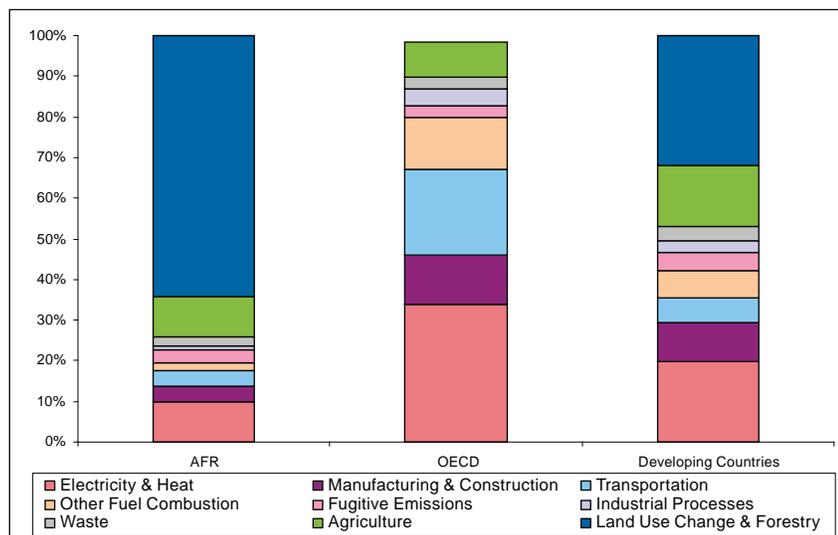
Other regional or country-specific projects that include adaptation activities are under execution or preparation in West Africa, Southern Africa, the Niger Basin, Ethiopia, Mozambique, São Tomé, Sudan, and Tanzania.

Linking Mitigation and Adaptation

Reducing vulnerabilities to climate variability and change within the development context represents a priority concern for Africa, as most African countries have small per capita greenhouse gas (GHG) emissions and contribute little in aggregate terms to the world's total emissions. However, it is important not to overlook opportunities for Africa through the emerging carbon market and to consider the implications of climate change for the energy infrastructure, given the high dependency of many African countries on hydropower.

Deforestation and land degradation processes are not only a source of GHGs (see *Figure* on next page), but often also contribute to an increased vulnerability to climate risks. Carbon finance provides new opportunities to counteract some of these trends while

A Comparison of Greenhouse Gas Emission Sources. While in other regions of the world emission sources are linked to the combustion of fossil fuels, the dominant emission sources in Africa are land use change, including deforestation. Land degradation processes not only contribute to an increase in atmospheric greenhouse gas concentrations, but often exacerbate vulnerabilities to climate-related risks.



contributing to local development objectives. Implemented under the World Bank's BioCarbon Fund, projects are under way in Kenya, Madagascar, Mali, Niger, and Uganda that combine carbon sequestration with sustainable development and environmental conservation objectives. The establishment of the new Carbon Forest Partnership Facility will provide additional value for the protection of existing forests by creating incentives for reducing forest degradation. This will help to further promote sustainable forest management.

As reflected in the World Bank's Africa Action Plan, improving energy access in Africa has to be a high priority for development. In Sub-Saharan Africa, only 25 percent of households have access to electricity. Investment decisions taken today will decide the type of energy infrastructure for decades to come. As climate change impacts are increasingly becoming visible, it is prudent to ask how climate change may impact on the ability to generate energy, for example, through changes in run-off and where opportunities exist for Africa to leapfrog to more energy-efficient or clean energy technologies.

Next Steps

In response to the internal and external recognition of climate change as a development issue that will threaten the development gains of recent years, the World Bank's Africa Region is now working on building a systematic approach to addressing climate change issues. The goal is to mainstream climate risk management perspectives into the general project portfolio of the World Bank to ensure that development objectives are sustainable and not compromised by climate change.

The Bank's Africa Region is currently developing a strategy for making development more resilient to climate variability and change. The main pillars of the strategy are (a) adaptation, (b) mitigation, and (c) knowledge and capacity building. This strategic and conceptual framework is accompanied by two analytical and technical assistance components that are focused on assessing the implications of climate variability and change for water resource and land management and on studying the economics of adaptation. The goal of this work is to generate a common and consistent

knowledge resource tailored to the information needs of the World Bank and its client countries to improve the resilience to current climate variability and be prepared for future change.

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East Asia and Pacific Region



IBRD 31562R JANUARY 2008

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INDONESIA

Nations in the East Asia and the Pacific (EAP) region have a number of characteristics that increase the region's vulnerability to climate change impacts. For example, over half of the region's population resides in coastal locations and in low-lying islands. In addition, the region relies heavily on agriculture and marine resources, and water and energy demand is growing rapidly. Climate change impacts will eventually be felt throughout the region, affecting virtually every major sector, undermining recent gains in economic growth and poverty alleviation, and impeding the region's progress toward achieving the Millennium Development Goals.

The Impacts of Climate Change in EAP

Over the course of this century, climate change is expected to have significant impacts in the East Asia and Pacific region. EAP is already characterized by extreme climate events—such as storm

surges, cyclones, floods, and droughts—with substantial economic consequences. Climate change is projected to increase the intensity and frequency of such events. According to the IPCC's middle-range scenario (IPCC 2007), EAP will experience a significant rise of about 2.5° C in temperature by 2100. In addition, precipitation patterns will change. The relationship between global average temperature changes and regional climate change is uncertain and will vary between countries and regions, especially with regard to changes in precipitation. Further inland, a significant increase in extreme precipitation is expected in areas such as the Yangtze River basin in China, suggesting the likely occurrence of severe floods.

Changes in climate would have diverse and potentially significant impacts on the region's people, environment, and economy. The major implications of climate change can be structured in three distinct but highly interrelated categories:

🌐 **Environmental**—changes in coastal and marine systems, forest cover, and biodiversity

- **Economic**—threats to water security, impacts on agriculture and fisheries, disruption of tourism, and reduced energy security
- **Social**—displacement, loss of livelihoods, and increased health problems; the greatest impacts would be on the poorest residents of cities and surrounding areas, such as slums in low-lying coastal cities.

Impacts by Sector

Agriculture. Agricultural activities account for 13 percent of the region's GDP, but in some countries they account for as much as one-third. An estimated 60 percent of people live in rural areas, and about 50 percent of the region's land is dedicated to agriculture. Agricultural productivity is likely to suffer severe losses due to high temperatures, drought, flooding, coastal inundation, soil degradation, and associated factors. Changes in agricultural output will vary significantly across the region, and will be closely linked to the availability of water for irrigation. Pest populations and crop pathogens are expected to increase, with negative impacts on productivity in the sector. Impacts on trade—and thus on overall economic growth—could be substantial.

Water resources. Water availability, critical to economic growth and poverty alleviation in the region, is especially vulnerable to climate change. There are already many threats to water security, including increasing demand, pollution, unsustainable extraction, and water rights conflicts. Climate change is expected to cause significant and complex water security changes associated with changes in temperature and precipitation, as well as changes in the delta regions of major river basins associated with sea level rise, coastal storms, and saltwater intrusion. In general, EAP will receive more precipitation. This could have both positive effects—such as more cereal production in rainfed areas in northern China—and negative effects—such

as increased floods, which would threaten livelihoods, infrastructure, and productivity. Rapid economic and population growth and migration from rural to urban areas also are placing severe stress on urban water supply and sanitation systems, increasing the competition for surface and groundwater resources and resulting in deteriorating water quality through point-source pollution and saltwater intrusion. The economy and livelihoods in the region could be fundamentally impacted by these changes.

Fisheries and marine resources. Commercial and subsistence marine and freshwater fisheries and aquaculture are important for food security and the economies of many countries in the region. Climate change is also expected to have significant impacts on fisheries. Climatic factors affect the elements that influence the number and distribution of marine fish species by impacting on food availability, breeding habits, and the presence and species composition of competitors and predators. In addition, competing demands for land and water, and the loss of inshore fish nursery habitats to coastal development, may cause significant change to ecosystems and losses to commercial aquaculture. Overfishing, excessive use of pesticides, industrial pollution, diseases, red tide, and construction of dikes and other coastal structures further increase the stress on marine resources.

Tourism. Tourism is a growing source of revenue for many countries in the EAP region. Climate change will have both direct and indirect effects on the tourism industry. As noted above, sea level rise will result in loss of beaches, degradation of coastal ecosystems, saline intrusion, and damage to critical infrastructure. The resulting economic impacts on tourism could be high.

Energy. Changes in hydrological cycles will affect hydro potential. In 2003, China's hydropower generation was 23 percent of the country's economically exploitable potential. However, glacial melt in the Himalayas and uncertain rainfall downstream may curtail the potential for hydropower in the long term. Flooding from storms and glacial melt is expected to increase sedimentation, adversely affecting drainage and efficiency of hydropower projects. Moreover, hydropower projects reduce sediment discharge to river deltas downstream, making them more susceptible to erosion and the effects of sea level rise. Renewables (other than hydropower) such as solar and wind present additional alternatives to fossil fuels, especially in isolated regions in EAP. In 2002, these sources accounted for 1.3 percent of EAP's generated electricity. Plans to increase energy security could be affected by climate change. At the same time, energy demand in EAP is increas-



ing due to industrialization, urbanization, and increased motor vehicle use.

Ecosystems and biodiversity. The region contains numerous global biodiversity hotspots and World Heritage sites that are home to some of the rarest and most endangered species and ecosystems (such as coral reefs) in the world. Human pressures, together with changing hydrology, may impact the productivity and resilience of these ecosystems.

Health. Human communities in EAP are already at risk from the health implications of degraded ecosystems. Cholera and other waterborne diseases are on the rise in coastal countries and may be related to declining water quality, climate, and algal blooms. There is also an increase in the incidence of diseases of marine organisms and the emergence of new pathogens, some of which are harmful to humans, such as ciguatera, which causes seafood poisoning (UNEP 2006). Kiribati already has one of the highest rates of ciguatera poisoning in the Pacific. The rise in temperatures is expected to increase

the incidence of ciguatera poisoning from 35–70 per 1,000 people to about 160–430 per thousand in 2050 (World Bank 2000).

Adaptation Challenge and the World Bank's Assistance

Adapting to the impacts of climate change poses a difficult challenge for developing countries. It is important that governments provide a clear policy framework to guide adaptation in the following key areas: (a) high-quality climate change information, including improved regional climate predictions, particularly for rainfall and storm patterns; (b) land use planning and performance standards to encourage private and public investments in buildings, capital, and infrastructure that are resilient to the effects of climate change, as well as protection of vulnerable utilities and facilities; (c) long-term climate-sensitive policies such as natural resource and coastal protection, disaster and emergency preparedness, and relocation of vulnerable human settlements; and (d) financial safety nets to help the more vulnerable sections of society, who are the least likely to be able to afford protection. These are critical building blocks that must be tackled through comprehensive, coordinated approaches at the national, sectoral, and local levels. Coastal cities, major river basins, agricultural areas, forests and drylands, marine ecosystems, and small islands will be areas of specific concern.

The EAP Region's evolving climate change strategy encompasses both adaptation and mitigation and outlines a "transformative" vision for the Bank. Specifically, it will focus on:

- Leading a shift in investment toward climate-friendly technologies, particularly for energy and transport, and catalyzing a scale-up of such investments; help-

ing to distribute the above-mentioned investments in an optimal way across private and public sectors, and encouraging financial institutions to invest

- Deepening the World Bank's engagement in the forestry sector and reduction of land use change by (a) working on avoided deforestation issues in Indonesia and Papua New Guinea and (b) developing a forestry strategy for EAP
- Responding to the adaptation needs of vulnerable cities, countries, and regions.

Adaptation is an emerging area of interest and cooperation between the Bank and governments in the region. The Bank is combining climate change efforts with the broader development and poverty alleviation agenda to foster more climate-resilient and sustainable economies. Given the dramatic variations in climate change impacts based on location, a localized analysis and assessment is needed to determine what those impacts may be and how best to deal with them. Mounting evidence also shows the need for a close linkage between disaster risk management and the climate change agenda. For example, compared to the past, the Central Equatorial Pacific is experiencing more intense rain (about a 30 percent change) and a hotter climate (0.6° C). Sea surface temperatures have increased by about 0.4° C (Hay and others 2003). As the EAP region is also climatically diverse, the region is particularly vulnerable to multiple climate change impacts. However, the time frames of major impacts seem distant or uncertain, and the costs and benefits of some adaptation actions might not be fully appreciated.

EAP has helped develop some actions that fall into the "win-win" category—that is, approaches that make sense under current conditions of climate variability and that will have even greater value in considering the compounding effects of long-term climate change. For instance, a number of vulnerability assessments and country risk profiles

Highlights from the EAP Portfolio

Some of the highlights of the EAP Region's portfolio with regard to adaptation include the following:

- An adaptation project is in an implementation phase for the Kiribati Islands (KAP-II). The key objective of the project is to assist the government of Kiribati in diagnosing climate-related problems and designing cost-effective adaptation measures, while continuing to integrate climate-risk awareness and responses into economic and operational planning.
- The World Bank is providing technical assistance to Indonesia on a National Strategy for Climate Change Adaptation. This will strengthen national adaptation plans and build a foundation for effective coordination in partnership with the UNDP.



Cambodia

have been completed or are under way for countries in the EAP Region (World Bank 2000, 2006, 2007) that will form the basis for future adaptation work.

A climate change and disaster risk management strategy is being developed for Papua New Guinea. Risk profiles are also being developed for a number of Pacific countries as part of the work program of the Global Facility for Disaster Reduction and Recovery. These will incorporate the risks posed by climate change. A regional study covering EAP and SAR has also been launched—in collaboration with the Japan Bank for International Cooperation and Asian Development Bank—on the impacts of sea level rise on coastal cities, with a focus on Bangkok and Jakarta.

As a result, the current EAP Region's approach to adaptation is to focus on highly vulnerable countries with little capacity to adapt. These generally fall into two main categories:

1. Low-lying Pacific Island countries, such as Kiribati and Vanuatu. These nations

are generally isolated and poor; have low human resource capacity, low per capita incomes, low borrowing capacity; and are highly dependent on aid. They require financing, technical assistance, and technologies for assessing risk and solutions development.

2. Middle-income countries that are expected to be particularly affected. These countries are characterized by several climate-related impacts. They are exposed to flooding, cyclones, and drought, affecting slum dwellers in coastal cities, food security, health, and transportation. However, these countries possess higher potential to absorb some part of their risk and impacts. The emerging strategies will reflect this with different policies on a country-by-country basis. Ongoing pilot studies in China and the Philippines will contribute to the development of these strategies.

Furthermore, the National Adaptation Programmes of Action have demonstrated success in responding to urgent and immediate needs of both highly vulnerable least-developed countries (including some Pacific

Island countries) and middle-income countries (many have been identified as hot spots for disasters and effects of climate change).

An EAP strategic document on adaptation and climate change will focus on supporting increased access to technical assistance to assess vulnerability and risks, as well as access to new technologies for adaptation. It should be completed in 2008.

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Europe and Central Asia Region



Ronald Hoffer

ALBANIA

To many citizens in the Europe and Central Asia (ECA) region, climate change is not just a problem of the future, but one of the present. Following hot summers in 2003 and 2006, the summer of 2007 was particularly severe in southeastern Europe, causing widespread blackouts, forest fires, and several hundred deaths (see *Box*, top of next page). Only two months later, Slovenia—once an ECA client and now a funding partner—faced quite a different challenge, when devastating storms caused severe flooding that led to six deaths and estimated damage of over 200 million euros (0.3 percent of GDP).

Such events have heightened concerns in the region regarding the impacts of climate change. In response, the European Commission (EC) has placed climate change at the forefront of the Community-wide political agenda. For example, a 2007 EC “Green Paper—Adapting to Climate Change in Europe; Options for EU Action”—found that southeastern Europe and the Mediterranean Basin were particularly vulnerable areas due to the combined effects of temperature increases and reduced precipitation in areas

already coping with water scarcity. In addition, the increased risks of storms, intense rainfall, and flash floods pose new threats to the region’s densely populated floodplains.

The increasing frequency and severity of such events is often linked to climate change by citizens in the more than half of ECA’s clients that are members/candidates or acceding countries of the European Union (EU). Those still borrowing from the Bank or that have active projects include EU member states Lithuania, Latvia, Poland, the Slovak Republic, Hungary, Romania, and Bulgaria; EU candidate and potential countries include the former Yugoslav Republic of Macedonia, Croatia, Turkey, Bosnia and Herzegovina, Montenegro, and Albania. Kosovo (under UN Security Council Resolution 1244) is a current grant recipient.

Awareness Beyond the EU

Awareness among citizens in countries outside the EU sphere is more diverse but generally highest among the scientific community and

Heat Wave of 2007 Devastates Europe

On July 24, 2007, Reuters news service¹ reported that: "Twelve Romanians died and firefighters, soldiers and volunteers battled wildfires across southeastern Europe on Tuesday as a heat wave broke temperature records across the Balkans. There was a blackout in many parts of Macedonia and some parts of Albania and northern Greece as power lines struggled to cope with temperatures of over 40 degrees Celsius and an increased load from air conditioners. In Romania, new deaths pushed the toll from the heat wave up to 30. After forecasts of easing temperatures, health officials were preparing to downgrade emergency measures from 'Code Red,' although in some parts of the country temperatures soared to an all-time record of over 44 degrees Celsius (111.2 Fahrenheit). Some 19,000 Romanians have been admitted to hospitals in the region's second devastating hot spell this year. More than 35 people died in Romania, Turkey and Greece in June when the mercury shot up to 46 degrees Celsius. Serbia battled 50 forest fires on what meteorologists predicted would be the hottest day of the year, with the temperature topping 43 degrees Celsius...."

That same day, the BBC reported that over 500 people had died in Hungary from the heat wave in the previous week.²

Notes:

1. <http://uk.reuters.com/article/worldNews/idUKL2477782520070724?sp=true>.
2. <http://news.bbc.co.uk/2/hi/europe/6914490.stm>.

environmental civil society organizations. For example, the Russian Hydrometeorological Service (Roshydromet) is projecting a significant increase in hazardous events (floods, snow avalanches and mudflows, hurricanes, squalls, etc.) as recent tendencies

for warmer, wetter climates continue. From 1991 to 2006, the number of hazardous events in Russia more than doubled, increasing from 153 to 387 events annually.

Roshydromet is paying particular attention to the likely continuation of this trend, both in the shorter term (to 2015) and longer term (to 2050). Risks are expected to be highest in the northern Caucasus and Volga-Vyatka economic zones, Sahkalin, Kemerovo, Ulyanovsk, Penza, Ivanovo, Lipetsk, Belgorod, Kaliningrad, and the Republic of Tatarstan. The most vulnerable sectors are considered to be water supply, hydropower, pipeline transport, river transport, the safety and maintenance of buildings and structures, and public health. The energy sector may benefit due to a reduction in the heating season and increased energy saving programs. The agriculture sector also may benefit as a result of improved crop growing conditions and increased productivity.

Countries in the southern Caucasus—such as Armenia, Azerbaijan, and Georgia—also are faced with more severe flooding events. National concern has generally focused on

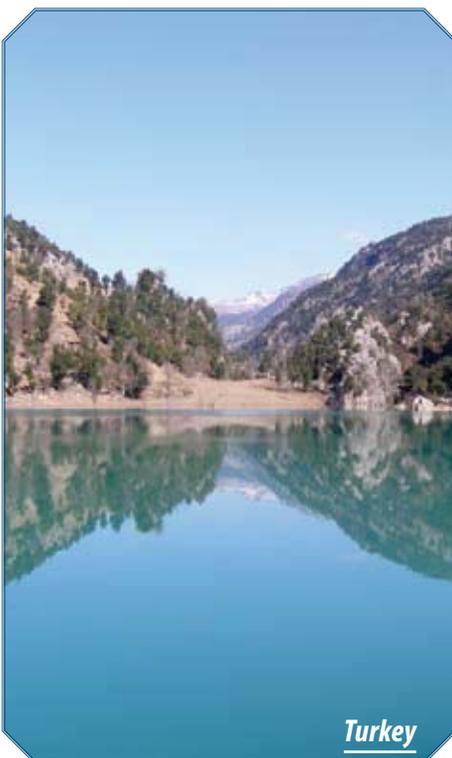
immediate disaster response rather than longer-term problems. Model simulations of regional climate change (Hovsepian and Melkonyan 2007) by the Armenian national hydromet service (supported in part by the World Bank) suggest both positive and negative consequences. Productive agriculture will be able to extend to higher elevations and growing seasons will be longer. Increases in flooding, however, could require a major expansion in water storage reservoirs by as much as 2 billion cubic meters for effective flood regulation. More sporadic rainfall recharge will require improvements in national water management strategies and improvements in water efficiency.

Water resource management issues in Central Asia are already a core element in regional dialogue. Water specialists know that despite some recent successes—such as the World Bank-supported project to restore the Northern Aral Sea—melting glaciers and reduced snowpack due to warming trends over the next few decades will exacerbate water scarcity issues, especially for irrigated agriculture. Plans for extensive hydropower development in Tajikistan to serve major regional power needs, to cite another example, will also need to take these factors into account.

Responses by Partner Countries on Adaptation

The European Union has an ambitious program of research. While emphasizing European problems and solutions, the EU also looks at developing-country and global approaches to both mitigation and adaptation. This is increasing understanding of problems and solutions, while also spurring significant policy debate on the response to adaptation between the European Commission and EU member states, candidates, and acceding countries.

Ronald Hoffer





Turkey

Active since the 1980s, the EU research program on climate change has increased in recent years and played an important role in providing scientific information to the Fourth IPCC report. Under the 6th Framework Programme, over 45 research projects were launched in seven areas: (1) carbon and nitrogen cycle sources and sinks, (2) atmospheric pollutants and their regional impacts, (3) stratospheric ozone and climate interactions, (4) climate dynamics and variability, (5) prediction of climate change and its impacts, (6) adaptation and mitigation strategies, and (7) observing and forecasting systems. Technical meetings are held among and across thematic research teams to help foster information sharing. The 7th Framework Programme announced in December 2006 allocates 1.9 billion euros for climate change and the environment over the next six years.

On the policy side, the European Commission released a Green Paper in June 2007 that looks at options for an EU response on adaptation to climate change (CEC 2007). The paper lays out the technical bases for action, raises key questions for the public (to be covered in four public meetings and through the Internet), and sets the stage for a proposed policy response in a White Paper planned for November 2008.

Ongoing research and policy analyses, which will support the White Paper, were discussed at a November 2007 International Symposium on Future Climate, Impacts, and Responses held in Brussels. Based on those discussions, it seems likely that the EU policy response will first target the review and adjustment of existing community-wide legislation (such as the Water Framework Direc-

tive and agricultural policies) and responses in process (such as the Floods Directive) to eliminate disincentives and conflicts with sound adaptation policies. Financial incentives from the EU for encouraging “soft” adaptation measures to reduce impacts, which will help in both the short and longer term, are also likely in the years ahead.

World Bank Engagement on Adaptation

ECA is already including climate considerations in its investment lending portfolio. Watershed projects under way in Armenia, Tajikistan, and Turkey, for example, include support for farming and forest systems adapted to drought. Irrigation and water

management projects under way in Albania, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Romania, Tajikistan, and Uzbekistan support improved water management and conservation approaches, which will further ensure climate resilience. Flood management investments in Poland, Romania, and Serbia help mitigate the effects of extreme weather events, which are expected to increase in the decades ahead.

The ECA Region's strategic goal on climate change is to assist partner countries in meeting their obligations to mitigate the global impacts of climate change and expand national adaptation planning and investments to reduce impacts in vulnerable locales and sectors. The Region is focusing its efforts on three client groups. First, in the case of EU members and candidate and acceding countries, the Bank will support their efforts to respond to new Community-wide legislation and initiatives as well as any national initiatives. This work will expand as the EU's policy position is presented in November 2008 and as EU Council action on that paper is taken in early 2009. For the second group of clients outside of this direct linkage to the EU, the Bank will help inform decision makers and the public on emerging national adaptation planning and resilient infrastructure investments. Finally, as in all Bank Regions, ECA staff must have the state-of-the-art tools to improve advice and facilitate financing of "climate-proofed" investments.

While there is global consensus on the importance of addressing climate change, the many uncertainties on actual impacts by sector, by location, and over time presents an understandable barrier to action in some cases. A number of ECA clients are considering what action can be taken in the very near term to improve national disaster risk reduction and adaptation. For example, if flooding is already more severe and more frequent, then improvements in disaster risk reduction and management in the next few years set the stage for longer-term adapta-

tion response. A pilot program in southeastern Europe (SEE) (in cooperation with the United Nations and other organizations) has recently been completed that is paving the way for a longer-term, phased program on Disaster Risk Reduction and Adaptation. The objectives of this effort would be to extend financing to countries in and beyond SEE to implement activities to promote disaster risk reduction and adaptation. A flexible approach is envisaged with two elements: (1) regional projects such as meteorological and flood early warning systems and regional insurance pools and (2) country-specific investments such as emergency management, flood control, strengthening enforcement of land use plans, and development controls.

Another "win-win" activity is the strengthening of national weather and climate forecasting services. A recent review found that 20 to 30 years ago, weather forecasting and overall provision of hydromet services in many ECA countries were at the leading edge of world capacity. But the status of most weather services among the Bank's ECA clients has deteriorated considerably in the last two decades, mainly as a consequence of persistent underfinancing. The scope of the accumulated problem is so great that without massive modernization, networks in

some ECA countries are on the way to becoming completely dysfunctional. This has very serious implications for both short-term forecasting (where up to 35 percent of flood damage can be mitigated if a flood warning is issued in reasonable time), mid-term climate projections (for example, for designing new hydropower plants), and longer-term climate work. The Bank is currently lending to Russia to improve its hydrometeorological services and is expanding both its analytical support and proposed lending to other countries.

In mid-fiscal year 2008, the ECA Region launched an ambitious program of sector work to advance the dialogue on medium- and longer-term adaptation needs. This will lead to a region-wide aggregation of understanding in key sectors and regions in Spring 2008 and a series of targeted subregional analyses in vulnerable sectors over fiscal years 2008–09. The approach to the latter includes (a) reviewing observed impacts in targeted areas, (b) aggregating and peer-reviewing existing forecasts of climate change in these areas, (c) funding value-added downscaling models and sectoral impact assessments, (d) using these assessments to frame adaptation options, (e) assessing institutional capacity, (f) engaging decision makers and stakeholders, and (g) scaling up the assessments for ECA-wide applications in fiscal years 2009–10.

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Poland

Latin America and Caribbean Region



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MEXICO

Heriberto Rodriguez

One of the most urgent development issues for Latin American and Caribbean countries is to better understand and prepare for the impacts of global climate change. Accounting for about 6 percent of global emissions, Latin America as a region is not a major contributor of greenhouse gas emissions, despite the presence of rapidly growing economies and industries such as in Brazil and Mexico; however, as a result of climate change, the region is expected to suffer irreversible impacts to key ecosystems and the services they provide.

Impacts of Climate Change

The most certain effect is sea level rise resulting from ice melting in the poles and thermal expansion of the oceans. The Intergovernmental Panel on Climate Change (IPCC) projects that by 2100, sea levels could rise by between 20 and 60 cm. This would have a dramatic direct impact in low-lying areas in deltaic regions and the Caribbean islands. Sea level rise is expected to exacerbate inunda-

tion, storm surge, and other coastal hazards, thus threatening the livelihoods of island communities. Sea level rise and warmer sea-surface temperatures are linked to coral bleaching, which has affected more than 80 percent of coral reefs in the Caribbean, according to a 2006 NOAA assessment. The result is a serious degradation of the role of coral reefs in protecting coastal areas against storm

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Trinidad and Tobago

surges, functioning as marine nurseries critical to Caribbean biodiversity and fisheries, and attracting tourism. In addition, sea level rise may contribute to salinization of aquifers and hence affect the availability of drinking and irrigation water resources.

Changes in precipitation and the rapid melting of glaciers are projected to significantly affect water availability for human consumption, agriculture, and energy generation. For example, the reduction of glacier mass in the Andes during recent decades is well-documented and accelerating. Between 1970 and 2002, the area covered by glaciers in the tropical Andes (Bolivia through Venezuela) declined by about 15 percent. Glaciers at altitudes below 5,500 meters could disappear by 2015. Retreating glaciers will dramatically reduce flows in dry seasons and could produce flooding in wet seasons.

Increase in extreme weather events. There is evidence indicating that global warming is associated with increases in both weather variability and the incidence and severity of extreme weather events. Recent studies (Hoyos and others 2006; Webster and Curry 2006) show a trend toward intensification of hurricanes in the Caribbean, which will have significant impacts on regional ecosystems, populations, infrastructure, and economies. The occurrence of extreme weather events from 2000–05 was almost 2.5 times higher than during the 1970–99 period, including a number of unusual occurrences. For example, in 2004 Brazil was hit by the first hurricane ever observed in the South Atlantic. Similarly, in 2007 Buenos Aires saw snow for the first time in 89 years.

Risk of Amazon dieback. One of the most significant projected consequences of climate change is its impact on the ecosystem integrity of the Amazon basin. Temperature increases and associated changes—including decreases in soil water, disruption in precipitation cycles, and increased wildfires—are projected to lead to a gradual replacement

of tropical forest by savanna in eastern Amazonia. The Amazon rain forest plays a critical role in global climate, locking away vast quantities of carbon and serving as an “engine” of global climate circulation that affects rainfall in places as far away as Europe and Central Asia. Moisture injected by the Amazon ecosystem into the atmosphere also plays a critical role in the region’s precipitation patterns. In drier areas, climate change is expected to lead to salinization and desertification of agricultural land. Moreover, productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security.

Additional losses from land conversion. Compounding the impacts of climate change on the Amazon there are additional losses from land conversion. While fossil fuels account for two-thirds of LAC’s emissions, a solid 20 percent is accounted for by land use change. Over the past 15 years, the Latin America region has lost about 45,000 square kilometers of forest per year—777,000 square kilometers since 1990. LAC accounts for slightly more than 50 percent of global annual deforestation. Most of the deforestation has taken place in Amazonia, with Brazil accounting for 60 percent of lost forest areas in the region since 1990.

Risk of significant biodiversity loss. There is a significant risk of species extinction in many areas of tropical Latin America. For example, an increase in sea-surface temperature due to climate change is projected to have adverse effects on Mesoamerican coral reefs, and cause shifts in the location of southeast Pacific fish stocks. Similarly, with higher temperatures, increased invasion by non-native species is expected to occur, particularly in middle- and high-latitude islands.

Impact on páramos. The effect of climate change on Andean páramos (unique mountain ecosystems of mixed grasslands, shrublands, bogs, and lakes) requires further

analysis. However, recent data (Ruiz and others 2007) suggest that significant changes in atmospheric stability, increases in sea-surface temperature, and changes in local vegetation cover have altered the circulation patterns responsible for producing and moving water vapor to the region and could fundamentally modify the ecology of the páramos. These changes have likely contributed to the disappearance of some high-altitude water bodies and increased the occurrence of natural and human-induced fires. These fragile ecosystems are not only home to globally unique biodiversity, but they also play an important role in the water supply of some major urban centers such as Bogotá and Quito.

Increased exposure to tropical diseases. Colombia has experienced a gradual increase in outbreaks of tropical disease, particularly malaria, that may be an indicator of future trends in parts of Latin America that are projected to have long-term increases in local temperature and precipitation. The strong correlation between precipitation and malaria and between temperature and dengue, documented in a 1997 study of 715 municipalities in Colombia (Blanco and Hernández 2007), suggests that these and other diseases may be more prevalent in the region as a result of climate change.

Vulnerability of energy supply. Latin America relies heavily on clean hydroelectric power to generate electricity. The share of this source is about 60 percent of electricity production, more than three times higher than the next region. Given the region’s dependence on hydroelectric power, the extent to which climate change will affect hydrology and potentially reduce hydropower potential is of critical importance to the region’s economic growth. Because of the region’s high dependence on hydropower, it is critical to “climate proof” its energy production, for example, through design of hydropower installations taking into account more variable as well as changing average flows, and

through moving toward a greater mix of clean energy sources.

Highlights from LAC Portfolio

The LAC Region has a large adaptation portfolio, with seven active projects addressing some of the most critical impacts identified by the scientific community. Development of this portfolio has been guided by (a) seeking to address critical impacts caused by scientifically documented trends such as glacier retreat and coral reef bleaching and (b) using an approach based on the projected impacts of climate change on ecosystems and the services they provide.

The Bank's regional adaptation work, summarized below, has been strategically focused on responding to impacts on key ecosystems. The identification of these impacts is being supported by key observation networks, monitoring coral systems, sea level rise, sea-surface temperature, and glacier dynamics. These activities are being complemented through the application of Earth Simulator runs to model future climate in Latin America. In collaboration with the Bank, this modeling of future climate scenarios is being undertaken under a pioneering partnership with the Meteorological Research Institute of Japan, the Mexican National Institute of Ecology, the Colombian Institute of Environmental and Meteorological Studies, the Peruvian National Service of Meteorology and Hydrology, the Ecuadorian National Institute of Meteorology and Hydrology, and the Bolivian Institute of Hydraulics and Hydrology.

Caribbean—Mainstreaming Adaptation to Climate Change. Now in its third year, this project is helping internalize climate change considerations into decision making and sectoral planning among members of the Caribbean Community (CARICOM), as well as expanding the monitoring network

to document trends in climate impacts in the region. It has supported further capacity building by transferring project management to the regional Caribbean Community Climate Change Center, which is responsible for guiding and implementing CARICOM's climate change strategy and designing and proposing projects. This center has installed a coral reef early warning system to monitor conditions that might lead to coral reef bleaching.

Colombia—Integrated National Adaptation Program. This program is supporting Colombia's efforts to define and implement specific adaptation measures and policy options on a pilot basis to address anticipated impacts from climate change. These efforts are focused on high-mountain ecosystems and insular areas, as well as human health concerns related to malaria and dengue (almost half of Colombia's population lives in areas where an increase of 2° Celsius in mean temperature is likely to result in significantly greater exposure to these diseases). Impacts in the Caribbean and Pacific coastal areas are also a major concern; vulnerable infrastructure, cities, and ecosystems could be at risk from higher sea levels, increased sea-surface temperatures, and more intense and frequent extreme weather events. The project, currently in its second year, has begun

to implement specific adaptation measures in the health sector, mountain habitats, and coastal zones.

West Indies—Implementation of Adaptation Measures in Coastal Zones. This project supports efforts by Dominica, Saint Lucia, and St. Vincent and the Grenadines to implement integrated, pilot adaptation measures that address the impacts of climate change on the natural resource base, with a focus on biodiversity and land degradation along coastal and near-coastal areas. The project is being implemented by the Caribbean Community Climate Change Center, now widely recognized in the region as a source of expertise on climate issues in the Caribbean.

Andes—Adaptation to the Impact of Rapid Glacier Retreat in the Tropical Andes. This project, currently under preparation, will implement adaptation measures to address the anticipated consequences of catastrophic glacier retreat induced by climate change. This is expected to be achieved by (a) supporting the detailed design of selected adaptation measures, (b) implementing regional and strategic adaptation pilots to target key impacts from rapid glacier retreat on selected basins, and (c) supporting continued obser-



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vation and assessment of glacier retreat and its associated impacts on the region.

Mexico—Adaptation to Climate Impacts in the Gulf of Mexico Wetlands. Also under preparation, this project is expected to reduce vulnerability to the anticipated impacts of climate change on the country's water resources, with a primary focus on coastal wetlands and associated inland basins. The project aims to identify national policies to address these impacts at the national level, to assess current and anticipated effects of climate change on the integrity and stability of the Gulf of Mexico wetlands, and to implement pilot adaptation measures to protect environmental services from the impacts of climate change.

A Regional Approach to Climate Change

In light of the significant and potentially irreversible impacts from climate change, the Bank's Latin America and Caribbean Region has pioneered analytical work and pilot adaptation projects for several years. This year's groundbreaking regional flagship study looks at the relevance of climate change concerns in the LAC context and will contribute to the policy debate regarding the implementation of mitigation and adaptation interventions in specific country contexts. Other analytical work includes low-carbon studies for Brazil and Mexico and a landmark modeling study of the projected impacts of Amazon dieback.

LAC's approach is to strengthen the institutional capacity of regional agencies and national governments to (a) formulate climate change policies, standards, and guidelines, including the planning, management, and monitoring of these policies and (b) support the transfer of global best practices and strategies in vulnerability assessment, adaptation, and mitigation. The analytical work currently under way will determine the region's relative priorities—in some cases focusing on miti-

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gation, while in most cases helping countries adapt to the effects of climate change. Critical to this will be to help countries secure financing for their adaptation needs through a mix of financing instruments.

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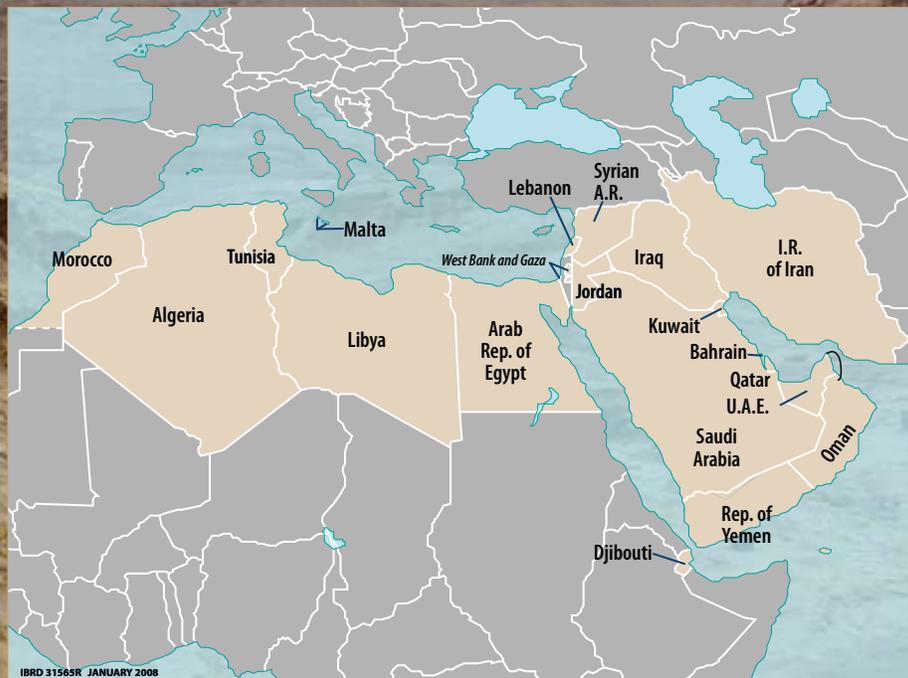
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Middle East and North Africa Region



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YEMEN

Among the world's regions, the Middle East and North Africa (MENA) is especially vulnerable to climate change. It is one of the world's driest, most water-scarce regions, depends on climate-sensitive agriculture, and has a large share of its population and economic activity in flood-prone urban coastal zones. In addition, climate-induced resource scarcity could further tensions in the region's conflict-ridden areas, potentially escalating violence and political turmoil even beyond the region's boundaries.

On the other hand, societies of this region have had to deal with water scarcity and high temperatures for thousands of years, and have over time developed adaptive mechanisms to cope with these challenges, ranging from large-scale water management to drought-resistant crops selection. Furthermore, some areas of the world are expected to experience changes that will render their climate increasingly arid. Thus the MENA region, where adaptation to such conditions has already taken place and various strategies have been tried and tested, is a valuable repository of traditional and institu-

tional knowledge. This could prove an important contribution to the effort to address climate change globally.

Climate Change in MENA

High average temperatures and low precipitation levels are important physical constraints to the habitability of the Middle East and North Africa region, forcing those living there to find adaptive strategies to cope with the conditions. Climate change is putting additional stress on the region's marginal environment. For much of the region, the climate is predicted to become even hotter and drier, according to recent scientific assessments (IPCC 2007).

Higher temperatures and reduced precipitation will increase the occurrence of droughts, an effect that is already materializing in the Maghreb. Climate change will also require a more severe adjustment in the management of the region's water resources than any other region, since over three-quarters of MENA's water resources are already being exploited for human uses.

Global models predict sea levels rising from about 0.1 to 0.3 meters by 2050 and from about 0.1 to 0.9 meters by 2100 (Dasgupta and others 2007). For MENA, the social, economic, and ecological impacts are expected to be relatively higher compared to the rest of the world. Low-lying coastal areas in Tunisia, Qatar, Libya, UAE, Kuwait, and particularly Egypt are at special risk.

It is estimated that an additional 80–100 million people will be exposed by 2025 to water stress, putting further pressure on groundwater, which is currently being extracted in most areas beyond the aquifers' recharge potential. In addition, agricultural yields, especially in rainfed areas, are expected to fluctuate more widely, ultimately falling to a significantly lower long-term average. In urban areas in North Africa, a temperature increase of 1–3° C could expose 6–25 million people to coastal flooding. In addition, heat waves, an increased “heat island effect,” water scarcity, decreasing water quality, worsening air quality, and ground ozone formation are likely to lead to an overall worsening of public health and, more generally, to worsening living conditions.

Impacts of Climate Change on Regional Development

Notwithstanding its recent impressive economic performance, largely driven by the oil boom, the region faces a number of persistent challenges to its longer-term development prospects, including high unemployment, limited access to export markets, social exclusion, and weak public governance.

While several countries in the region have embarked on ambitious reform processes to tackle such challenges, much of the progress could be jeopardized by climate change. Income and employment could be lost to more frequent droughts in rural areas and to floods and sea surges in urban and coastal areas. Changes in temperature and precipita-

tion patterns could damage strategic sectors such as tourism or others with growth potential such as high value-added agriculture. The combination of such impacts could slow down the reform process in governance and public sector management, discourage trade and foreign investments, and ultimately offset the growth benefits generated by high oil prices.

Priorities for MENA in Climate Change Adaptation

In terms of adaptation, the main regional challenges are in water resource management, agriculture and rural development, urban development, and other cross-cutting issues. Climate change also could add a new challenge in the region's efforts to create new jobs and to address poverty, which currently affects about 20 percent of the total population, equal to 59 million people (using a poverty line of \$2 per capita per day for a largely middle-income region) (Iqbal 2006).

Agriculture. In the agricultural sector, climate change could accelerate desertification, reduce yields and increase their volatility (especially in cereals), threaten rural jobs, increase the fiscal burden of government intervention in support of the sector, and thwart efforts to improve access to foreign markets for high-value crops.

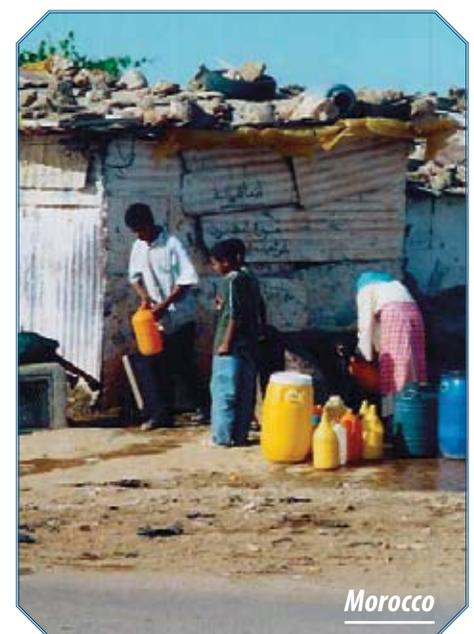
Urban areas. About 167 million people—56 percent of the region's total population of 298 million—live in cities, and 63 million in cities of 1 million and more. The cities of the region are the heart of all social, cultural, and political life and are the hub of all economic activities. Climate change poses many challenges to the region's cities. Rising sea level could affect 43 port cities—24 in the Middle East and 19 in North Africa. For example, sea level rise is expected to heavily impact Alexandria, Egypt. A 0.5-meter rise would leave more than 2 million people displaced, with \$35 billion in losses in land, property, and

infrastructure, as well as incalculable losses of historic and cultural assets. The region's urban areas also will be adversely affected by heat waves, water scarcity and decreasing water quality, and worsening air quality. In turn, these direct impacts could affect migration flows, in and out of urban areas.

How the Bank Can Help

The Bank has a key role to play in integrating adaptation into the region's regular development effort, strengthening the knowledge base, and promoting partnerships and regional cooperation. The Bank is currently strengthening existing initiatives that support adaptation to climate change and is in the process of developing plans for additional, innovative action, as well as plans to adopt suitable tools to ensure that all of its projects are “climate-proofed”—that is, they are not designed, sited, or implemented in ways that render them vulnerable to climate change impacts.

Partnerships. Successfully tackling climate change will depend significantly on the ability to promote consensus on the need to act and to support the growth in institutional



Pier Francesco Mantovani

and technical capacity. To achieve these objectives, the Bank will establish a region-wide program of cooperation and technical assistance on climate change adaptation and mitigation, building on the remarkable success of the Mediterranean Environmental Technical Assistance Program (METAP) in advancing the environmental agenda in the region.

The Bank has started piloting a comprehensive approach to support adaptation in the region through a combination of analytical and advisory (AAA) work and project-based investment. In Morocco, the impacts of climate change are being analyzed through three separate studies on agriculture, water resource management, and urban development. In addition, support to water management in irrigation is being promoted in the Oum Er Rbia basin as a strategy to cope with climate change (see *Box*, top right). Similarly, in Yemen, the Bank has started AAA work to analyze climate change impacts on water management. A project that will promote agrobiodiversity to enhance resilience to climate change on rainfed lands is in preparation (see *Box*, bottom right).

Issues and Risks

Ultimately, the success of climate change initiatives depends on client commitment to action. In some countries, particularly the region's International Development Association (IDA) countries and those affected by conflict, the prospects for action are constrained by short-term issues. The region's two IDA countries are particularly vulnerable to climate change impacts—Djibouti, which is threatened by floods and sea-level rise, and Yemen, where climate change could affect rainfed agriculture, fisheries, and groundwater resources.

In parts of the region affected by conflict (Iraq, West Bank and Gaza, Lebanon), climate change could appear as a longer-term concern when compared to the present need to tame internal violence or end hostilities

Water Management and Adaptation to Climate Change in Morocco

The Oum Er Rbia River basin contains half of Morocco's public irrigated agriculture and produces 60 percent of its sugar beets, 40 percent of its olives, and 40 percent of its milk. For the past decade, lower-than-predicted rainfall patterns have reduced available irrigation water to about half the designed volume. As a result, farmers are supplementing surface water by pumping groundwater, and aquifers are falling by up to 5 meters per year. Uncertainty about irrigation water supplies is a major factor deterring farmers from switching to higher-value crops, and tensions over access to water resources are rising.

The Moroccan government is working with the Bank to design ways to make irrigation in the basin more sustainable and more profitable. The authorities will commit to providing a fixed amount of water to the farmers on an on-demand basis, so they have confidence that water will be available at exactly the time they require it. The farmers will have to commit to not exceeding a fixed quantity of water consumption and will be sanctioned if they exceed this limit. The project will subsidize localized irrigation equipment (drip, micro-sprinklers, etc.), promote private investment in post-harvest infrastructure, and help farmers link to domestic and international markets.

with neighboring countries. In fact, climate change is already affecting livelihoods in many communities in these countries.

Climate change is also expected to add new challenges to the social and political agenda, spanning across class boundaries and administrative jurisdictions, and affecting rural and urban spaces alike. First, worsening of living conditions in rural areas could affect internal and international migratory flows. Second, the impoverishment of the natural resource

base (water, soil) might lead to renewed social tensions and conflict. Third, climate change could also impede efforts to advance prospects for women, thus delaying progress on gender issues of particular significance to the region. Finally, climate change could put additional stress on the region's already fragile political institutions and systems of governance.

The challenge for governments and development partners is to mobilize sufficient

Agriculture and Adaptation to a Changing Climate in Yemen

In Yemen, the poorest economy among the Arabian Peninsula countries, agriculture contributes more than 15 percent to GDP and employs more than 55 percent of the economically active population. Many of the poor derive their livelihoods and incomes exclusively from agriculture and agriculture-related activities. Climate change is a real concern for Yemen, particularly should the frequency of precipitation events diminish, putting rainfed agriculture in peril.

In the Yemen highlands, farmers have long traditions of agrobiodiversity farming practices and traditional knowledge. The Bank is currently working on coping strategies for adaptation to climate change for highland farmers who rely on rainfed agriculture. These strategies include the conservation and utilization of biodiversity important to agriculture (particularly the local landraces and their wild relatives) and associated local traditional knowledge. The project will emphasize the conservation of agrobiodiversity and developing a range of coping mechanisms using predictive climate modeling.



resources to act promptly, thereby reducing the cost of adaptation by minimizing climate change impacts, especially on the more vulnerable social groups.

Directions for the Future

An increasing level of awareness is building among all stakeholders in the region on the significance of climate change, reflecting both the global increase in sensitivity to and awareness of the climate change issue, as well as mounting concerns in the region about increasingly frequent droughts and looming water supply shortages. There is a general sense of the inevitability of assuming some kind of action, but questions remain on establishing priorities and developing an appropriate response.

There seem to be three broad areas of partnership where the World Bank and its MENA counterparts can make a dent in the adaptation agenda.

1. **Infrastructure investment.** The World Bank has an annual pipeline of some \$1.1 billion over the next three years. Projects will need to be sited, designed, and implemented in ways that will

minimize their vulnerability to climate change. In addition, enhancing climate resilience is likely to require scaling up planned infrastructure investment in key sectors such as water resources or urban development, which in turn will necessitate additional resource mobilization from governments, the private sector, and the donor community, including the World Bank.

2. **Knowledge strengthening.** Adequate design of adaptation interventions will require better knowledge on the timing, location, and magnitude of impacts, as well as identification of least-cost options to minimize such impacts. Building on the analytical work already under way in Morocco, Tunisia, Djibouti, and Yemen, and drawing on experience accumulated in the rest of the world, the Bank will expand its support to enhancing the knowledge required for MENA to adapt to climate change.
3. **Policy reform.** Significant progress in adaptation can be achieved by improving the policy and incentive framework. Fiscal reforms can encourage more efficient use of land, water, and energy resources, thereby promoting their allocation to more climate-resilient uses and freeing up valuable public funds, which could be used for protecting

the most vulnerable social groups. The World Bank will continue to work with its MENA clients to identify, analyze, and implement these reform options by mobilizing global knowledge and by providing targeted financial support.

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South Asia Region



Will Davies

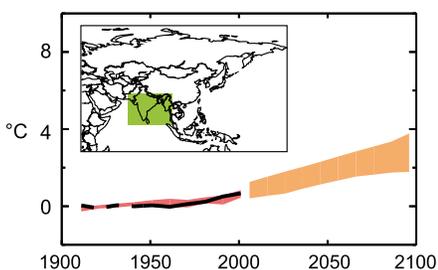
NEPAL

High levels of population density and poverty, coupled with low resilience to climate risks, make the South Asia region (SAR) highly vulnerable to climate change. Livelihoods are heavily dependent on natural resources across the region. Changes in the availability of these resources, accentuated by climate risks, are expected to have far-reaching implications. These risks could undermine the gains made in poverty reduction and livelihoods and impede

progress toward meeting critical national development goals. Recognizing the development significance of promoting adaptation to climate variability and climate change and dictated by government priorities, the World Bank's engagement on adaptation in the region is rapidly strengthening. The Bank seeks to integrate climate risk management in sector strategies and programs through innovation and reform.

Temperature Projections for South Asia Region

Temperature anomalies with respect to 1901 to 1950 for the SAR land region for 1906 to 2005 (black line) and as simulated (red envelope) by MMD models incorporating known forcings; and as projected for 2001 to 2100 by MMD models for the A1B scenario (orange envelope).



Source: IPCC, 2007. *Climate Change*. The Fourth Assessment Report of the UN Intergovernmental Panel on Climate Change.

The Impacts of Climate Change in the Region

SAR is home to the largest number of poor people that are at risk from changes to climate and extreme weather events. Over 1 billion people reside in vulnerable landscapes and are exposed to the wide ranging impacts of climate variability and change. Climate change is projected to increase the intensity and frequency of natural disasters, such as storm surges, cyclones, floods, and droughts across the region, with substantial economic consequences. By 2100, the

IPCC Fourth Assessment projects a median increase of 3.3 degrees Celsius in annual mean temperature (*Figure*, bottom of previous page) in the region and a median increase of 11 percent in precipitation. Moreover, water-related stresses from changes in precipitation, recession of glaciers, and sea level rise are likely to be the most critical concerns for the region in terms of urgency and economic consequence. The most significant impacts are projected to affect agriculture, water resources and critical river basins, ecosystems, and natural resources.

Agriculture. Agriculture employs over 60 percent of the region's labor force. The real risk lies in the impacts on the monsoon system on which much of the SAR rural economy is reliant. Climate change will affect agricultural yields by altering the timing and magnitude of water availability, temperature, soil moisture, atmospheric carbon concentration, weeds, and pests. Regional models project a 15 to 30 percent decline in the productivity of most cereals and rice. Livestock and fisheries may also be impacted.

Water resources. The availability of freshwater in South Asia is highly seasonal; about 75 percent of annual rainfall occurs during the monsoon months. An increase in the variability of precipitation, coupled with increases in temperatures, will impact the hydrologic cycle, including the timing and magnitude of floods, droughts, sediment discharge, and drainage of river systems. Climate change is predicted to increase both coastal and inland flooding, especially in Bangladesh. Moreover, reduced freshwater availability during low flow times will become a serious problem. These risks will significantly impact rural economies, affecting irrigation, fisheries, navigation, energy, and household water use. Finally, since many of the rivers in the region are shared transboundary systems, climate change will require international coordination and cooperation for both understanding the nature of the challenges and devising approaches for addressing them effectively.

Sea level rise. Sea level rise due to climate change is a serious threat to coastal areas in South Asia. Potential impacts include heightened flood and submergence risks across the coastal zone, salinization of surface and groundwater, and morphological change, such as erosion and wetland loss. Groundwater aquifers and coastal ecosystems could also be affected through increased salinization and pollution, threatening rural livelihoods. The coastal ecosystems of Bangladesh and the Maldives are particularly vulnerable to sea level rise.

Ecosystem and biodiversity impacts. South Asia contains numerous global biodiversity hotspots (e.g., Sundarbans) and World Heritage sites, which are home to some of the rarest and most endangered species in the world. Human pressures, together with changing hydrology, may impact the productivity and resilience of these ecosystems.

As a result of these impacts, climate change could hamper the achievement of many of

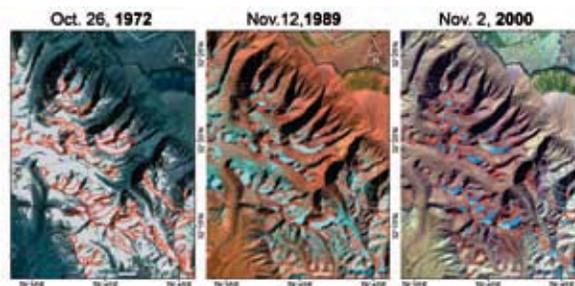
the Millennium Development Goals, including those on poverty eradication, child mortality, malaria and other diseases, and environmental sustainability. In addition, the impacts of climate change will exacerbate existing social and environmental problems and lead to possible migration within and across national borders. In sum, climate change is clearly not just an environmental issue, but a multisectoral issue with severe socioeconomic implications for South Asia.

The Role of the World Bank

Adaptation to climate variability and climate change is an emerging area of interest and cooperation between the Bank and governments in the region. The Bank is combining climate change efforts with the broader development and poverty reduction agenda to foster more climate-resilient and sustainable economies. To better mainstream adaptation into existing and future development

Impacts in the Himalayan Region

The ice mass over the Himalaya-Hindu Kush (HHK) region is the third largest in the world and a source of the nine largest rivers in Asia. It is home to over 1.3 billion people and an important source of water to the Ganges, Indus, and Brahmaputra rivers. In the last two decades,



Changes in glacier cover in western Himalayas

the ice mass has retreated faster than the world average (ranging from 0.3 to 1 m per annum) due to increasing temperatures. The expected changes will alter the timing and rate of snow melt and have largely unknown consequences for agriculture and livestock productivity, hydropower, ecosystems, and water supplies for population and industrial centers. The uncertainty in supplies will be exacerbated by increased incidence of extreme events such as glacial lake outburst floods (GLOFs).

Because of the transboundary nature of the river systems, a regional approach based on international coordination and cooperation will be necessary. The Bank is seeking to design cooperative adaptation projects focusing on water resource management.

Source: R. Singh and A. Prasad. 2007. "Changes in Himalayan Snow and Glacier Cover Between 1972 and 2000." *EOS*, 88(33) 326.

programs, the Bank has identified three key pillars in its regional climate change strategy for the South Asia Region.

1. Focusing on building climate resilience in the poorest and most vulnerable communities and ecosystems, particularly in rural economies that are more exposed to climate risks through stand-alone adaptation projects.
2. Mainstreaming adaptation measures through sectoral operations that reinforce existing development strategies and recognize that sustainable economic growth and poverty reduction are integral to minimizing the impacts from climate change.
3. Strengthening the knowledge base of climate risks and related adaptation responses through analytical work in areas where significant information gaps exist and where the Bank has a comparative advantage.

The broad aim is to help countries in the region to incorporate climate risk management in the country planning process and development programs, including the strengthening of institutional mechanisms to manage these risks. Scaling up the water resources agenda, which plays a key role in the region's development, is a high priority. SAR governments are already facing the need for additional expenditures to develop climate and adaptation aspects of their various development and infrastructure programs. In addition to building knowledge and capacity in the region, the Bank expects to play a role in finding financial mechanisms for adaptation in coordination with other development partners.

Highlights from the SAR Portfolio

Activities that are planned or under way in South Asia respond directly or indirectly to the multiple climate-related burdens faced by the region. A bulk of the ongoing adaptation portfolio has focused on knowledge

management and technical assistance, with a particular focus on India. However, future engagement in the region is actively picking up to include adaptation projects or sector operations with adaptation-related components. In addition, ongoing sectoral projects on improved river basin planning, modernization of irrigated agriculture, capacity building of water management institutions, agricultural research and extension, watershed management, and urban planning and design are providing important co-benefits by building greater resilience to climate variability and risks. The Bank puts a priority on strengthening existing programs that have already shown a strong client engagement and demonstrated success on the ground, as well as on harmonizing efforts with other development partners. Highlights from the portfolio include:

Improving natural disaster forecasting capacity. With Bank and the U.K. Department for International Development support, a flood management information system is being developed to support flood-prone areas in the Indian state of Bihar. Furthermore, a much-needed thrust to improve hydro-climatological monitoring and related decision support system development is under way in 13 states and eight central agencies through the Hydrology-II project in India. To mitigate the risks and vulnerabilities of the population to cyclones, the Bank is assisting the government of India in developing a National Cyclone Risk Mitigation Project. There are also projects in India and the Maldives to help the region recover from the devastating tsunami in 2004.

Water resources. A wide range of activities in the water resources sector is helping the region better adapt to existing climate variability, a prerequisite to building capacity to adapt to future change. Specifically, in India, a comprehensive study and technical assistance on groundwater management and multiple state projects to restructure and modernize irrigation systems, basin-level planning, and management (for example,

Maharashtra, Rajasthan, Uttar Pradesh, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, and Orissa) and to improve smaller water bodies (Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, and West Bengal) are under way. Furthermore, to improve the productivity of water and land resources and provide benefits to rural communities, several watershed projects are being implemented (Himachal Pradesh, Uttaranchal, and Karnataka). Nepal is initiating an Integrated Water Resources Management Program to improve water resources management and irrigation systems. Sri Lanka is also initiating a Dam Safety and Water Resources Management Project to improve the performance of aging dams, strengthen hydro-climatological networks, and initiate systematic basin planning. In Afghanistan, the Bank is supporting basin planning in the Kabul Basin through the development of decision support systems and strengthening institutions.

Adaptation to droughts. The Bank has completed two analytical studies in India and is implementing a promising pilot activity in Andhra Pradesh to build comprehensive drought resilience through innovative techniques and management approaches in agriculture, natural resources management, and institutional development. The pilot is complementing the World Bank-supported Andhra Pradesh Rural Poverty Reduction Project and establishing synergies with programs, such as the government of India's National Rural Employment Guarantee Scheme. Lessons and results from the pilot are expected to be applicable to other arid regions of India and will be widely disseminated in order to build support and demand for wider replication. The India GEF Sustainable Land Management Program, which is under preparation, has considerable scope to upscale adaptation and environmental sustainability into agriculture.

Coastal zone management. The Bank is working with the federal government and with three states in India to develop and implement a strategic project relating to the

Adaptation — What Can Be Done in South Asia?

An effective strategy to build climate resilience and ignite growth needs to take into account the comparative advantage of the region, resource constraints, and the impending changes brought about by climate. The exact policies and interventions will differ by location and circumstance. Initial assessments and knowledge management activities in the region emphasize the following overarching approaches to address adaptation:

- **Better understand impacts.** Improve the knowledge base of climate risks, vulnerability analysis, and operational implications of climate change over historical variability, higher-resolution impact studies, and coping strategies. The resultant changes in runoff—given changes in precipitation, temperature, and demands for major basins under various scenarios—need to be better understood to develop resilient adaptation strategies. Coastal areas, populations, and infrastructure at risk need to be mapped in detail.
- **Improve flexibility in natural resources management and agriculture.** In addition to direct agricultural impacts of changes in climate variability (and their cascading impacts on livelihoods, poverty, and hunger), the long-term suitability of areas for various crops could change. All this would require innovative approaches to agricultural systems, including sustainable modes of dryland farming with low costs of production, intensifying agro-forestry and livestock systems, improving flexibility in water management systems, smart incentives, value chains, and facilitation of markets.
- **Income diversification.** Income diversification remains one of the most obvious ways to reduce exposure of vulnerable populations to climate risks, especially in areas where the natural productivity of agriculture is low and threatened by repeated extreme events. This brings a number of transitional risks that can be tackled through financial incentives, building of skill sets, and access to markets, among others.
- **Improve water resources planning and management.** There is a need to improve sustainable water development and management of water resources, including major basins to promote resilience. Appropriate watershed management could be a key element of such strategies. Coastal zone management depends both on inland and coastal area management (including mangrove conservation/enhancement).
- **Improve insurance systems.** In addition to crops and livestock, insurance systems could be considered for infrastructure, such as for vulnerable infrastructure in coastal areas.
- **Improve planning.** Planning processes should include improved and sustainable land and surface and groundwater management, planned retreat (or protection) in vulnerable coastal areas, and improved awareness. Disaster preparedness needs to be improved—through appropriate hydrometeorological networks, improved flood/drought/storm forecasts, and strengthened preparedness, communication, and response strategies. Provision of improved access (even redundancy) in water supply (e.g., for key cities/towns) needs to be explored. Capacity-building programs to improve awareness and adaptation strategies need to be designed and implemented.
- **Promote climate-resilient policies, programs, projects, and institutional capacity development.** There is a strong need for the countries of SAR to adapt their policy, institutional, and investment climate to better enable them to adapt to climate risks, including both current variability and future expected changes.

management of coastal areas. A complementary analytical study will identify adaptation measures for select coastal Indian cities. In Bangladesh, the Bank has been requested by the government to develop an adaptation project in coastal areas with a focus on coastal planning and zoning based on risk assessments, improved weather information management systems, protection of assets and infrastructure, and climate-resilient policies to guide developmental decisions.

Urban sector adaptation. The greatest economic damage from sea level rise will be in the cities, according to a 2007 Bank-led study of South Asia. A host of initiatives in Bangladesh and India are helping to improve the understanding of the scale of the problem and to identify feasible solutions.

Future Direction

Climate variability and change will have significant implications for agriculture, in-

frastructure, and environment and energy security, all of which will impose additional development burdens on economies. There are thus strong reasons to scale up Bank engagement and better integrate climate risks into project design and policy operations. The ability to respond to these risks depends crucially on the reliability and availability of local information, since developing climate risk management approaches will have to be tailored to fit local conditions. The future adaptation program in South Asia is expected to include continuing support for programs that help the region better adapt to historical climate variability, as well as for anticipated climate change.

However, there remain substantial gaps in understanding climate impacts in the vulnerable zones in countries of South Asia. Moreover, uncertainty is perhaps one of the central and most prominent features of climate change. For instance, little is known about the effects of climate change on the

Himalayan glaciers and consequent impacts on downstream agriculture, habitats, and livelihoods. Accordingly, a high priority for South Asia is to fill crucial knowledge and information gaps. This also requires building capacity and knowledge institutions within countries to develop capabilities to assess these emergent risks. The challenge will be to translate and use this climate risk information to guide investment decisions and inform project design and implementation. The Bank is currently also developing a climate change strategy for the region that is expected to guide its operational and knowledge program in the coming years.

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Adaptation to Climate Change at the IFC

Private Sector Perspectives on Climate Change Risks

The International Finance Corporation (IFC) portfolio includes many investments potentially at risk from climate change, including hotels in low-lying coastal areas, water systems potentially affected by rising sea levels and changes in precipitation, and food and wood processing companies dependent on agricultural and wood supplies and subject to threats from rising temperatures, from changes in the timing and amount of rainfall, and from severe storms.

In the past, evaluating the exposure to climate risk was considered a reasonably predictable and insurable matter based on historic climate data. Climate change is causing a rethinking of the methodologies for assessing these risks, but the needed data and tools have not yet been developed. Along with other leading banks and insurance companies, the IFC is exploring these issues, but with the additional responsibility and perspective that comes from its role as a publicly funded development institution.

As the private sector arm of the World Bank Group, the International Finance Corporation faces distinct challenges and opportunities in responding to climate change. Because the World Bank lends to governments, it can adopt a long-term and country-wide perspective in common with the public sector. In contrast, IFC is typically lending for projects—factories, power plants, hotels—or companies using a shorter time frame (most commonly 7 to 12 years) and more limited geographic coverage. Evaluating climate risks is even more difficult in the context of investments in the financial sector (loans to commercial banks and other financial institutions), which account for about 40 percent of IFC's annual commitments in recent years.

While awareness of the seriousness of climate change and its consequences has increased greatly in the past year, identifying the risks and potential adaptive responses from the perspective of private investment continues

to be challenging. Much of the fundamental difficulty arises from the limited ability to accurately forecast the short-term localized impact of the continued buildup in greenhouse gases. The study of climate change developed primarily around complex computer models designed to project the worldwide, long-term consequences of a buildup in greenhouse gases over decades. A global view was required in order to capture the fundamental relationship between the oceans, land, and atmosphere, all of which influence the Earth's climate. Global climate models typically were designed to produce global (and to some degree regional) results based on economic activities projected over decades, not to describe localized changes over investment periods more typical of Bank lending.

The most authoritative and up-to-date source of information on the science of climate change, the Intergovernmental Panel on Climate Change (IPCC), also typically only releases information over relatively long time frames, ranging from several decades to the end of the century. While important to know, these periods go far beyond an investment perspective. Just as no individual experiences a global average temperature, most investments cover limited geographic areas and periods of a decade or less.

An additional factor limiting the time period of investments is that one way investors deal with the higher risk of many developing country projects is to reduce their exposure by offering shorter loan periods. Another issue in many developing countries is the availability of climate change information. The end result is that evaluating the risks of climate change is difficult.

The challenge facing private sector assessment of climate change risks is evident from recent reviews of business responses to the issues. While many banks and insurance companies have issued climate change reports, the reality is that actual work to identify and respond to the consequences of climate



Some IFC investments, such as this seaside hotel, may be highly exposed to climate change risks.

change remains surprisingly limited. The most common actions have been to support mitigation measures, including investment in clean energy. Few programs are in place to mitigate their own risks, aside from simply withdrawing or reducing coverage periods for areas that have recently experienced hurricanes or other weather-related disasters. For example, an October 2007 report by the NGO Ceres—“From Risk to Opportunity: 2007, Insurer Responses to Climate Change”—concluded: “Most insurers are behind the curve in developing forward-thinking products and services in response to climate change. . . . [O]nly about one in ten . . . are working in a visible way on contributing to understanding the mechanics and implications of climate change, with a similarly small proportion incorporating these considerations into asset management.”

In order to better understand these issues, IFC plans to undertake several assessments of climate change risks during fiscal 2008. These studies will use existing investments and will test the sensitivity of different types of projects to most likely changes in climate variables, looking at both risks to IFC during the expected investment period and risks

to the client over the life of the investment. The objectives will include (a) assessing the availability of data necessary for use in climate modeling in various locations consistent with requirements of IFC investments and (b) studying the applicability and appropriateness of climate models for the particular location and climate variables of most relevance for a number of pilot case studies. Insofar as possible, a key objective will be to assess the potential impact of climate change on financial return. An additional objective will be to identify adaptation options that might be employed to reduce the most significant risks. In undertaking the proposed studies, IFC will seek to engage both its clients and environmental specialists in coming to a better understanding of the issues, tools, and implications of climate change risks.

IFC’s approach to assessing climate change impacts will also reflect the increasing emphasis on decentralization, with more authority and staff moving to field offices. For example, the IFC strategy for Africa is likely to have a particular focus on identifying and responding to climate change risks as they relate to community development, water availability, and an overall focus on creating

an investment climate conducive to private sector growth. The issues and approach in higher-income regions with more-developed financial structures are likely to be considerably different.

One adaptation option of particular interest is the possibility of new insurance products. IFC already reviews the adequacy of insurance for each of its investments and promotes the growth of insurance as part of its approach to financial markets. One possibility already being actively explored with the World Bank is the use of weather derivatives, insurance products for farmers that pay off in the event of extreme weather events.

While IFC’s evaluation of climate change risks is at an early stage, discussions with other private banks and insurance companies have shown significant shared interest in these issues. In the near future, IFC expects to share its assessment of “best practice” responses to climate change risks as part of this ongoing discussion with the wider financial community.

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DEC

Climate Change Research by Development Economics

Impacts and Adaptation Strategies for African Agriculture

Research at the World Bank on climate change and agriculture has gained momentum in recent years, recognizing both the important role agriculture plays in the economies and the livelihoods of the poor in developing countries, as well as the vulnerability of the agricultural sector to climate change. Major research efforts have been focusing on the agricultural sectors of India, Africa, Latin America, and China.

Much of this research has been carried out by the Development Economics Research Group (DECRG) (see *Box*). This article focuses on recent research dealing with the impact of climate change on African agriculture.

A Focus on Africa

Even without climate change, African agriculture faces serious challenges—land

degradation, high rainfall variability, lack of storage infrastructure, inadequate irrigation systems, and a relatively stagnant contribution to economic growth. In addition, many rural areas in Africa also must deal with rural-to-urban migration, political instability, persistent poverty, and a high disease burden. Agriculture and agro-ecological systems are the most vulnerable sectors in Africa because the climates of many African countries are already hot and variable. Climate warming is expected to further reduce crop productivity. Additional constraints include low technological progress and a lack of access to information on how to cope with climate change.

Research addressing the potential impact of climate change on the agriculture sector in 11 African countries suggests that much of the continent will be hit hard by climate change under various scenarios. Large re-

Recent Research on Climate Change in The World Bank's Development Research Group

Within the Bank, the research work program in the Development Economics Research Group covers issues of impact incidence; adaptation in agriculture; incentive systems to reduce pollution and greenhouse gas emissions; investment in clean energy mechanisms; mitigation, adaptation, and growth; water resources; transportation; and hydropower. Important recent studies include the following:

- Adaptation in developing countries
- Barriers to expanding access to cleaner electricity in Africa
- Carbon-related issues and research
- Climate change and agriculture
- Climate change and economic growth
- Climate sustainability of hydropower-based energy generation treaties
- Country stakes in climate change negotiations
- Economic and policy aspects of bio-energy/biofuel production and use
- Economics of energy consumption and pollution emission in large cities
- Government policies, monetary incentives, effects on adoption of energy-efficient technologies
- Impact of and adaptation to climate change in agriculture in Africa and South America
- Impact of and adaptation to climate change in agro-ecological zones in Africa
- Impact of sea level rise on developing countries
- Measures to increase energy efficiency in transportation systems in India
- Reducing vulnerability—adaptation to climate variability and change
- Role of flexible mechanisms in reducing greenhouse gases
- Role of markets in directing investments under the Kyoto Protocol

gions of marginal agriculture in Africa may be forced out of production by 2100, while others may thrive. Some countries are more vulnerable than others, so it is important to focus help where it is needed most. In several scenarios, many African farmers gain, whereas others lose.

The study, funded through the Impact of and Adaptation to Climate Change in Africa project, was supported by the Global Environment Facility, the World Bank, the Office for Global Programs of the U.S. National Oceanic and Atmospheric Administration, the Center for Environmental Economics and Policy in Africa, and others. Many of the results have been published in a number of World Bank reports, which are listed under selected references at the end of this article. DECRG has played an important role in this research effort.

The study was intended to provide empirical evidence on the role that climate plays in agriculture in Africa today, how that might change with global warming, and what role adaptation could play. The following countries were included in the study: Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia, and Zimbabwe. (The project website is at http://www.ceepa.co.za/Climate_Change/index.html).

The research effort integrated socioeconomic household surveys, climatic and soil data across key agro-climatic zones and farming systems (cross-sectional modeling), and river-basin hydrological modeling. Cross-sectional models allowed quantitative estimates of the economic impact of climate change in sampled locations in each country. For these models, baseline data for climate, agricultural production, and water flow were collected for each sampled district in each country.

Pulling observations from across the continent permitted region-wide analyses with extrapolations to any location in Africa, assuming comparable country settings. Two

types of analyses were conducted: (1) an estimate of marginal impact using only the cross-sectional coefficients, and (2) an analysis involving predicted climate scenarios, which provided more comprehensive estimates of impact. Within these two approaches, the first assumed a uniform change across the country, and the second involved specific climate scenarios from global circulation models (GCMs), accounting for within-country variability. Three different GCM scenarios by 2100 explored the consequences of a range of climate changes considered plausible by climate scientists.

Study Results

Results predict a number of significant impacts in Africa, including heightened impacts on streamflow after 2050, differing marginal impacts of temperature and precipitation on net farm revenues, stronger positive/negative impacts on rainfed farms, and differing effects on large and small livestock farms.

Heightened impacts on streamflow after 2050. The range of possible Africa-wide climate change impacts on streamflow (by countries) increases significantly between 2050 and 2100.

Implications of crop choice. There is an optimal precipitation and temperature range for each crop within which production

value is maximized. Farmers can reduce crop and livestock sensitivity to climate variables through the choice of species and by introducing new technologies and management practices. Better-equipped farmers can adapt to and survive change in climatic conditions more easily with increased levels of technology, which can help widen the temperature range for crop growth and make water supplies less dependent on short-term fluctuations in precipitation

Differing marginal impact of temperature and precipitation on net farm revenues.

For rainfed farms, evaluated at their mean temperature, net revenues fall by an average of \$27/°C. In contrast, the marginal effect of temperature on irrigated farms, evaluated at their mean temperature, is a positive \$35/°C. Assuming a given availability of water and present level of soil quality, warmer temperatures increase the net revenues of irrigated farms because the mean temperature in regions with irrigated farms in the countries included in the study is relatively cool and because irrigation buffers net revenues from temperature effects such as evapotranspiration.

In uniform climate change impact scenarios for Africa (2.5° and 5°C temperature increase and 7 and 14 percent precipitation decrease by 2100), values per hectare and the total Africa impact suggest a big loss for rain-

Net revenue impacts from uniform climate scenarios

Impacts			Warming increase of 2.5°C	Warming increase of 5°C	Precipitation decrease of 7%	Precipitation decrease of 14%
Rainfed						
ΔNet (\$ per ha)	revenue		-72.2 (-16%)	-120.4 (-30%)	-14.1 (-6%)	-28.3 (-11%)
ΔTotal (billions \$)	net	revenue	-22.6	-37.7	-4.4	-8.9
Irrigated						
ΔNet (\$ per ha)	revenue		110.3 (9%)	258.8 (23%)	-15.9 (-1.4%)	-31.5 (-2.7%)
ΔTotal (billions \$)	net	revenue	1.4	3.4	-0.21	-0.41
Total (Africa)						
ΔNet (\$ per ha)	revenue		-49.2 (-11.3%)	-95.7 (-21.9%)	-18.3 (-4.2%)	-37.2 (-8.5%)
ΔTotal (billions \$)	net	revenue	-16.0	-31.2	-5.96	-12.1

Note: Values in parenthesis represent percentage changes from present climate.
Source: Kurukulasuriya and Mendelsohn 2007.

fed agriculture if temperature increases (see *Table* on page 59). However, assuming sufficient water availability, irrigated agriculture is likely to gain from rising temperatures.

Stronger positive/negative impacts on rain-fed farms. Net revenues from crops will rise in a mild wet scenario by as much as \$90 billion across Africa, while a very hot scenario could lead to losses of \$48 billion by 2100.

Despite these aggregate impacts, irrigated farms are predicted to generally benefit because they are less climate-sensitive and located in relatively cool places. Rainfed farms are likely to be affected the most, whether in terms of benefits or losses.

Differing effects on large and small livestock farms. The results suggest that net revenues for small livestock farms increase with warming by 25 to 58 percent. The net revenues of large livestock owners, however, are expected to fall, except in a very dry scenario.

In general, small farms can more easily substitute animals that are heat-tolerant, whereas large farms are more dependent

on species, such as cattle, that are less heat-tolerant. Wetter scenarios imply a shift from grasslands to forests, an increase in harmful disease vectors, and a shift from livestock to crops.

Overall, the livestock sector in Africa loses from climate change, because most animals are raised on large farms. While livestock earnings for small farmers increase with warming, these gains are generally smaller than the losses they face from crops. Still, the analysis suggests that under certain future climate change scenarios livestock may become more attractive than crops in many regions in Africa.

Possible Adaptation Strategies

The study highlights the importance of equipping millions of agriculture-dependent and water-deprived Africans in the most vulnerable countries with the information, technologies, and supporting institutions they need to adapt to further climate deterioration.

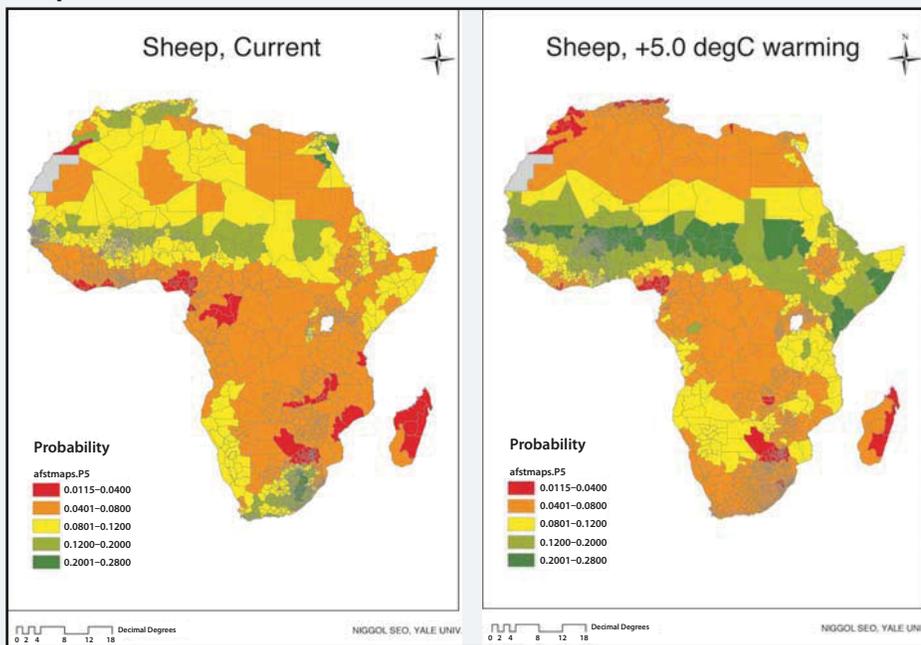
The results strongly suggest that adaptation policies to climate change must take into account crop selection, improved livestock management, and promoting irrigation where surface water is available.

Crop selection. There is an important role for agronomic research in developing new varieties more suited for higher temperatures. Although income from agriculture in Africa will still suffer losses, these will be much smaller if farmers are not confined to their current set of options.

Importance of improved livestock management. The model results predict that managing livestock in Africa is likely to be relatively more profitable than crops under certain future climate conditions. This, on the other hand, could lead to overstocking of rangeland and increased land degradation, which has not been addressed in the research so far. Furthermore, the species mix of livestock chosen is likely to be slightly different than today. Farmers just south of the Sahara are predicted to switch species, diversify their portfolio, and move from cattle toward sheep. Small farmers may be able to adapt without much change in expected net income, but large sheep farmers in South Africa may have to abandon sheep, as the area suitable for sheep farming will shrink as climate changes (see *Figure*, at left). These changes are predicted to reduce the net incomes of large farms considerably.

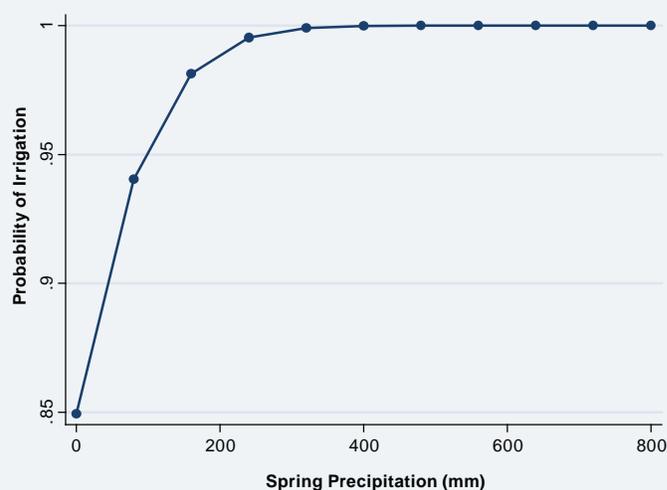
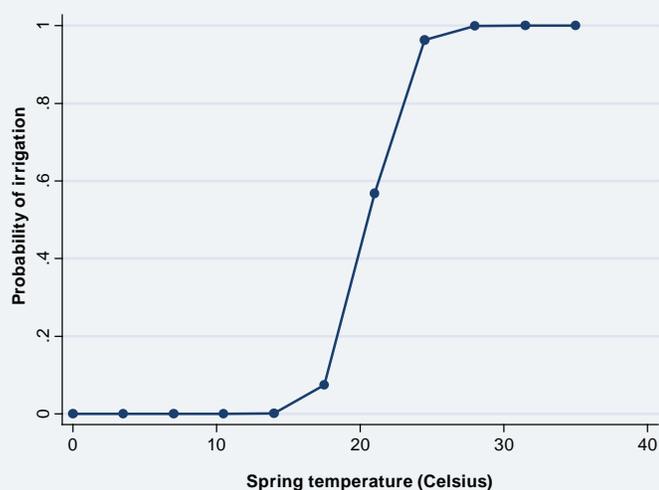
Promoting irrigation where surface water is available. Irrigation is an effective adaptation strategy against reduction in rainfall. However, for many regions, there is no available surface or groundwater and a lack of storage infrastructure, so warming scenarios with reduced rainfall are particularly deleterious. Furthermore, policy makers have to address the fact that many farmers in Africa have limited experience and hence capacity to deal with irrigation. Conducive policies include marketing policies and access to markets. Policy makers also should consider

Change in the probability of choosing sheep in Africa with a uniform temperature increase of 5°C



Source: Seo and Mendelsohn 2007.

Probability of Adopting Irrigation Based on Temperature and Precipitation



Source: Kurukulasuriya and Mendelsohn 2007.

making resources available to allow the transition from rainfed to irrigated agriculture.

Future Work

Several of the results obtained in this study were based on assumptions that warrant further exploration. Some are based on analytical tools that can be improved.

For example, studying the relationship between climate change and surface and groundwater hydrology is a necessary condition for a more precise understanding of the possible role of irrigation in adapting to climate change (see *Figure*, above). While the study in Africa used a certain approach to assess the available runoff, there is certainly room for improvement in the methodology.

An analysis of the impact of climate change on the quality of soil—and therefore on the ability of farmers to adapt—is needed for a more precise analysis of adaptation options. One approach is to predict how present agroecological zones may shift as climate changes, mainly due to changes in soil quality. With additional information on water availability and soil quality, the set of options farmers

face would change, which in turn would alter government interventions.

Any adaptation process necessitates experimentation and know-how. With a new cause that can be much better justified by economic cost/benefit figures, the role of public investment in research and extension may be reinvigorated. Future work in this direction would be extremely useful and would inform policy makers.

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For more information on the DECRG work program and the individual studies, see <http://go.worldbank.org/K3KFKLUBH0>.

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WBI

Capacity Development

A Necessity for Effective Response to Climate Change Adaptation

The World Bank Institute (WBI) helps client countries share and apply global and local knowledge to meet development challenges. Climate-change-related activities are primarily pursued in WBI's Sustainable Development Division. The main emphasis of WBISD is on improving the capacity to apply relevant knowledge, reform policies, and improve enabling environments for delivery of services and management of resources for long-term benefit (see *Box*). A process for collaborating with regional or national partners to strengthen the effectiveness of organizations, especially capacity building organizations, is an integral part of WBISD's approach, with the intention to sustain and further develop that capacity.

On the mitigation side, through its multiple national and regional activities, CF-Assist (see www.carbonfinance.org) helps developing countries and economies-in-transition to facilitate the creation and management of carbon assets, reduce the costs of participation, and help client countries achieve their sustainable development goals while contributing to global environmental benefits. With the evolution of climate change work within the World Bank Group, WBISD has recently initiated a program on adaptation focusing on institutional strengthening to

help client countries become more resilient to observed and projected impacts of climate change. The starting point for many client countries is to improve their capacity to cope with the adverse impacts of present climatic extremes—such as floods, droughts, and storm surges—and thus minimize the risk to their development gains and future plans.

Initial international efforts to support developing countries in reducing the adverse impacts of climate variability and change have focused on developing national plans for adaptation and/or implementing small-scale projects that address adaptation options in a particular area, such as natural resource management. There has been some effort to disseminate existing adaptation options and technologies, but more effort is needed to strengthen the institutional and policy enabling environment for their effective application.

Many countries express a need to raise awareness about the effects of climate variability and change to decision makers in development-oriented sectors. Another urgent need is to transfer skills and knowledge about approaches, practices, and tools that can help move from plans to action, especially when climate change adaptation is integrated into development plans.

WBI and Its Approach to Capacity Development

Successful capacity development has to move from individual training events to increased emphasis on organizational capacity development. To that end, technical assistance emphasizing multi-year commitment and a process of learning material development to mentoring support is becoming increasingly important.

WBISD works collaboratively with different parts of the Bank and with external partners, including bilateral donors, foundations, the private sector, nongovernmental organizations, community-based organizations, learning agencies, and sectoral and lead agencies in client countries. WBI and its partners deliver learning activities through courses, seminars, knowledge networks, communities of practice, and expert advice in different regions. The audience for these programs includes policy makers, academics, and development practitioners, parliamentarians, journalists, teachers, youth, and civil society leaders. WBISD uses a range of interactive technologies and blended applications of new and traditional learning methods, such as face-to-face, distance learning, and e-learning, to deliver its learning programs.



WBISD is initiating a comprehensive effort to help create awareness and develop the capacity to initiate country- and sector-level analysis to formulate policies and strengthen institutions for mainstreaming adaptation into sectoral and national strategies. It is placing special emphasis on work with the “Least Developed Countries”—the poorest of the poor and many in Africa in urgent need of capacity to reduce the impact on development. The key focus of WBISD’s adaptation activities will be:

- Awareness raising.** The aim of awareness raising is to build constituencies within selected countries for effective response to climate change. As part of this, in collaboration with other parts of the Bank and external partners, WBISD will develop high-quality learning packages, including a regional and selected sector-specific overviews of climate change impacts and approaches to adaptation.
- Knowledge/skills building.** In this area, the aim is to develop a critical mass of expertise in a country or region for designing and implementing adaptation measures. These activities will include a range of initiatives focusing on

integrating climate change adaptation knowledge into economic sector-based existing learning activities (for example, in agriculture or water) and other programs in various regions such as sustainable land management, urban planning, and community-based projects.

- Applying knowledge to policy formulation.** This area will focus on the application of knowledge to help formulate strategies and policies that incorporate climate risk management and thus adaptation considerations within a wider development agenda and demonstrate their implementation through piloting activities. This will include development of learning material that brings together experiences from countries that have developed such strategies and policies, as well as platforms/forums to share such knowledge.
- Strengthening institutions.** WBISD also seeks to strengthen institutions for knowledge generation, application, and capacity development and maintenance focused on adaptation. This is an essential component to enable client countries to formulate and implement climate change adaptation in the long

term. National and regional institutions will be essential partners.

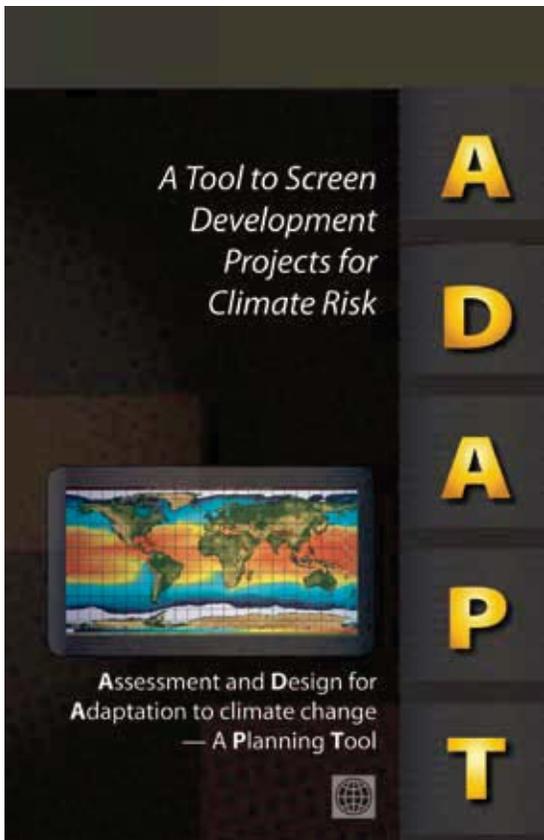
The expected outcomes would include improved capacity of decision makers and key stakeholders in client countries to better cope with the impacts of current and future climate variability and change and thus to help minimize the risk climate change poses to economic development. Some of these outcomes are particularly focused on short- to medium-term capacity development and some on longer-term issues.

Capacity development is essential. Given the long-term nature of climate change and its impacts, the capacity and skills needed have to endure for many decades. In particular, capacity development has to help client countries develop their own context-specific responses to climate change impacts within their development and poverty reduction goals.

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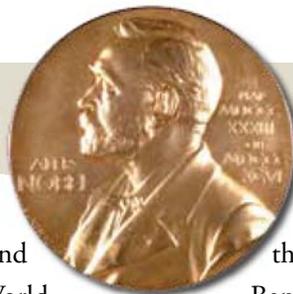


On average, a quarter of the World Bank's annual investment lending is climate-sensitive, mostly in sectors such as agriculture, biodiversity, coastal infrastructure, and rural roads. In light of this, the World Bank Climate Change Team has developed a new software-based tool that can be used to assess development projects for potential sensitivities to climate change and climate variability.



Known as ADAPT (Assessment and Design for Adaptation to Climate Change—A Planning Tool), it provides a simple and quick way to assess development projects for potential sensitivities to climate change. The tool brings together climate databases and expert assessment of the threats and opportunities arising from climate variability and change. It provides a summary of climate trends at a project site, identifies project components exposed to climate risk, explains the nature of the risk, and provides guidance regarding adaptation options and appropriate resources. ADAPT is intended for project team members, both within the Bank and within client countries, who do not have specialized knowledge of climate change issues. ADAPT is available on CD by request from Ian Noble (inoble@worldbank.org) and Michael Westphal (mwestphal@worldbank.org). Related to ADAPT, a climate and climate-related data web portal is being developed, the first version of which will be launched in February 2008. For further information please see www.worldbank.org/climatechange.

Nobel Prize Awarded to IPCC



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The 2007 Nobel Peace Prize was shared by Al Gore and the Intergovernmental Panel on Climate Change (IPCC). The World Bank now has a number of current or recent staff with a claim to a small share of that honor. The most obvious is Bob Watson, who was Chair of the IPCC for its Third Assessment and who attended the award ceremony to help represent the thousands of other authors and reviewers in the IPCC process. Other former staff include Ajay Mathur, Eric Martinet, and Mohan Munasinghe, who is currently a Vice Chair of the IPCC. Current staff include Habiba Gitay and Ian Noble, both of whom have led the preparation of IPCC reports; Philippe Ambrosi and Anal Markandya, who contributed as authors to the Fourth Assessment; and Sofia Bettencourt, Sandra Cointreau, and Frank Sperling, who helped review material.



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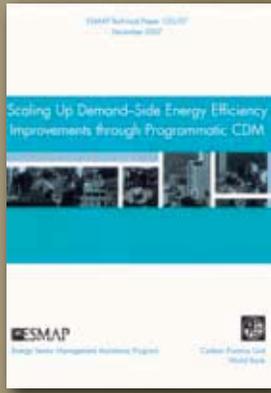
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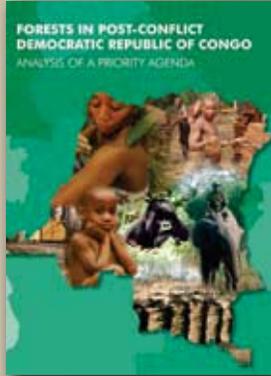
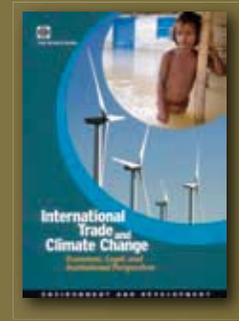
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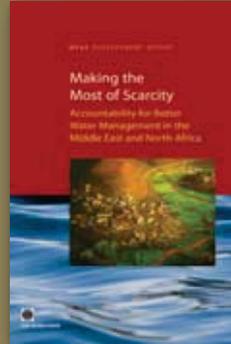
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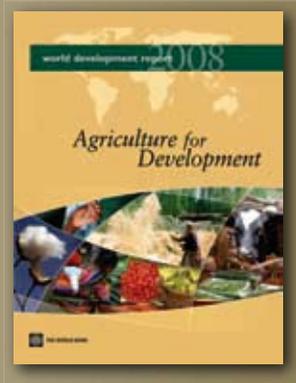


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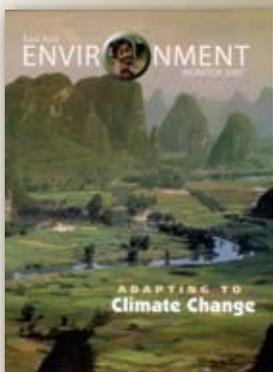
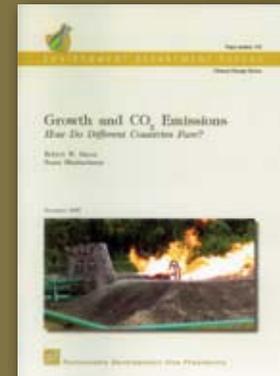
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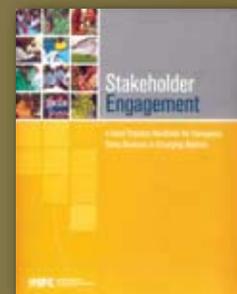
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