

# Rising Temperatures, Rising Risks

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A dry lake bed in Hubei Province, China.

**G**LOBAL warming is already taking its toll. In Darfur, where several hundred thousand people have died in recent years from the internal conflict, climate change has exacerbated water and land shortages (because of growing desertification), undermined agriculture, and fueled conflict over these scarce resources among the poor. On the opposite side of the globe, many Pacific islands (and the Maldives) that are often only centimeters above sea level are threatened with inundation by rising seas. In the distant north, melting of the sea ice is affecting polar wildlife and undermining the already precarious livelihoods of native peoples.

These grim harbingers of climate change underline the need to better understand the phenomenon and address the consequences. The latest report of the UN's Intergovernmental Panel on Climate Change (IPCC) says that global warming is a reality and has almost certainly been caused by recent human activities that have increased greenhouse gas (GHG) emissions. It also indicates that climate change (characterized by temperature increase, sea level rise, and precipitation changes) will continue into the foreseeable future and intensify (see Box 1), with potentially disastrous consequences for the planet and its inhabitants.

The most vulnerable groups will be the poor, the elderly, and children, including those living in rich countries. The most affected regions will be the Arctic, sub-Saharan Africa, small islands, and Asian megadeltas. High risks will be associated with low-lying coastal areas, water resources in dry tropics and subtropics, agriculture in low-latitude regions, key ecosystems (such as coral reefs), and human health in poor areas. Moreover, extreme weather events will worsen, especially tropical cyclones and heat waves. The result is that prospects for achieving many of the eight 2015 Millennium Development Goals—which include poverty reduction, better health and education, gender equality, and saving the environment—will become even more remote.

How can this destructive cycle be broken? The best hope lies in crafting strategies that address climate change and sustainable development simultaneously. This is because the two issues are highly interconnected: climate change affects development prospects and development paths determine the future climate. At the global level, countries need to act in a concerted fashion to reshape human activities on an unprecedented scale although, sadly, current trends are not at all promising (see Box 2). At the national level, however, the outlook might be more hopeful, given that practical methods now exist for integrating

**Making  
development  
more  
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climate change**

climate change responses into sustainable development strategies. Indeed, the existence of these tools should help to dispel the concern of many policymakers that tackling climate change might divert resources that are sorely needed to deal with more immediate development problems, such as growth, poverty, food security, ill health, unemployment, and inflation.

### How humans can cope

The two specific ways that humans can respond to climate change are through adaptation and mitigation. Adaptation tries to reduce the vulnerability of human and natural systems to the stresses of climate change, whereas mitigation aims to lower, or even remove, GHG emissions.

**Adaptation responses.** Adaptation efforts need to be stepped up, given that long-term, unmitigated climate change is likely to exceed the adaptive capacity of natural, managed (agricultural), and human systems. Natural organisms and ecosystems tend to adapt autonomously (for example, migration of animals as habitats change, and growth-cycle changes in plants), but many may not survive if the rate of temperature rise is too rapid. Humans are capable of preplanned (or anticipatory) adaptation, although reactive measures are often necessary. Proven adaptation methods exist—including building dikes against sea level rise, developing temperature- or drought-resistant crops, and widening hazard insurance coverage—but they need to be disseminated more widely and implemented by governments, businesses, and civil society. Take coastal areas threatened by flooding and storms as temperatures rise. With constant expenditures on coastal protection, about 55–90 million people will be affected annually by a 2°C warming. However, these numbers may be drastically

cut (to 2–10 million) by marginally raising annual coastal protection spending to match GDP growth rates.

**Mitigation responses.** Current mitigation efforts—primarily, reducing the emission intensity of energy use and increasing carbon dioxide absorption by planting forests—similarly need to improve. The result would be lower GHG concentrations, along with other benefits, such as better health, lower energy demand leading to greater energy security, and greater energy availability for poor and rural areas. At this point, we know the

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technological and policy options that could stabilize GHG concentrations in the range of 450–550 parts per million by volume (ppmv) within the next 100 years. The estimated median costs of mitigation measures to achieve 550 ppmv might amount to about 1.3 percent of world GDP by 2050 (equivalent to an annual reduction of GDP of less than 0.1 percent a year up to 2050), although the cost of stabilization at the 450 ppmv level may exceed 3 percent of 2050 GDP.

#### Box 1

### The scientific facts

For decades, the public debate over global warming boiled down to a little science and a lot of conjecture. But in recent years, the world’s scientists have found their voice, and in the 2007 *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC)—which was founded 20 years ago by the UN to provide an authoritative review of climate change information—many of the world’s leading scientists spoke with one voice. Their message was a grim one.

**What we know.** For more than 10,000 years, carbon dioxide concentrations in the atmosphere were stable at about 280 parts per million by volume (ppmv), but, following the industrial revolution, these concentrations rose rapidly and now exceed 380 ppmv. As a result—and with the help of other minor greenhouse gases (GHGs), such as methane and nitrous oxide—over the past 100 years, the planet’s surface has warmed by an average of 0.75°C, and the rate is accelerating. Other evidence of global climate change includes a systematic rise in the mean sea level (about 16 centimeters during the past century), the melting of ice in polar areas and glaciers, increased damage caused by extreme weather events, less precipitation in dry areas and more precipitation in wet areas, and significant shifts in ecological cycles and animal behavior.

The IPCC predicts that in the absence of a serious effort to curb emissions, by 2100 carbon dioxide concentrations will be about twice the preindustrial level (550 ppmv), the average global temperature will increase by about 3°C above current levels (the range being 1.1–6.4°C), and the mean sea level will rise 35–40 centimeters. Extremes of climate and precipitation will worsen, and the melting of ice will accelerate because of the greater warming of polar regions. Even if emissions were sharply curbed, the IPCC estimates that temperatures would rise at least 1.5°C more by 2100.

**What we don’t know.** The IPCC is continuing to work on some important gaps in knowledge. For example, the level at which GHG concentrations are dangerous is not scientifically certain, although the European Union has made a value judgment that 2°C (corresponding to 450–500 ppmv) is the tolerable risk threshold. One key parameter, to be determined more accurately, is the sensitivity of climate to GHG concentrations. The accuracy of the economic costs of impacts also needs to be increased, especially since many of them will occur in the distant future. Because of time lags, often involving decades or even centuries, catastrophic outcomes such as the melting of polar ice or changes in oceanic circulation are hard to predict.



How would this mitigation take place? A key way is through the flexibility mechanisms in the 1997 Kyoto Treaty to combat global warming—such as the Clean Development Mechanism, Joint Implementation, and Emissions Trading—which permit industrial countries to transfer part of their Kyoto emissions-reduction obligations to other nations in exchange for payment. Consider a Clean Development Mechanism project implemented in a developing country, where the incremental cost of planting a forest to absorb carbon would be only \$10 a ton of carbon. The absorbed carbon would be credited to an industrial country and set off against the industrial country's mitigation obligations under the Kyoto Protocol—which might otherwise have involved retrofitting an existing power plant at a cost of \$50 a ton of carbon. This process would be efficient because mitigation is done at the lowest cost. Further, the money transfer from a rich to a poor country would be equitable, provided the developing country received more than the minimum payment of \$10 a ton (to cover costs)—that is, it shared the \$40 cost saving. Recent compensation levels have ranged from \$5 to \$10 a ton in developing countries to about \$50 in Europe.

Box 2

**A snapshot of global efforts**

The 1992 UN Framework Convention on Climate Change (UNFCCC), accepted by 190 countries, is the guiding document for international actions. It seeks “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” . . . “on the basis of equity and in accordance with [nations’] common but differentiated responsibilities and respective capabilities.” It notes that developed countries “should take the lead in combating climate change” and recognizes “the specific needs and special circumstances” of developing countries. While accepting the “right to promote sustainable development,” the UNFCCC invokes the precautionary principle that “where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason” for postponing measures to prevent climate change.

In an effort to implement the UNFCCC, participating countries agreed in late 1997 on the Kyoto Protocol, which came into force in February 2005. It specifies that, by 2012, Annex I (industrial) countries will collectively reduce their emissions by 5 percent relative to 1990 levels, and Non-Annex I (developing) countries are exempt from mandatory emissions reductions. Currently, 174 countries have ratified this agreement, although the United States (the largest greenhouse gas (GHG) emitter) has rejected it.

Nevertheless, global GHG emissions rose by more than 70 percent from 1970 to 2004, with major increases since Kyoto. The road map agreed at the UNFCCC Bali meeting in December 2007 set out the agenda and timetable to craft a post-Kyoto mitigation agreement—along with helping poor countries adapt to climate change (with improved financial and technical help)—but participants failed to agree on specific mitigation targets, mainly because of U.S. reluctance.

Of course, these mitigation and adaptation efforts raise tough questions about equity and burden sharing, which often dominate global debates. To date, the bulk of greenhouse gases—chiefly carbon dioxide from the burning of fossil fuels and deforestation—have been emitted by the rich countries (in 2004, average per capita GHG emissions in industrial countries were four times greater than those in developing countries).

But as the years progress, developing countries will need to boost their energy use (often relying heavily on coal) to alleviate poverty and promote development. Although per capita emissions will remain far lower in developing nations than in industrial countries for the foreseeable future, total emissions in the more populous countries will become increasingly significant. The International Energy Agency estimates that by 2015, China will take over from the United States as the world's top carbon dioxide emitter, and India will move up from fifth to third place. And, further complicating matters, the poor countries will be the ones hardest hit by climate change. For now, developing countries should focus on adaptation, especially to protect their poor, whereas rich countries (which are better endowed financially and technically) should lead the mitigation effort and also assist poorer countries in both their adaptation and mitigation work. Meanwhile middle-income countries need to join the mitigation effort over time as they become richer.

**A framework for action**

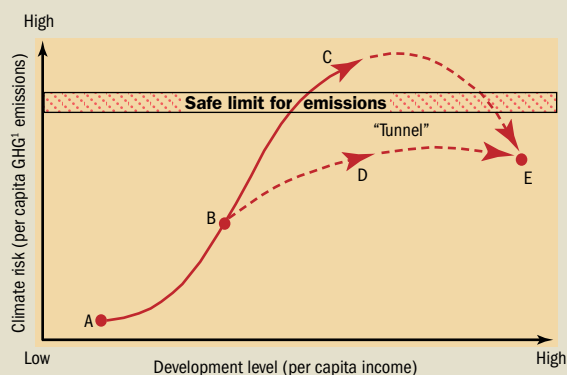
What will it take for global warming to grab the attention of policymakers, who are invariably preoccupied with the problems of today? The answer lies in convincing them to integrate climate change policies into each country's national sustainable development strategy. And the good news is that many practical ways to do just that have been developed and used over the past 15 years. One promising framework—known as “sustainomics”—offers some initial practical steps to help make the transition from the risky business-as-usual scenario to a safer and more sustainable future. It draws on three basic principles:

- First, the main goal must be to make development more sustainable. This step-by-step approach is more practical and permits us to address urgent priorities without delay, because many unsustainable activities are easier to recognize and implement (for example, conserving energy). Sustainable development is defined here as a process (rather than an end point).
- Second, the three elements (or vertices) of the sustainable development triangle need to be given balanced treatment. That means weighing *social* (inclusion, empowerment, and governance), *economic* (growth, efficiency, and stability), and *environmental* (biodiversity, natural resources, and pollution) dimensions.
- Third, deliberations should transcend traditional boundaries (involving academic disciplines, space, time, and stakeholders). Transdisciplinary analysis is essential, because issues and solutions cut across conventional disciplines. Problems such as climate change also span the planet, play out over centuries, and concern every human being.

These principles could help guide policymakers trying to shape a long-term consensus on reconciling mitigation costs

## Tunneling through

Developing countries need to avoid the carbon-intensive path of industrial countries.



Source: Munasinghe (2007).  
<sup>1</sup>Greenhouse gas.

and development aspirations. As the chart shows, a country's level of environmental risk (represented by GHG emissions per capita) varies with its level of development (measured by GNP per capita). A typical developing country might lie along the curve AB, whereas an industrial nation might be at C. Ideally, industrial countries (exceeding safe limits for "dangerous" climate change) should mitigate and follow the future growth path CE by restructuring their development patterns to delink carbon emissions and economic growth. Developing countries could adopt innovative policies to "tunnel" through (along BDE) by learning from the experiences of the industrial world—thus, the tunnel would lie below the safe limit. That way, they could simultaneously continue to develop (and grow) more sustainably, follow a less carbon-intensive growth path, and reduce their climate vulnerability.

The framework also provides policymakers with a variety of practical tools—both new and conventional methods applied innovatively. At the national level, tools include macro and sectoral modeling, environmentally adjusted national income accounts, poverty analysis, and the Action Impact Matrix. At the project level, they include cost-benefit analysis, multicriteria analysis, and environmental and social assessment.

Useful policy instruments include pricing, taxes and charges, regulations and standards, quantity controls, tradable permits, financial incentives, voluntary agreements, information dissemination, and research and development. These tools help to identify and implement the most desirable "win-win" climate policies that simultaneously yield economically, environmentally, and socially sustainable paths. They also help resolve trade-offs among conflicting goals.

## Ensuring food security

Among the various sustainomics tools, the Action Impact Matrix (AIM) excels in its ability to show how to integrate climate change and sustainable development—making it an extremely useful tool for decision making at the national, sectoral, and project levels. It identifies and prioritizes how the main national development policies and goals affect the key adaptation and mitigation options, and vice versa. It analyzes key economic-environmental-social interactions to identify potential barriers to making development more sustainable. And it helps determine the key macro policies and strategies that would facilitate the implementation of adaptation and mitigation to overcome the effects of climate change.

Take the case of the 2006 AIM for Sri Lanka, as illustrated in Table 1. The cells with values of  $-3$  and  $-2$  indicate the more adverse effects and should have the greatest priority. Conversely, cells with values of  $0$  or  $-1$  may effectively be ignored because the effects are small. Consider the row marked "(S1) Status," where the cell (S1, 6) has a value of  $-3$ , indicating that climate change will have a severe negative impact on future water resources. Looking down column (6), we note that cell (C6) also has a value of  $-3$ , showing that this lack of water resources will severely affect food security. Similarly, looking down column (1), we see that climate change will also have highly negative effects on food

Table 1

### Identifying climate-development links in Sri Lanka

An Action Impact Matrix helps pinpoint impacts of key climate change vulnerabilities on major development goals and policies, determines "win-win" policies, and resolves trade-offs.

		Key vulnerabilities: economic sectors and ecosystems									
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Agricultural output	Hydro power	Deforestation	Biodiversity (flora and fauna)	Wetlands and coast ecosystems	Water resources	Poor communities	Human health	Infrastructure	Industries and tourism
(S0)	Status (natural variability)	-1	0	-2	-1	-1	-2	-1	0	2	2
(S1)	Status (+climate change impacts)	-2	-1	-2	-2	-2	-3	-2	-1	-1	-1
<b>Major development goals/policies</b>											
(A)	<b>Growth</b>	-1	-1	-1	-1	-1	-2	-2	-1	-1	-1
(B)	<b>Poverty alleviation</b>	-2	0	-1	-1	-1	-2	-2	-2	-1	-1
(C)	<b>Food security</b>	-3	0	-1	-1	-1	-3	-1	-1	0	0
(D)	<b>Employment</b>	-1	0	-1	0	-1	-2	-1	-2	-1	-2
(E)	<b>Trade and globalization</b>	-2	-1	0	0	0	-1	-1	0	-2	-1
(F)	<b>Budget deficit reduction</b>	-1	-1	0	0	0	0	0	-2	0	-1
(G)	<b>Privatization</b>	0	1	1	0	0	1	0	0	-1	-1

Source: Munasinghe (2007).

security through the agriculture sector, as indicated by the -3 in cell (C1). Each such cell is linked to a separate detailed description—for example, the description for cell (C1) describes outputs of all major crops in different parts of Sri Lanka, under different temperature and rainfall conditions.

In light of the very high AIM priority assigned to food security, agriculture, and water, a more detailed study of this issue was quickly undertaken. A Ricardian agriculture model was applied to identify how past output changes in important crops such as rice, tea, rubber, and coconut had depended on natural variations in climate (mainly temperature and rainfall). Then, a downscaled regional climate model was used to make detailed temperature and precipitation predictions specific to Sri Lanka. The combined results of both models showed that the impact on future rice cultivation would be negative and significant (almost 12 percent yield loss by 2050) and would affect poor farmers in the dry zone, where incomes are lowest. Meanwhile, some areas in the wet zone, where tea is grown and incomes are higher, would experience gains (+3.5 percent yield by 2050).

These findings raise several important policy issues. First, given that rice is the staple food and a large portion of the population depends on rice farming, adaptation measures are essential to protect national food security, protect livelihoods, and reduce the vulnerabilities of the rural poor in the dry zone. Second, the different effects of climate change on poor farmers and richer landowners have income distribution and equity implications that also need to be addressed. And third, population movements from dry to wet zones are a potential risk that policymakers will need to deal with.

### Encouraging renewable energy

At the project level, another AIM was generated to study Sri Lanka's links between mitigation and development goals. Small hydropower was identified as a promising renewable energy option, and that, in turn, raised the question of which small hydropower sites should be selected. In an effort to assess social, economic, and environmental indicators, a multicriteria analysis was undertaken. Its advantage was that it allowed policymakers to look at all of these spheres in a bal-

anced manner—in large part, by quantifying and displaying trade-offs that had to be made between conflicting objectives that are difficult to compare directly. The multicriteria analysis thus provided useful additional information to supplement the economic data from a cost-benefit analysis.

As in all sustainable development studies, the indicators chosen were crucial. In this case, the economic indicator was cost, the social indicator was number of people resettled, and the environmental indicator was a biodiversity loss index. All indicators were measured per ton of carbon mitigated at each site (because fossil fuel use was displaced by the hydroelectric energy generated).

Which hydropower projects ranked highest? It was those that provided the most balanced path for integrating mitigation with national sustainable development objectives. Table 2 shows the top 10 sites (out of 22 examined) based on their high score on a simple composite sustainability criterion, which gave equal weight to the economic, social, and environmental indicators. The best 2, Projects E and V, also scored highest on the economic indicator, but third-place Project R managed to edge out Project H, even though the latter scored higher on economic terms alone.

### A higher profile

In recent months, three developments—the release of the IPCC Fourth Assessment Report, the awarding of the 2007 Nobel Peace Prize to the IPCC and Al Gore, and the December 2007 Bali conference of the UN Framework Convention on Climate Change—have combined to raise the profile of climate change and helped to highlight the difficulties that policymakers face in coming to grips with this important challenge. Although there is a growing consensus worldwide on the need to take early action on climate change, important practical issues remain unresolved, including burden sharing and equity.

Nevertheless, one can conclude on an optimistic note. Although climate change and sustainable development are complex, interlinked problems that pose a challenge to humanity, they could be solved together by integrating adaptation and mitigation response measures into the broader rubric of sustainable development strategies. We know enough already to immediately take the first step toward making development more sustainable—helping to usher in a safer and brighter future. ■

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Table 2

### Prioritizing small hydropower projects in Sri Lanka

A multicriteria analysis offers policymakers a way to pick the best mitigation projects that make development more sustainable.

Indicator	Project rank									
	1	2	3	4	5	6	7	8	9	10
Sustainability <sup>1</sup>	E	V	R	I	P	J	U	L	H	S
Social <sup>2</sup>	L	O	P	Q	R	V	M	I	C	E
Environmental <sup>3</sup>	G	R	I	O	Q	L	E	V	S	T
Economic <sup>4</sup>	E	V	H	R	I	P	J	U	L	S

Source: Munasinghe (2007).

Note: Individual letters stand for individual projects, which are ranked by social, environmental, and economic impact.

<sup>1</sup>The sustainability index is a composite that gives equal weight to the social, economic, and environmental indicators.

<sup>2</sup>Measured by number of people displaced.

<sup>3</sup>Measured by a composite biodiversity loss index.

<sup>4</sup>Measured by cost.