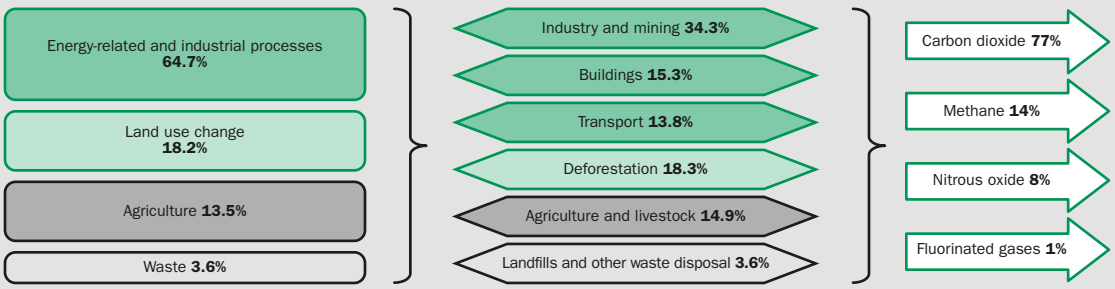
Climate change by the numbers

Greenhouse gas emissions by sector and by activity 3a



Source: World Resources Institute 2005.

Numbers tell the story. The natural climate has changed, and the change is accelerating as our planet warms. The rate of warming has been nearly twice as fast in the last 50 years as in the last 100 years, with the 13 warmest years since 1880 experienced in the last 15 years. Since 1978 annual mean arctic sea ice has been declining. Temperatures at the top of the permafrost have increased by up to 3 degrees centigrade. Sea levels rose more from 1993 to 2003 than in the previous 30 years. Concentration of atmospheric carbon dioxide, the main cause of global warming, increased one-third faster in the last decade than over the last 50 years (IPCC 2007a).

Climate change poses risks for the environment and for development in most economies, disproportionately affecting those with the lowest capacity to adapt to such impacts. That makes climate change a development issue critical to poverty reduction. It is also an environmental issue vital to sustaining growth and preserving the ecosystem. Countries need measures to mitigate it—and to adapt to its unavoidable outcomes.

Knowledge about climate change has grown greatly in the last few years. The most comprehensive treatment is in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which presents the findings of hundreds of experts in the field:

- All greenhouse gas concentrations—the main causes of climate change—have increased since the start of the industrial revolution. From 1750 to 2005 carbon dioxide grew from 280 parts per million to 379, methane from 715 parts per billion to 1,774, and nitrous oxide from 270 parts per billion to 319.
- Warming of the climate system is unequivocal—now evident in global averages of air, surface, and ocean temperatures; in widespread melting of snow and ice; and in rising global mean sea level.
- The likely consequences of climate change are uneven across regions, with more profound negative impacts for developing countries and for more vulnerable socioeconomic groups.
- It is very likely (90+ percent confidence) that human activities are causing global warming.
- Changes in technology, management, and behavior can mitigate climate change.
- Even with mitigation, climate change will continue, and adaptation will be needed.

Why the natural climate has changed

The IPCC's assessment concluded that global greenhouse gas emissions have drastically increased since preindustrial times, with a 70 percent increase between 1970 and 2004. More than 75 percent of these emissions come from carbon dioxide, mainly from burning fossil fuels, manufacturing cement, and cutting forests. Carbon dioxide emissions grew by about 80 percent, accelerating in recent years (a 28 percent increase since 1990).

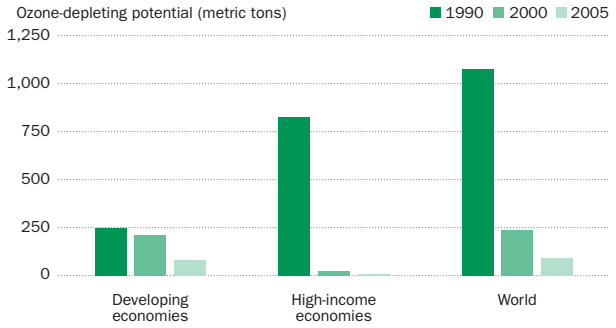
The other major greenhouse gases are methane and nitrous oxide, mainly from agriculture, energy use, industrial processes, waste, and savannah burning (see figure 3a for a schematic representation of greenhouse gas emissions). Their emissions have grown as well (table 3.9). But emissions of ozone-depleting substances, also greenhouse gases, have declined significantly since the 1990s, controlled under the international treaty known as the Montreal Protocol. By 2005 consumption of these substances was less than 10 percent of their 1990 level (figure 3b).

Global energy intensity declined 33 percent during 1970–2004. But the favorable impact on carbon dioxide emissions has been more than offset by per capita income growth (67 percent) and population growth (73 percent).

Country trends and contributions to climate change vary substantially, with the United States and China contributing most (figure 3c and tables 3.7 and 3.8). The average resident of a rich country produces far more carbon dioxide than does the average resident of a low- and middle-income country. Per capita emissions of carbon dioxide in 2004 averaged 0.9 metric tons in low-income countries, 4.0 metric tons in middle-income countries, and 13.2 metric tons in high-income countries (figure 3d). High-income economies, with 15 percent of the world's people, produced 55 percent of global GDP (in purchasing power parity terms) and emitted nearly half of the global carbon dioxide emissions in 2004 (figure 3e and table 3.8).

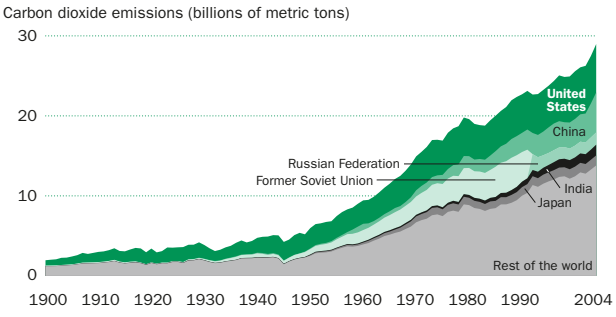
Global trends in emissions of greenhouse gas sources also vary substantially. The power sector contributes almost a quarter of global greenhouse gases, and transport, industry, buildings, and other energy-related activities account for another 41 percent (figure 3f). The biggest growth between

Use of ozone-depleting substances has dropped substantially since 1990 3b



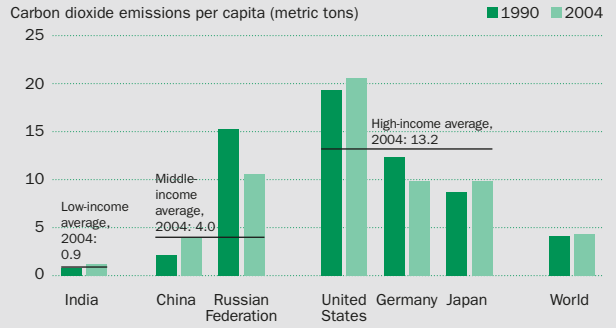
Source: United Nations Millennium Development Goals database.

The United States and China lead the world in carbon dioxide emissions 3c



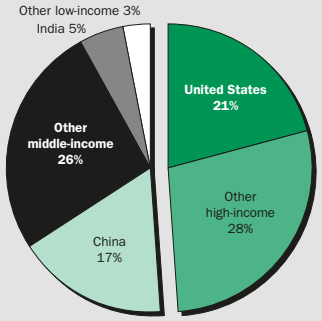
Source: Carbon Dioxide Information Analysis Center.

High-income countries produce far more carbon dioxide emissions per capita than low- or middle-income countries 3d



Source: Table 3.8.

High-income economies emitted half the global carbon dioxide emissions in 2004 3e



Source: Table 3.8 and Carbon Dioxide Information Analysis Center.

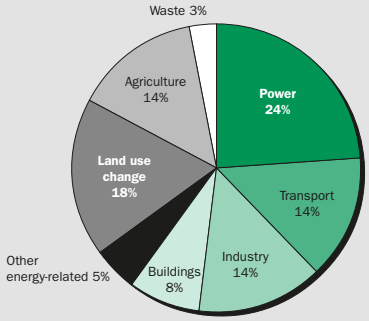
1970 and 2004 was from power generation (145 percent) followed by transport (120 percent). Fossil fuels account for three-quarters of the energy used in the power sector, with coal dominant (figure 3g and table 3.10). Coal is responsible for the majority of emissions from the power sector (figure 3h). Almost half the electricity and heat produced is used in buildings (residential and commercial), and around one-third in industry (WRI 2006).

North America accounts for by far the largest amount of power sector emissions (3 gigatons of carbon dioxide equivalent), followed by China (1.7 gigatons), European Union (1.6 gigatons), and transition economies (1.4 gigatons). North America also has among the highest emissions per capita (7 tons of carbon dioxide per person), more than twice those of the European Union and six times those of China (WRI 2006).

Transport accounts for 14 percent of global greenhouse gas emissions, behind power and land use change but about the same as agriculture (see figure 3f). Most of these emissions are from road transport (76 percent) and aviation (12 percent; figure 3i). By far the largest source of transport emissions is North America, producing 37 percent of the global total. This partly reflects the fact that the United States has the highest vehicle ownership in the world (814 vehicles per 1,000 people, compared with 604 in the European Union and 15 in China) and also lags in fuel efficiency, which is about two-thirds that in the European Union (An and Sauer 2004).

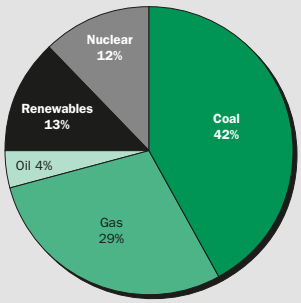
Agriculture and deforestation are responsible for one-third of greenhouse gas emissions. In many countries soil degradation, along with the loss of agricultural land through urbanization and population growth, has led to substantial deforestation. The global forested area in 2005 was about 4 billion hectares, covering 30 percent of total land area (table 3.4). But deforestation continues at about 13 million hectares a year. Reforestation reduced the net loss of forest areas to 7.3 million hectares a year during 2000–05, an improvement from losses of 8.9 million hectares a year during 1990–2000. Sub-Saharan Africa and Latin America continued to have the largest forest loss after 1990.

Power generation and land use change were the two largest sources of greenhouse gas emissions in 2000 **3f**



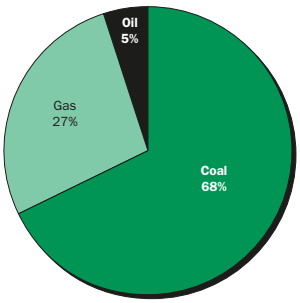
Source: WRI 2006.

Fossil fuels accounted for three-quarters of the fuel used in the power sector in 2002 **3g**



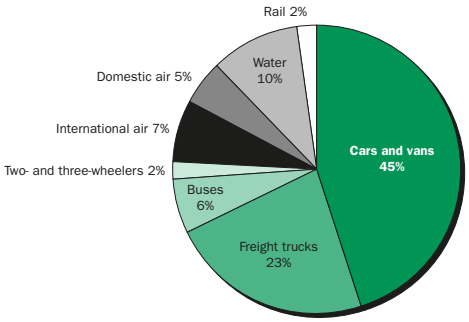
Source: WRI 2006.

Coal was responsible for the majority of emissions from the power sector in 2002 **3h**



Source: WRI 2006.

Road transport accounted for more than three-quarters of total transport carbon dioxide emissions in 2000 **3i**



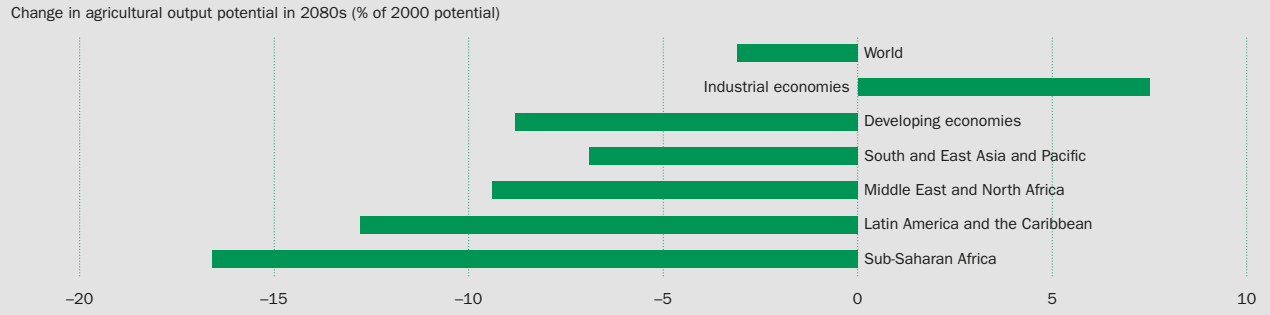
Source: WRI 2006.

Climate change and vulnerable people and regions

Climate change will have different effects on different regions (depending on geography) and different income groups (depending on livelihoods and adaptive capacity). The effects will also vary by the extent of adaptation, exposure to temperature change, and socioeconomic conditions. Potential impacts could include:

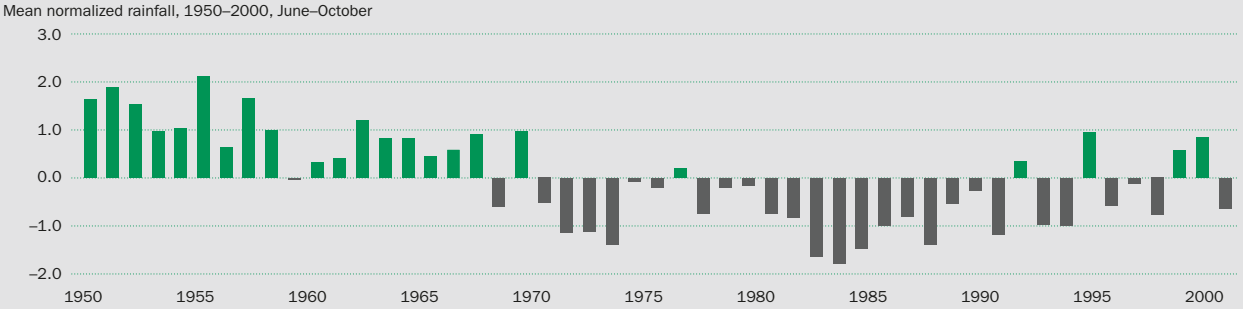
- *Lower agricultural productivity.* Climate change has the potential to drastically affect food production (figure 3j). In parts of Sub-Saharan Africa and South and East Asia losses in agricultural productivity are linked to drought and rainfall variation. Drought has already become more frequent in Sub-Saharan Africa (figure 3k). Because a large share of the world's poor people depend directly on agriculture, drought and other negative effects of climate change put poverty reduction efforts at risk. But global warming could potentially benefit agriculture in some temperate areas—mostly in developed countries.
- *Greater water scarcity.* The rise in global temperature is accelerating (figure 3l). If it exceeds the 2° C threshold (as some scenarios project), the distribution of the world's water resources will change drastically. While water's availability could increase in the moist tropics and in high latitudes, it will decline in the midlatitudes and in semiarid low altitudes, increasing droughts and water shortages. Accelerated glacial melt in the Himalayas will compound severe ecological problems in northern China, India, and Pakistan, increasing floods but reducing water flow to major river systems vital for irrigation. In Latin America accelerated melting of tropical glaciers will threaten water supplies for urban populations, agriculture, and hydroelectricity, especially in the Andean region. Water shortages could contribute to regional conflicts.
- *Heightened health risks.* Climate change will affect human health. Globally, 220–400 million more people could be at increased risk of malaria, particularly in Sub-Saharan Africa, where exposure to malaria is projected to increase 16–28 percent (UNDP 2007b; IPCC 2007b). Climate change could also increase the incidence of malnutrition, diarrhea, and infectious diseases—and change the distribution of disease vectors, adding to the burden on health services.

Climate change would hurt developing countries' agricultural output **3j**



Source: Cline 2007.

Less rain is falling in the Sahel, with dire consequences **3k**



Note: The averages are standardized for the period 1950–2000 so that the mean of the series is zero and the standard deviation is one.
Source: World Bank 2002e.

- *More exposure to climate disasters.* Climate-related disasters, mainly floods and droughts, have already increased. On average 262 million people a year were affected between 2000 and 2004, more than twice the number in the 1980s (figure 3m), and most of them (98 percent) live in developing countries (figure 3n). Temperature increases greater than 2° C would accelerate the rise in sea level, causing widespread displacement of people in countries such as Bangladesh, Egypt, and Vietnam and the inundation of several small-island economies. Rising sea levels and more intense tropical storm activity could raise the number of people experiencing coastal flooding by 180–230 million (Dasgupta and others 2007; Anthoff and others 2006; UNDP 2007b).
- *Harm to ecosystems.* Coral reef systems, already in decline, would suffer extensive bleaching, transforming marine ecologies, with large losses of biodiversity and ecosystem services. This would adversely affect hundreds of millions of people dependent on fish for their livelihoods and nutrition (UNDP 2007b).

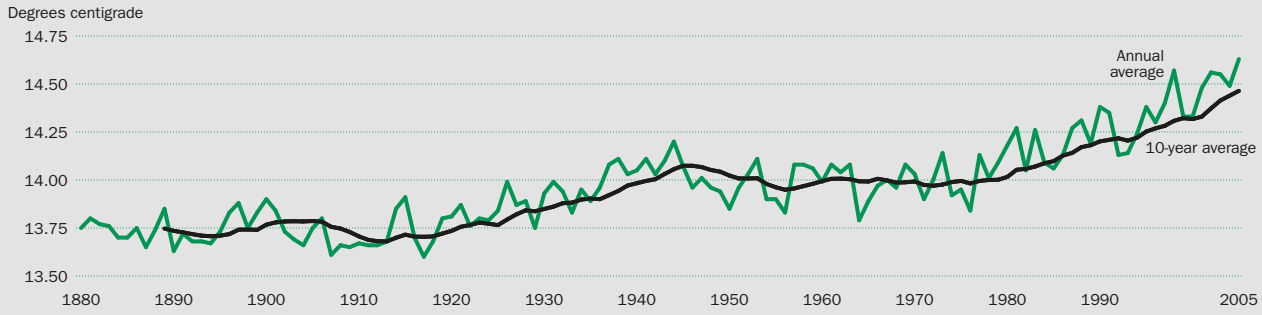
The negative impacts will not occur everywhere (IPCC 2007a). These impacts depend on two main factors: exposure to the effects of climate change and capacity to adapt to them.

Exposure is partly determined by environmental factors. People, flora, and fauna in areas prone to flooding or facing water scarcity have far greater exposure. The level of exposure also depends on the population density or the infrastructure in environmentally sensitive areas. Adaptive capacity is the ability to deal with climate change, such as by building levies to combat flooding or irrigation systems to deal with drought. It is closely associated with a society's wealth, education, institutional strength, and access to technology (Burton, Diringer, and Smith 2006; IPCC 2007e).

High exposure and low adaptive capacity occur mostly in developing countries, making them highly vulnerable to climate change.

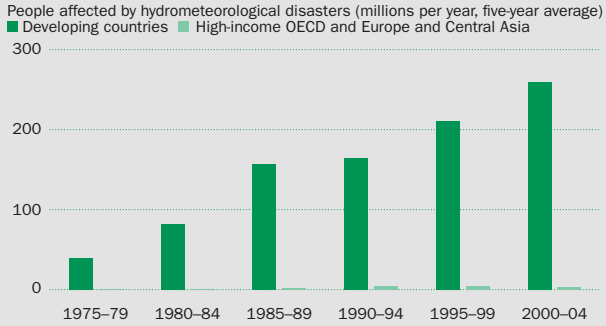
Poverty and political instability make the negative impacts of climate change more severe and weaken the ability to adapt.

The rise in global mean surface temperature is accelerating **3l**



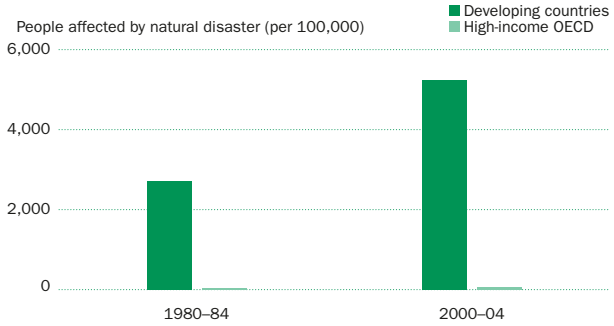
Source: Goddard Institute for Space Science Studies Analysis.

Climate disasters are affecting more and more people, mostly in developing countries **3m**



Source: UNDP 2007b, based on OFDA and CRED 2007.

Developing countries are exposed to higher risk of natural disaster **3n**



Source: UNDP 2007b, based on OFDA and CRED 2007.

The enormous costs of inaction

The impacts of climate change are costly—so is mitigating the causes of the climate change or adapting to the unavoidable outcomes of change. There is substantial economic and social justification for mitigating global greenhouse gases emissions over the coming decades (IPCC 2007d), offsetting the projected growth of global emissions or even reducing emissions below current levels. The costs of mitigation depend on the level at which emissions stabilize.

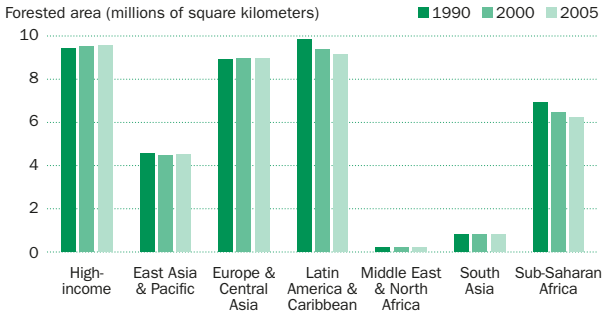
But the cost of inaction is significantly higher. The range of estimates is wide, depending on underlying assumptions, on which consensus is lacking. For example, the Stern Review (Stern 2006) estimates that without action the overall costs of climate change will be equivalent to losing at least 5 percent of global GDP each year, now and forever. They would be much higher under a wider range of risks and impacts.

Some steps to reduce carbon dioxide are economically and socially desirable, regardless of their mitigating impact. Conserving energy and promoting new technologies and energy alternatives (such as capturing and storing carbon and shifting to renewable and cleaner sources of energy) would reduce pollution while economizing on exhaustible resources. Preventing deforestation is important because forests protect biodiversity and provide livelihood for millions of poor people (figure 3o). But taking a low carbon path by shifting to alternative energy may be difficult for many developing countries that need to grow but can afford to use only fossil fuels—particularly coal, the "dirtiest" of energy sources.

With some 1.6 billion people lacking electricity (figure 3p; IEA 2006b), cheap and abundant coal is the fuel of choice in much of the world, powering economic booms in most developing economies, notably China and India, that have lifted millions of people out of poverty. Low-income countries use coal to generate 47 percent of their electricity. Coal generates 78 percent of China's electricity and 69 percent of India's (figure 3q). Worldwide, coal demand is projected to rise about 60 percent by 2030, to 6.9 billion metric tons a year, most of it going to electrical plants. So, greater coal efficiency can reduce carbon dioxide emissions (figure 3r).

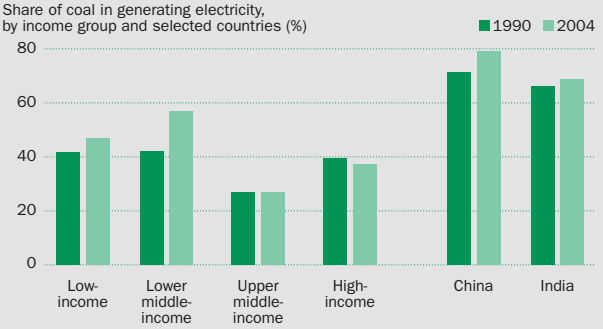
Burning coal does more than add to global warming—it is also linked to other environmental and health issues,

Forested areas are shrinking in Latin America and Sub-Saharan Africa—recovering in East Asia **3o**



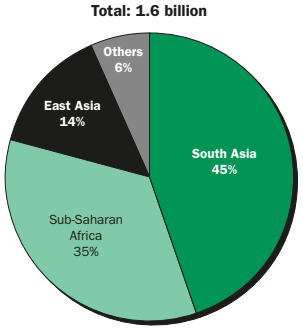
Source: Table 3.4.

China and India generate more than two-thirds of their electricity from coal **3q**



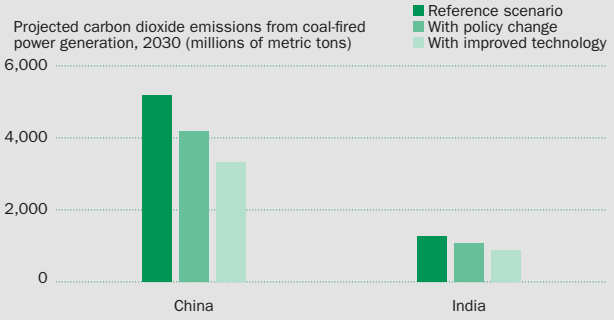
Source: Table 3.10.

The vast majority of people without access to electricity in 2004 lived in developing countries **3p**



Source: IEA 2006b.

Greater coal efficiency can reduce carbon dioxide emissions **3r**



Source: Watson 2007; UNDP 2007b.

including acid rain and asthma. Air pollution prematurely kills more than 2 million people a year. In China the health costs attributable to air pollution are estimated at $68 billion a year, nearly 4 percent of its economic output (World Bank 2007c). And acid rain has contaminated one-third of the country, destroying some $4 billion worth of crops every year. Chinese authorities have closed some polluting factories and by 2010 will retire 50 gigawatts of inefficient power plants (about 8 percent of the power grid; Pew Center on Global Climate Change 2007). The authorities have also mandated that solar, wind, hydroelectric, and other forms of renewable energy provide 10 percent of the nation's power by 2010—and ordered key industries to reduce energy consumption by 20 percent.

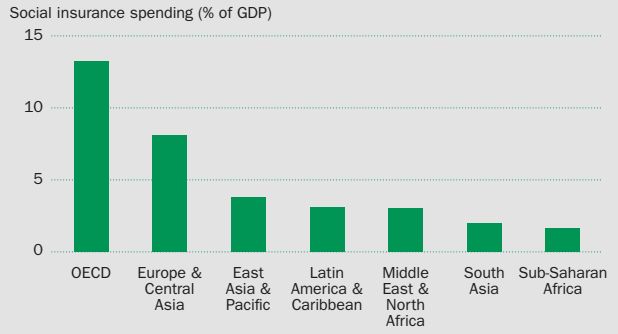
There is considerable agreement and much evidence that, even with current mitigation policies, global greenhouse gas emissions will continue to grow over the coming decades (IPCC 2007d). So, countries need to adapt to the unavoidable effects of climate change that are already affecting the well-being of their people, particularly those who are poor, the unintended victims of industrialized economies' past energy consumption.

With poor adaptive capacity, inadequate social protection, and gaps in climate information, developing countries will find it difficult to respond (figures 3s and 3t). Because climate change crosses national borders, a coordinated program of funding and new technologies is required. But the funding needed for adaptation is enormous, and the amount available for climate adaptation in developing countries is still insufficient. In June 2007 pledges totaled less than $220 million, with even smaller amounts allocated and disbursed (figure 3u). The Netherlands has already spent $2.2 billion for flood protection, and Austria has a $1.3 billion project to deal with water scarcity and extreme weather (WRI 2007).

There is still a window of opportunity to act before the economic and human costs become insurmountable (Stern 2006; IPCC 2007c). But action requires measuring and monitoring the state of the environment and human well-being and how they are changing. There are still information gaps, and many of the available data are not up to date. The impacts of carbon dioxide emissions are not well quantified, especially in developing countries. The impacts of extreme climate events are poorly tracked. Local impacts are not widely researched. Few projections on aquatic resources are available. Research on adaptation is still not comprehensive across a range of climate and socioeconomic futures. There is much to be learned about the impacts on biofuel and industrial crops.

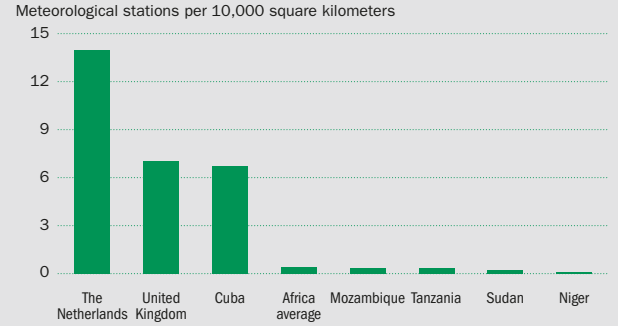
Numbers tell the story. But we still lack many of the numbers to tell the whole story.

Social insurance spending is lower in developing countries, where people are exposed to higher risk of climate change impact 3s



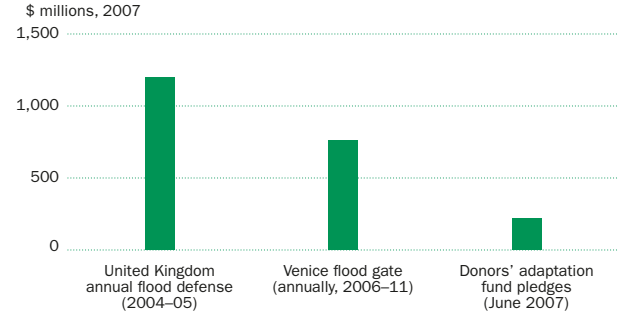
Source: World Bank 2005d.

The climate information gap makes adaptation more difficult 3t



Source: UNDP 2007b; WMO 2007; UN 2007.

Adaptation is expensive, and funding for developing countries is inadequate 3u



Source: UNDP 2007b; Abott 2004; DEFRA 2007; GEF 2007.