CHAPTER 2

Climate Change: The Global Scene

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This chapter begins with a brief overview of the problem, the scientific underpinnings, the certainties and uncertainties, and the likely effects of future climate change. It describes what climate change means, why it matters, and why it is not strictly an environmental issue, but is also a crucial development concern. It then outlines the contribution of sectors and countries to greenhouse gas emissions and the various approaches for stabilizing emissions.

The Science of Climate Change

Is there Evidence of Climate Change?

The Earth is warming and its climate is changing. Indeed, measurements show that the Earth has warmed by 0.74ºC over the past 100 years. Warmer surface temperatures heat the oceans, melt ice sheets, and alter weather patterns across the globe. As a result, sea levels have risen globally by 10–20 millimeters during the 20th century and snow cover has receded by about 10 percent since the 1960s, with a 5-kilometer retreat in the alpine and continental glaciers. In the Arctic, where the expanding ocean absorbs more heat, the ice cover has retreated faster than the global average. If this melting continues, science predicts that summers in the Arctic will be ice free within 100 years.

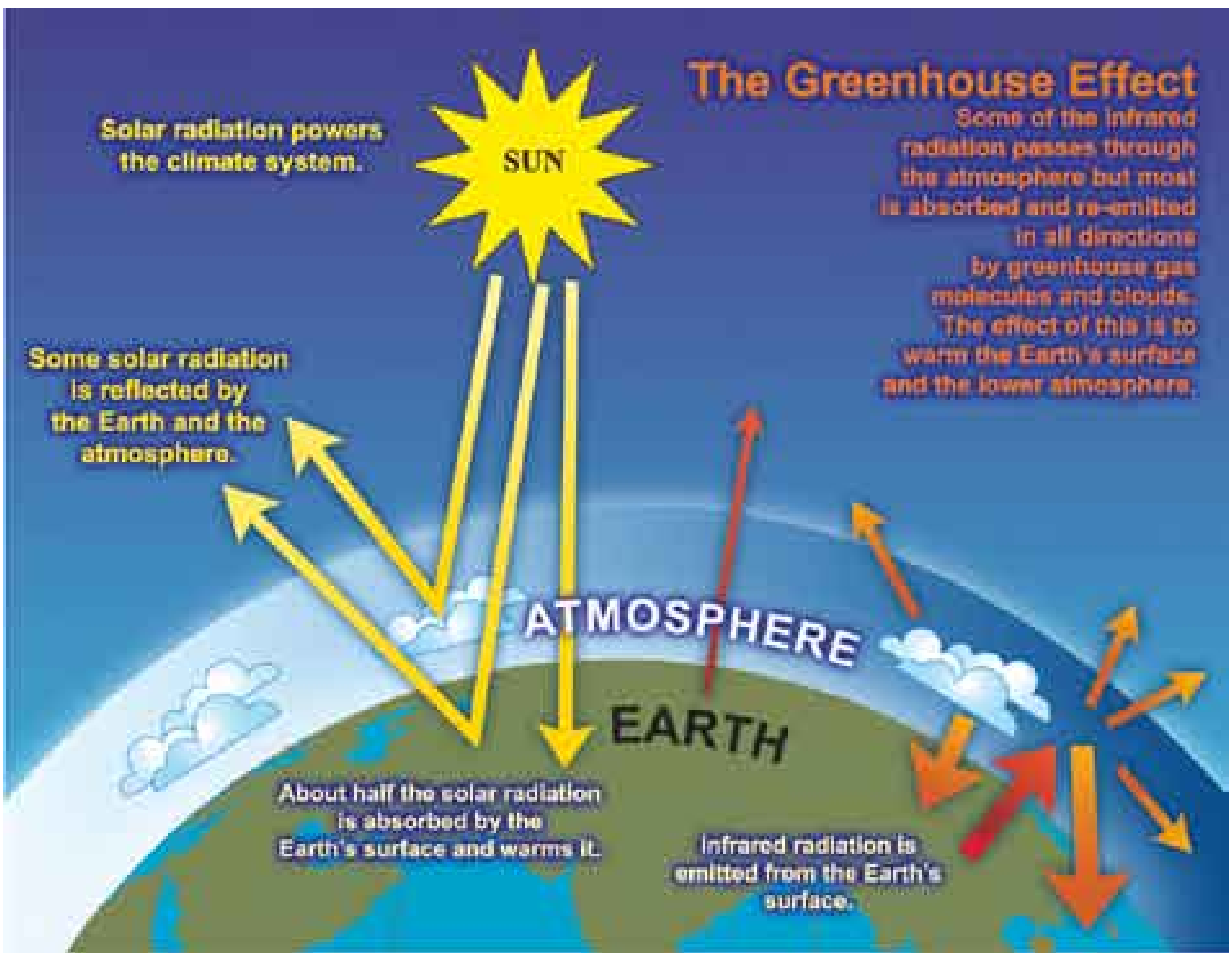
Climate change is about more than just rising temperatures. There are cascading effects, with such areas as the Sahel, the Mediterranean Basin, Southern Africa, and parts of Southern Asia becoming drier due to more heat and evaporation. Other areas are experiencing increased and more variable precipitation, particularly the east of North and South America, Northern Europe, and Northern and Central Asia. Over the past 50 years, weather patterns have also become more variable. Storm duration and peak winds of tropical cyclones have increased, together with ocean warming. These impacts do not register as apocalyptic events. However, increased exposure to droughts, floods, and environmental stress are beginning to take their toll on communities in climate-vulnerable parts of the world. In South Asia, the projected impacts of higher temperatures, more variable precipitation, more extreme weather events, and sea-level rise will likely continue to intensify. These changes would have the greatest impacts on the lives and livelihoods of millions of poor people who remain exposed to climate risks. This is the subject of subsequent chapters.

Why is the Climate Changing?

The scientific understanding of climate change is now sufficiently clear. The causes of global warming, the extent of climate change, humanity's contribution to it, and the consequences for development have all been vigorously disputed. The broad science has now settled and with rare unanimity a broad scientific consensus holds that climate change is a consequence of human activities. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_2) are the main greenhouse gases (GHGs) that are produced through human activities, primarily the burning of fossil fuels and deforestation. These GHGs trap heat inside the atmosphere and warm the surface of the Earth (see Box 2.1).

Box 2.1 What is the Greenhouse Effect?

The composition of the atmosphere is important in determining the Earth's climate because certain naturally occurring gases, such as CO_2 and water vapor, allow the passage of incoming short-wave radiation while trapping much of the long-wave radiation reflected from the Earth's surface, in much the same way as a greenhouse operates (see figure below). Life on Earth is made possible because of this effect, which maintains the global mean surface air temperature at around 15°C (59°F). As the volume of these "greenhouse gases" increases, so too does the Earth's temperature. Temperature changes in turn alter climate systems. A complex feedback loop may emerge whereby a change in one factor, such as temperature, changes another factor, such as the volume of water vapor, which either reinforces or offsets the initial temperature change. A substantial part of the uncertainty in projecting future climate change is due to an incomplete understanding of these feedback processes.



Source: IPCC 2007a (reprinted with permission)

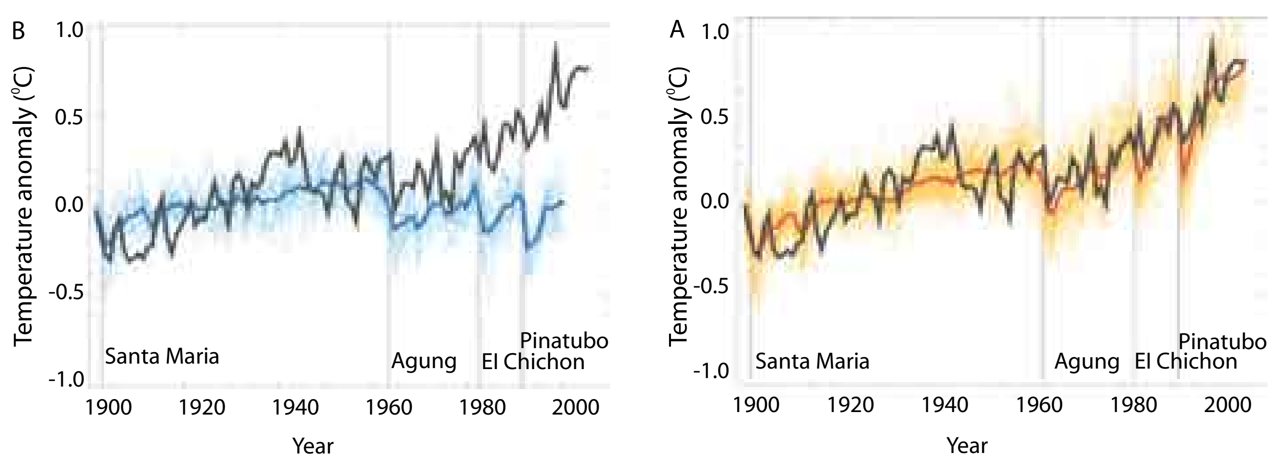
In a natural equilibrium the amount of CO_2 released in the atmosphere is in balance with the amount absorbed by plants, forests, the oceans, and other "sinks." Since the start of the Industrial Revolution, CO_2 emissions have risen sharply, from 280 parts per million (ppm) in 1780 to more than 380 ppm in 2005.[11] About half of this excess CO_2 is absorbed by the Earth's sinks, but the rest accumulates in the atmosphere, amplifying the natural greenhouse effect through higher temperatures (National Academies 2008).

How do we know that Human Activities are Responsible for Climate Change?

There is mounting evidence from a variety of sources that confirms the link between human activities and climate change. The climate has exhibited considerable variations in the past, so it is conceivable that current trends are part of this natural cycle of variation. While acknowledging the many uncertainties, the scientific community has reached a near unanimous verdict that the GHGs generated by human activities are responsible for the current temperature increases.[12] This conclusion has been reached through numerous sources of scientific information. First, climate models show that observed temperature changes can be predicted only when human factors are included in the models (see Box 2.2). Second, the pattern of warming is consistent with the greenhouse effect, with greater temperature increases over land and in the Arctic than are occurring over the oceans. Finally, data from ice cores drilled from the Antarctic

Box 2.2 Role of Anthropogenic Greenhouse Gases in Global Warming

Human activities have changed the climate of the Earth. The figures below have been used by the Intergovernmental Panel on Climate Change (IPCC) to conclude that natural factors alone cannot explain the recent temperature changes. In the left panel below, the temperature projections are based on natural accumulations of GHGs and exclude the human-produced component of GHGs. There is a wide divergence between actual and projected temperature changes. The models suggest that when the anthropogenic component of GHGs is excluded, temperatures would be lower than they have been. The right panel includes projections with both natural and anthropogenic accumulations of GHGs included. The models track actual changes in temperature with remarkable accuracy.



Source: IPCC 2007a (reprinted with permission)

[11] Data on other GHGs in the 18th and 19th centuries are unavailable.

[12] This assertion is made by the IPCC 2007a with 90 percent confidence probability.

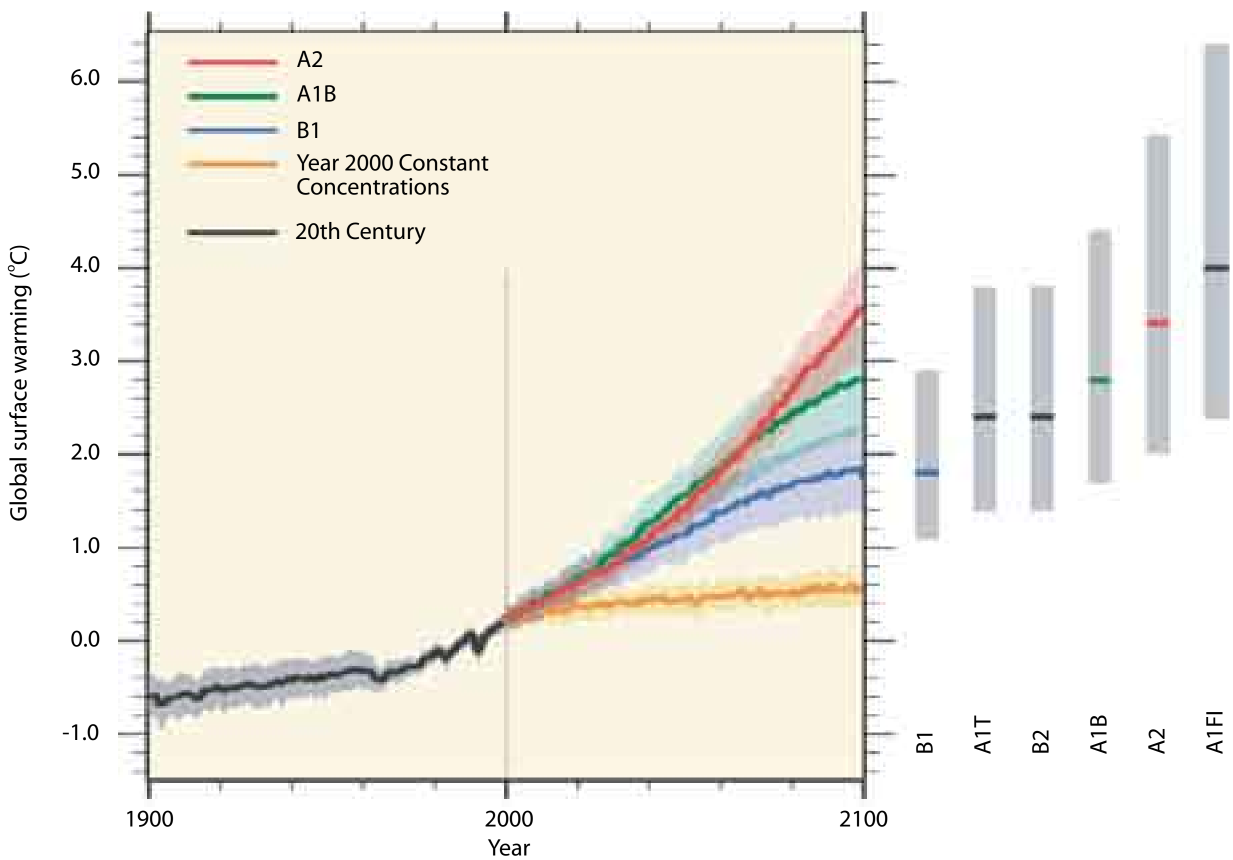
show that current CO_2 levels are higher than they have been in 440,000 years, and variations in CO_2 levels closely correlate with surface temperatures.

What might the Future Hold?

Projections of future climate change are much less certain. The extent of future climate change ultimately depends on global GHG emissions. These in turn depend on the scale and type of economic activities that will be undertaken over the next century. To compare possible outcomes the IPCC developed a variety of emission scenarios (Nakicenovic and Swart 2000) that span a range of plausible development pathways and possibilities. According to the IPCC *Fourth Assessment Report*, global GHG emissions will continue to grow in all plausible scenarios (IPCC 2007a). Figure 2.1 presents the various outcomes.

Three important messages emerge from these projections. First, despite the uncertainty in predicting future climate events, all the models suggest that there will be some degree of global warming. The projections cover a wide range of temperature increases—from a modest 0.6°C increase

Figure 2.1 Projected GHG Emissions and Global Surface Warming



Note: The graph lines are averages across different models for different scenarios relative to baseline average temperatures (1980–1990), while the bars illustrate the likely range of outcomes for each scenario.

SRES: *Special Report on Emissions Scenarios* (Nakicenovic and Swart 2000).

Source: IPCC 2007a (reprinted with permission) in the best-case scenario (with a low level of GHGs) to a potentially calamitous 6.4°C (with uncontrolled GHG emissions). Second, climate change is often viewed as a problem for the future, but some changes are projected to occur as early as 2020, regardless of potential mitigation actions (see the maps in Figure 2.2). Avoiding the negative impacts will require immediate adaptive responses to changing climate patterns. Third, higher concentrations of GHGs are associated with higher temperatures and increase the probability of harmful effects. In the worst-case scenarios emissions stabilize at about 650–750 ppm of equivalent carbon dioxide (CO_2e)[13] and carry a significant risk of temperatures rising by 5°C. The projected consequences would be highly undesirable, with parching droughts in parts of the subtropics, disappearance of the west Antarctic ice sheet, and some glacier melt in the high mountains of the world. A 5°C temperature rise also implies a higher probability that the "tipping point" would be crossed whereby changes become sudden, rather than gradual, with unpredictable shifts in climate patterns.

What are the Main Impacts of Climate Change?

There are many uncertainties in projecting the precise impacts of climate change on the economy. The response of physical systems to variations in climate is complex and often ambiguous. (See Box 2.3.) Even if these responses were known, the actual impacts would depend on how governments, organizations, and individuals react to climate risks. For instance, if there is early adaptation, some of the damage could be prevented. In other cases, losses

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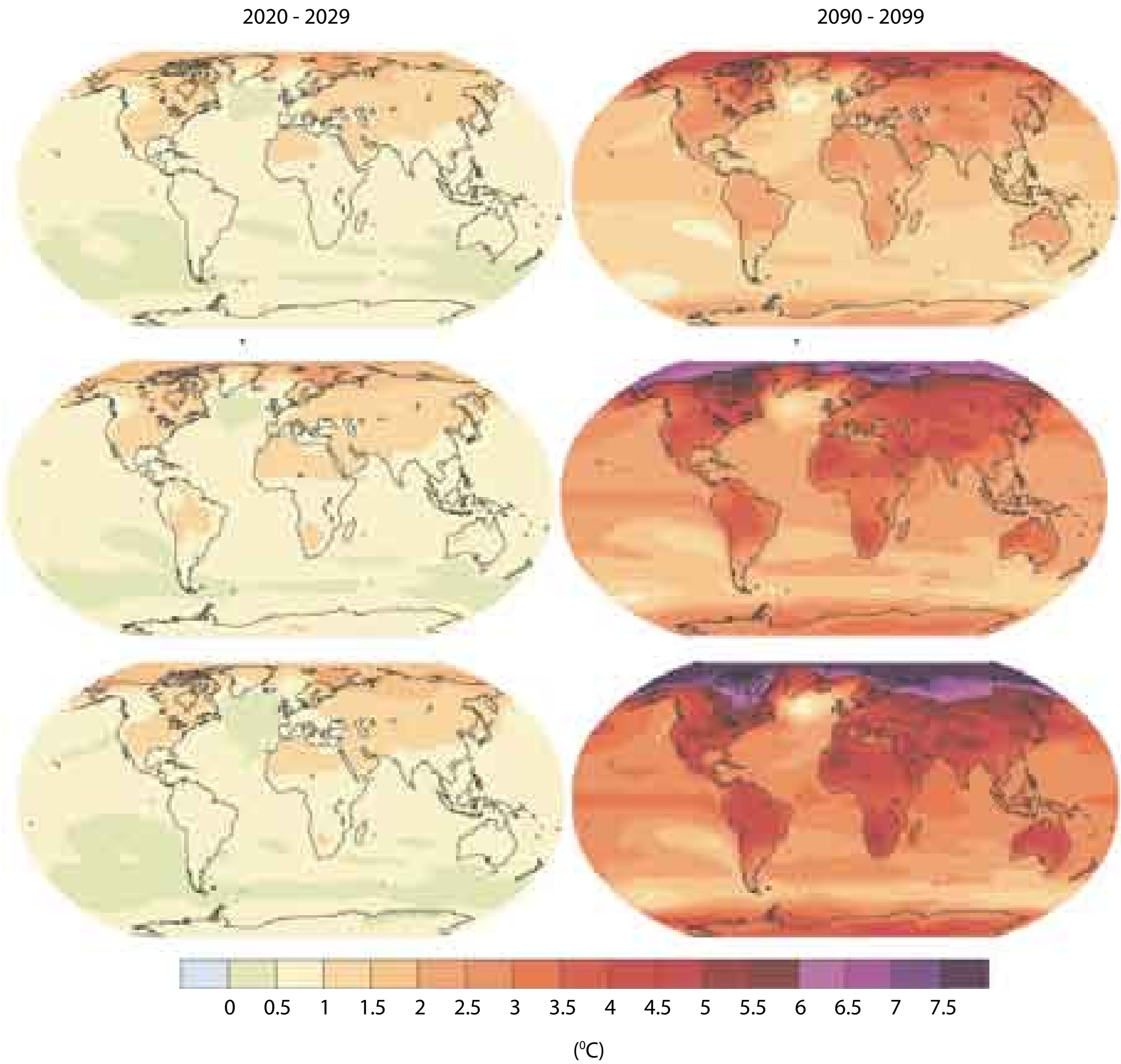
[13] See glossary for definition.

Figure 2.2 Projected Warming 2020–2099[14]



Note: The figures depict atmosphere-ocean general circulation model (AOGCM) projections of surface warming: projected surface temperature changes for the early and late 21st century relative to the period 1980–1999. The panels show the multi-AOGCM average projections for the A2 (bottom row, most pessimistic), A1B (middle row, mid-range), and B1 (upper row, most optimistic). SRES scenarios averaged over decades 2020–2029 and 2090–2099.

Source: IPCC 2007b (reproduced/modified with permission)

may be unavoidable or even exacerbated by practices that increase exposure to climate risks (maladaptation). The likely impacts of climate change are projected to encompass all areas of development, but there are six that are of most concern. These are briefly addressed in the following paragraphs and covered in more detail in subsequent chapters in the South Asian context.

[14] IPCC scenario families contain individual scenarios with common themes. The six families of scenarios discussed in the IPCC's Third Assessment Report (TAR) and Fourth Assessment Report (AR4) are A1FI, A1B, A1T, A2, B1, and B2. A2 is characterized by high emissions, B1 is an optimistic outlook with much lower emissions, and A1B is an intermediate outcome.

Agriculture: Of all potential negative consequences of climate change, the damage to agriculture could be among the most direct and immediate. With their economies closely tied to the natural resource base and to climate-sensitive sectors such as agriculture, developing countries are expected to suffer significant losses from climate change. In some climate scenarios the colder temperate regions (of Northern Europe, Russia, and Canada) could reap short-term gains through higher agricultural yields because of rising temperatures. In contrast, in some developing countries temperatures are already approaching the limits of crop tolerance. Any further increase would lead to declines in productivity. Rain-fed agriculture and rangeland-based pastoral farming remain especially vulnerable to more variable climate patterns.

Water insecurity: Along with agriculture, the availability and distribution of freshwater remains a primary concern. The arid and semi-arid zones, often the poorest parts of the globe, are projected to face diminishing water supplies that could further jeopardize agriculture and livelihoods. Additionally, the retreat of some glaciers and melting of snow cover will pose risks of flooding in low-lying areas and reduce water availability and seasonal flows in the long term.

Natural disasters and extreme climate events: An overwhelming share of the world's natural disasters occur in developing countries, a problem made worse by the growth of poor communities along coastal areas. In the 1990s, climate-related disasters affected more than 2 billion people in developing nations, representing about 40 percent of the total population in the affected countries.[15] Although forecasts are uncertain, projections indicate that with warmer surface temperatures the seas will fuel more violent tropical storms, increasing the risks to coastal areas. There could be a higher incidence of other extreme events such as floods, droughts, and storms. Many countries are already extremely vulnerable to natural disasters. The challenge now is that the natural disasters are augmented by climate change.

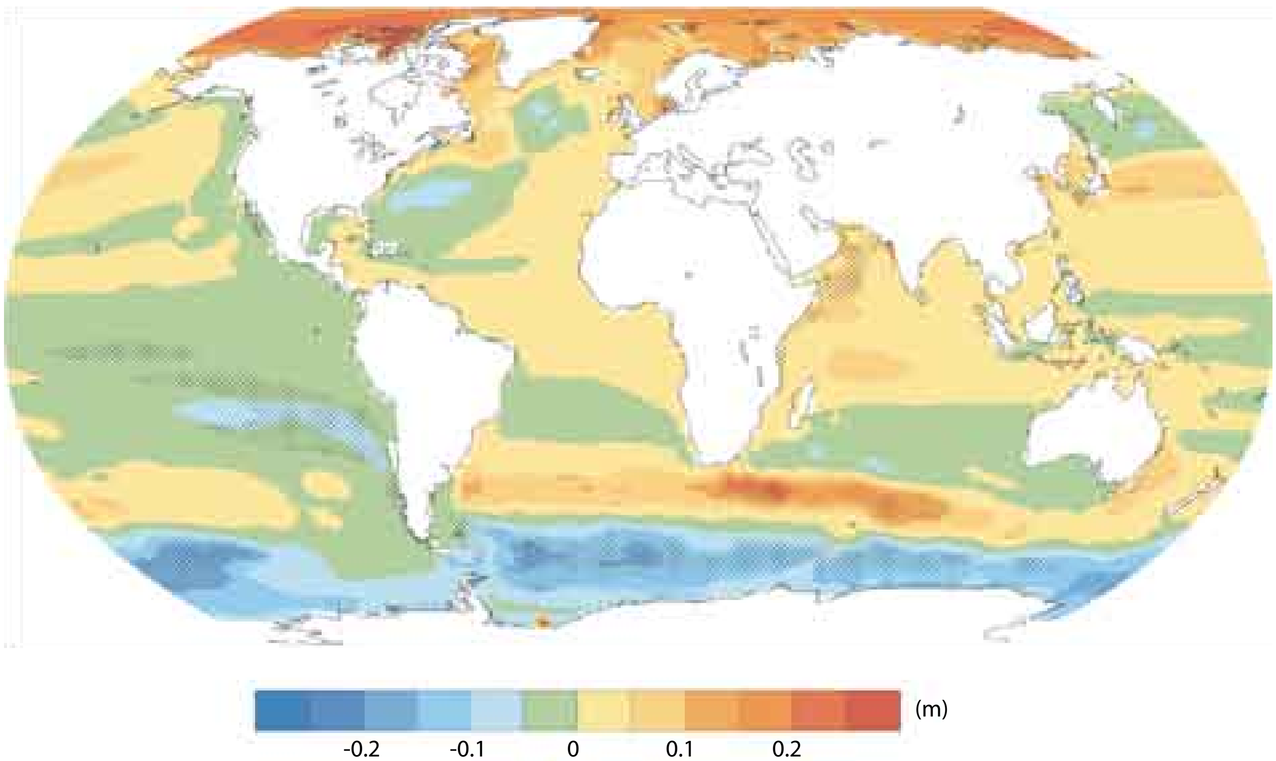
Sea-level rise: Sea-level rise threatens the existence of many small island nations and the development prospects of coastal economies (Figure 2.3). Estimated projections of sea-level rise by IPCC (2007c) for 2100 range from 9 to 88 centimeters, depending on the emissions trajectory. The threats are particularly severe for small island countries, which could be submerged in the worst-case scenarios.

Health: Climate change also brings new challenges for maintaining health. Many of the major vectors for diseases such as cholera, Rift Valley fever, diarrhea, malaria, and dengue are highly climate sensitive and could become more pervasive with rising temperatures. Equally important in poor communities are the indirect effects caused by declining farm yields and food availability that could lead to malnutrition and a heightened susceptibility to other diseases.

Ecosystems and biodiversity: The links between biodiversity and climate change run both ways. Biodiversity is threatened by climate change, but proper management of biodiversity can reduce the impacts of climate change. Human pressures together with climate change are having a discernable impact on the productivity and resilience of ecosystems that are, in turn, critical for life-sustaining environmental services such as watershed protection, soil fertility, and carbon sequestration. The resilience of ecosystems can be enhanced and the risk of damage to ecosystems and humans can be reduced through appropriate adaptive strategies. Though information is sparse and knowledge is limited, research suggests that maintaining and expanding natural habitats remains among the most cost-effective strategies for building climate resilience.

[15] EM-DAT: The OFDA/CRED International Disaster Database, http://www.em-dat.net.

Figure 2.3 Sea-level Rise in 2080–2099 from 1980–1999 Levels



The figure depicts local sea level change (in meters) due to ocean density and circulation change relative to the global average during the 21st century, calculated as the difference between averages for 2080 to 2099 and 1980 to 1999. Positive values indicate local sea level change greater than global change. These results are from an ensemble (arithmetic) mean of more than 16 atmosphere-ocean general circulation models forced with the A1B scenario from the *Special Report on Emissions Scenarios* (SRES). Stippling denotes regions where the magnitude of the multi-model ensemble mean divided by the multi-model standard deviation exceeds 1.0 (Nakicenovic and Swart 2000).

Source: IPCC 2007a (reprinted with permission)

Confronting Climate Risks: The need for Adaptation

Substantial climate change is inevitable, so countries will need to adapt to those changes and reduce their exposure to climate risks. Climate change impacts the poor disproportionately because they depend heavily on climate-sensitive natural resources and subsist in an environment of scarcity where even small shocks can cause irreversible loss. Hence, climate change poses an additional risk to development and could potentially delay or reverse the attainment of many of the MDGs, including those on poverty eradication, child mortality, malaria and other vector-borne diseases, and environmental sustainability. Some of the resulting damages could be in the form of new challenges (e.g., sea-level rise) or severe shocks (e.g., extreme events) that countries are not equipped to handle. Others could emerge as existing threats (e.g., flooding or irregular rainfall) made increasingly severe by climate change.

Is Development the Remedy for Building Climate Resilience?

Development is necessary to build climate-resilient economies, but it may not suffice.

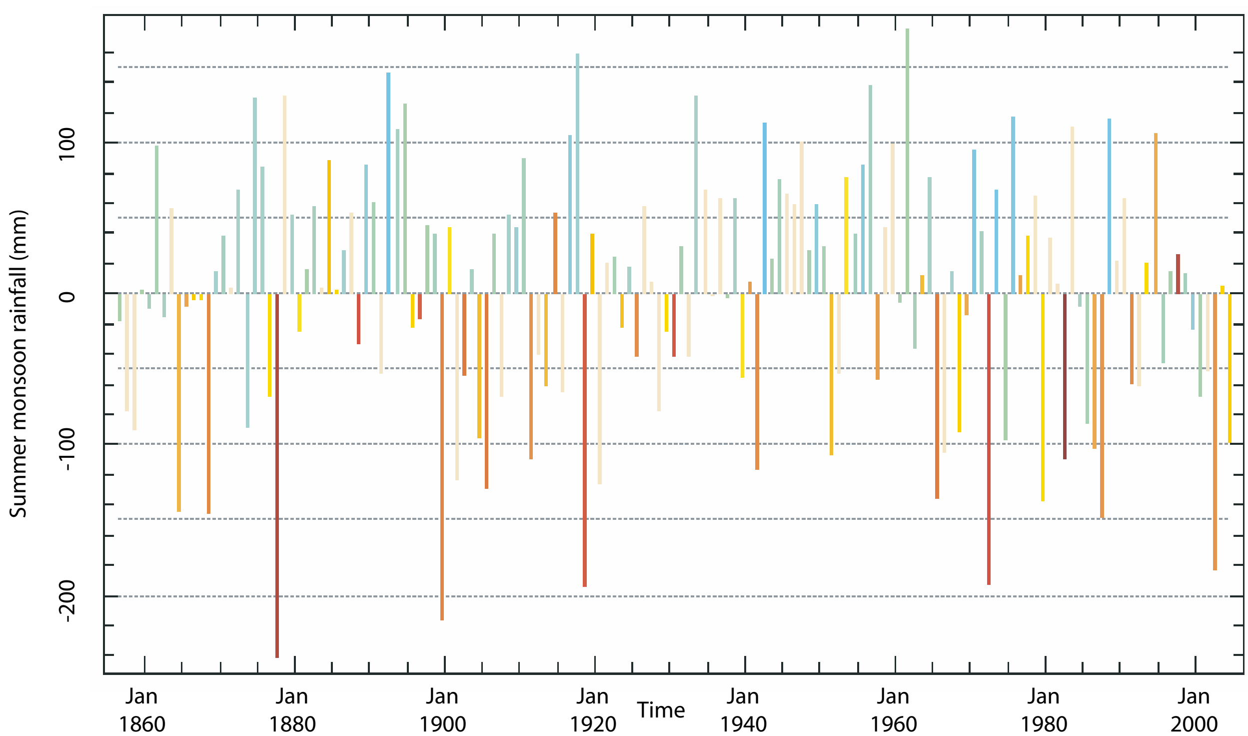
Box 2.3 A Word of Caution about Climate Models

Predicting the future is always a difficult endeavor. It is particularly challenging in the case of long-term climate change, which depends on a large number of parameters—temperature, precipitation, snow melt, and many others—with complex interactions. A number of increasingly sophisticated global climate models have been developed that can provide insight into possible future climate scenarios, particularly those arising from human development choices, offering the potential to further analyze the various environmental, social, and economic impacts of such choices and make appropriate decisions relating to climate-change adaptation.

Global climate models continue to evolve and improve, reflecting our growing understanding of complex biophysical and socioeconomic interactions and the use of more comprehensive databases, and their results have been interfaced with other models to downscale outputs to finer resolutions.

Despite these improvements in modeling techniques, the results can only be indicative of a very complex reality. Although many models agree on the broad climate-change implications at an aggregated spatial and temporal level, there is still significant divergence in results for specific locations or time periods in the future. The considerable uncertainty that remains in assessing the future trends of any one parameter (e.g., rainfall, temperature) is compounded when trying to predict how those parameters will interact with one another. For example, even if models show precipitation increases that may seem to be useful from, say, an agricultural viewpoint, the runoff or soil moisture may decrease due to increasing temperature and resulting evapotranspiration. Crop-water requirements and reservoir evaporation may increase, resulting in added demands and losses. This precipitation may also occur over shorter periods, thus increasing the threat of floods, droughts, and erosion.

Finally, complex climate interactions exist at a global scale. For example, rainfall in South Asia has been shown to be closely correlated with variations in the El Niño southern oscillation in the Pacific Basin. The figure below shows monsoonal rainfall variations against the norm over time. Variations in color shade reflect the intensity of hot El Niño events (red) and cold La Niña events (blue). The results indicate a close relationship between drought in South Asia and El Niño events in the Pacific. How climate change will affect the El Niño southern oscillation and its relationship with rainfall in South Asia is still unknown.



Sources: Rainfall data: Indian Institute of Tropical Meteorology (IITM). SST data: Kaplan NINO3 index from Optimal Smoother analysis of MOHSST5 monthly sea surface temperature anomalies

Economic well-being reduces vulnerability to climate risks. Developed countries are better equipped to deal with the impacts of climate change than developing countries. For instance, economic growth is typically accompanied by economic diversification, reducing the potential impact of climate change by spreading risk. Areas served by appropriate infrastructure will be more resilient to climate shocks. But the strategy of pursuing economic growth to combat the threat of climate change carries its own risks. First, climate variability itself may reduce growth capabilities. Second, climate change may outpace development, leaving the poor and vulnerable even more exposed to climate shocks. Third, vulnerability in the future depends not only on climate change but also on how development has been generated and sustained. A sustainable growth trajectory creates greater climate resilience by reducing the vulnerability of natural assets: for instance, healthy soils induce higher crop resistance to climate fluctuations. So the development paradigm of the past may not be enough, but development that integrates climate risks and sustainability would need to be part of the answer.

How should Developing Countries Adapt to the Risks of Climate Change?

The impact of climate change is diverse and the effects will vary across countries and sectors. Consequently, there can be no one-size-fits-all mindset when developing a climate risk-management approach. Any approach will have to be tailored to fit local risks and conditions. Appropriate policy will consist of a portfolio of options on risk management, at all levels of governance, and will include possible collaboration with private entities, local communities, and international agencies.

Climate change increases the costs of development. It alters the comparative advantage and productivity of many natural-resource-dependent economies. It calls for building climate-resilient infrastructure, which raises construction and maintenance costs. To counter the risks of natural disasters, greater investment is needed in preparing for disasters and building climate resilience. Estimates of the likely additional costs of adaptation vary widely, from a relatively modest US$4 billion a year to an exorbitant US$86 billion a year[16] Nevertheless, the provision of new and additional financial resources is essential to meet global development aspirations when faced with the burdens of climate change. Indeed, it was a commitment to such extra resources that provided the common ground to bind diverse parties to the Bali Action Plan in 2007.[17]

Are there limits to "Climate-Proofing?"

An effective response to climate change must combine adaptation to address the inevitable and mitigation to prevent the avoidable. Ultimately there are limits to the ability to adapt to fundamental and rapid climate change, and the economic costs would become prohibitive. It will not be possible to climate-proof countries or people against all possible climate outcomes, particularly if the changes become excessive. Adaptation to climate change therefore needs to be combined with mitigation. The two strategies are related and the cost of each will influence the global choice of policies for both. Hence there is a balance that needs to be struck.[18]

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[16] The lower bound is from the Bank's Clean Energy Investment Framework (CEIF) and the upper bound is reported in the United Nations Development Programme (UNDP) *Human Development Report 2007/2008* (Watkins 2007). It should be noted, however, that these figures are imprecise, make numerous assumptions, and use widely different approaches. Considerably greater research on both methodological and empirical issues is needed to provide more reliable figures.

[17] Bali Action Plan, http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf.

[18] To be precise, when interior solutions are available, the two policies (adaptation and mitigation) are strategic substitutes and thus a simultaneous decision on the optimal choices of each can achieve a given level of welfare at *lower cost* than sequential decisions in which one policy option is fixed first (for instance, adaptation) and the other (for instance, mitigation) determined in a subsequent stage.

The Global Emission Footprint

What are the Main Sources of GHGs?

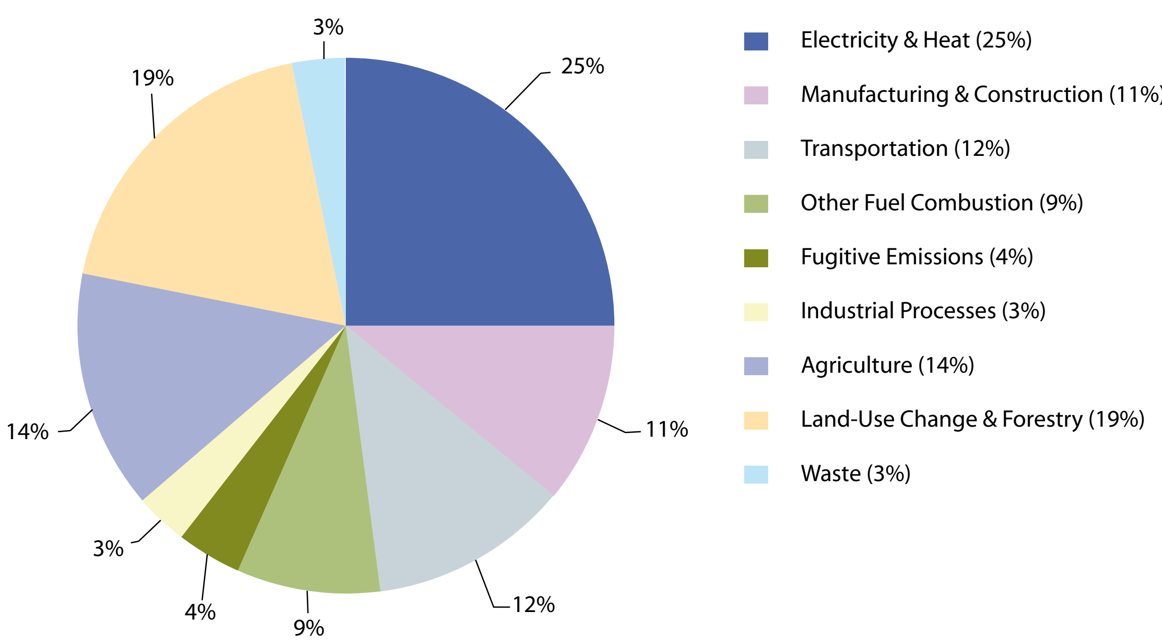
The emissions that drive climate change are ubiquitous and derive from almost every economic activity: transport, industry, energy use, agriculture, and deforestation. Energy-related emissions (from production, transformation, and consumption) account for more than 65 percent of GHGs, followed by deforestation, which contributes about 18 percent. The remainder comes from agriculture and wasteland use (Figure 2.4). Deforestation and fossil fuel consumption primarily produce CO_2, while agriculture and waste are the main sources of methane emissions. Methane is a highly potent GHG.

Which Countries are Responsible for Emitting GHGs?

Measuring a country's GHG emissions and consequent contribution to climate change is surprisingly complex and highly controversial. There are a variety of methods by which emissions can be measured, each producing different results and different country rankings. Historical emissions reflect a country's past responsibility for the current climate challenge. Current emissions reflect the ongoing additions to the stock of GHGs in the atmosphere. Other indicators, such as emissions per person or emissions per unit of production as measured, for example, by gross domestic product (GDP), offer more nuanced measures and acknowledge that countries differ in responsibility, circumstance and capacity to reduce GHGs.

Historical contribution of GHGs: Climate change is a consequence of the cumulative build-up of GHGs, dating back as far as the Industrial Revolution. It is therefore no surprise that developed countries are largely responsible for the build-up of GHGs and still emit, in total, slightly more than developing countries. The United States ranks as the highest contributor to cumulative CO_2 emissions (with a

Figure 2.4 Sources of GHG Emissions



Total Emissions 40,809 Metric Tons (Mt) Co_2 in 2000

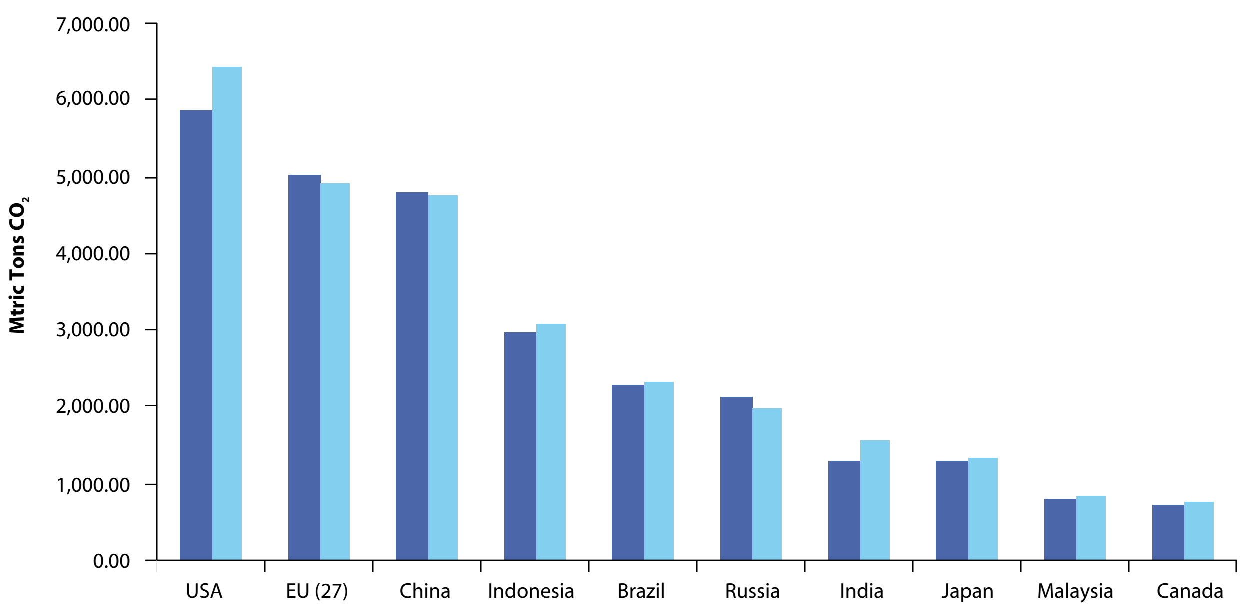
Source: WRI 2009

share of 29 percent), followed by the countries of the present European Union (26 percent) and Russia (8 percent).[19] Overall, developing countries have contributed only 24 percent to historical emissions, but their emissions are rising rapidly and at current trends would soon overtake the developed countries. Recognizing the importance of historical GHGs, there is a global statement that developed countries should take the lead in combating climate change.[20]

Current emissions: A relatively small number of countries, those developed and some developing, account for the bulk of current emissions. These countries are large emitters either by virtue of their burgeoning populations (such as China, Brazil, Mexico, and India) or their affluence (such as the United States and members of the European Union). In 2005 the largest emitters were the United States, the European Union, and China (Figure 2.5), which together accounted for about 40 percent of global emissions. More importantly, the 20 largest emitters are responsible for more than 80 percent of global emissions. The distribution of emissions is therefore highly skewed, but this also reflects the distribution of global GDP and population.

Emissions per person: The sheer size of population in some economies implies that to achieve any level of development they will need to consume considerably more resources (including GHG-emitting fossil fuel) and would therefore have larger total emissions. A ranking of countries based on per capita emissions standardizes for these differences.

Figure 2.5 GHG Emissions of 10 Highest Emitters, 1995 and 2000



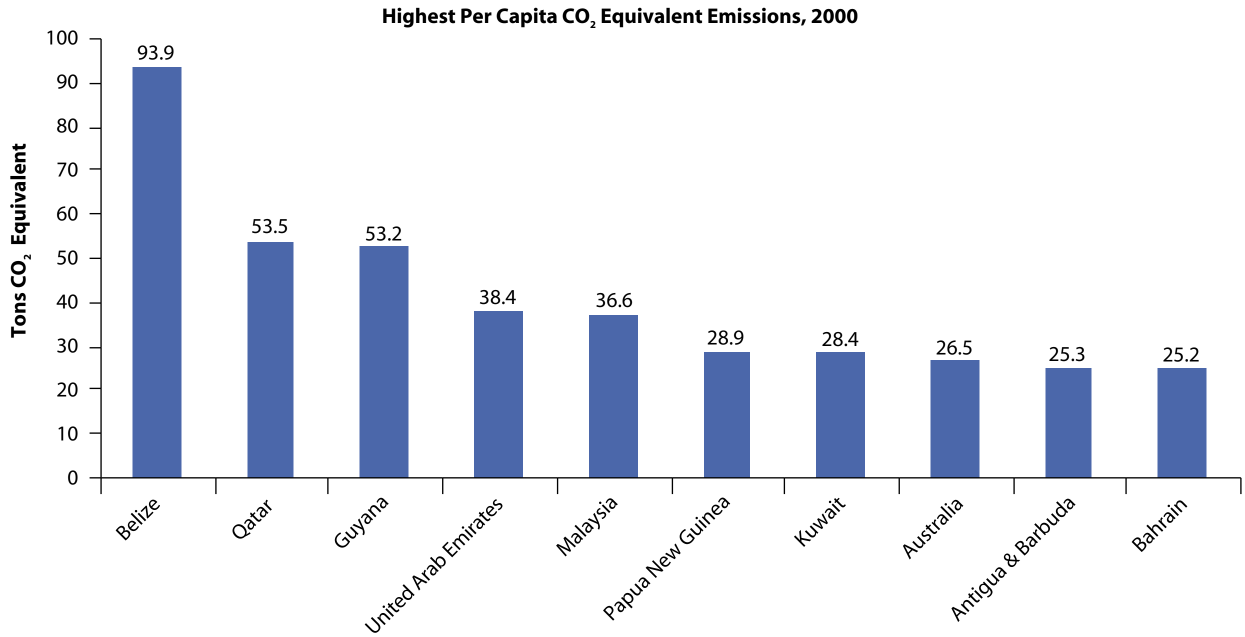
Source:. WRI 2009

In general, richer countries, with more affluent consumption patterns, tend to have higher emissions than poorer countries. However, generalization can be misleading as there are significant differences and variations within any cluster of countries ranked by development levels. Figure 2.6 shows countries

[19] These figures are based on emissions from 1850 to 2002. The European Union is treated as a single party reflecting its status in UNFCCC.

[20] Article 3.1 of the United Nations Framework Convention on Climate Change (UNFCCC), http://unfccc.int/essential_background/convention/background/items/1355.php) and paragraph 1(b)(i) of the Bali Action Plan (http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf.

Figure 2.6 Countries with the Highest Per Capita CO_2eq Emissions,[21] 2000



Source: WRI 2009

with the largest per capita emissions; the list includes both developed and developing countries.

What Determines Per Capita Emission Levels?

Per capita emission levels are influenced by resource endowments and geography. In some countries an abundance of fossil fuels has created a comparative advantage in pollution-intensive activities (e.g., coal in Australia and oil in United Arab Emirates). In other cases, deforestation has contributed to high levels of per capita emissions. Colder countries, though often wealthier, have greater heating needs and as a result are predisposed to higher per capita emissions. This variability in per capita emissions has troubling implications for global agreements to reduce emissions. An international agreement predicated on per capita entitlements would likely face difficulties in garnering support, for example, from the low-income countries with higher per capita emissions than many developed countries.

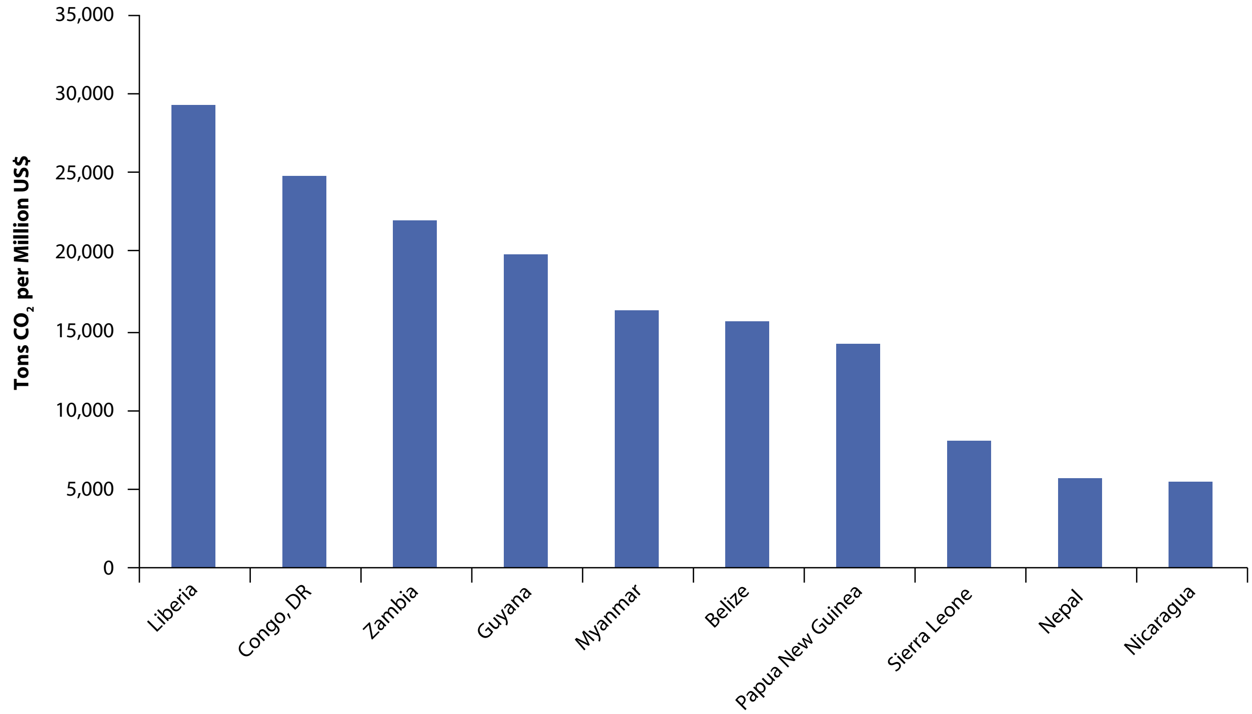
Emission intensity: Emission intensity measures the amount of GHG emitted per unit of GDP output. It varies widely across countries at all levels of development and income (Figure 2.7). There are three key factors that determine a country's emission intensity. First, in economies with rapid growth, emission intensity declines over time as GDP typically increases faster than emissions.[22] Second, the emission intensity in a country reflects its economic structure and the mix of agriculture, manufacturing, and services. Clearly, in some sectors (such as cement production) more pollution is generated in producing a unit of value than in other sectors (such as banking and insurance). Finally, emission intensity also depends on the mix of fuels used to generate electricity, and the efficiency of energy use.[23]

[21] See glossary for definition.

[22] This is an obvious arithmetic necessity because the emission elasticity of GDP must be less than unity in any economy with a diversified economic structure comprising sectors that encompass low and high pollution-intensive industries.

[23] As with all other measures, rankings based on emission intensities remain controversial. In an increasingly globalized world products are exported across national boundaries. Emission intensities attribute pollution to the source of production and not its destination of consumption.

Figure 2.7 CO_2 Intensity: Main Emitters, 2000



Source: WRI 2009

At What Level should the World Stabilize GHG Emissions?

Determining the appropriate stabilization level and path remains the most controversial and divisive issue in global climate negotiations. The current level of GHG concentrations is approximately 430 ppm CO_2e and is rising at about 2 ppm each year.[24] Some favor rigorous and immediate stabilization of emissions; others propose a more cautious approach and emphasize the need for addressing priorities such as poverty and the MDGs. There are two broad analytical approaches that guide judgments on the appropriate stabilization path: the precautionary approach (following the precautionary principle) and the economic approach.

The precautionary approach: The precautionary principle places a high priority on avoiding calamitous and irreversible outcomes, even if these are highly uncertain. This is the view advocated by the United Nations Development Programme's *Human Development Report* (UNDP 2007), which calls for stabilization at 450 ppm CO_2e, an emission level that will likely produce a 2ºC to 3ºC increase in temperatures. The approach aims to avoid concentrations that would risk reaching tipping points: levels at which feedbacks would cause GHG concentrations to rise further through, for example, the release of methane from permafrost (mostly in the Arctic regions), release of carbon dioxide from oceans, and increased solar radiation from polar icecap melts, resulting in a rapid rise in temperatures with largely unknown consequences. Critics of this approach contend that with the many uncertainties and the large unknowns the risks of wasteful expenditure on mitigation could outweigh the potential costs of climate change. The suggested approach involves a wait-and-see

[24] The implication is that the Earth is likely committed to a 2ºC warming.

stance, with an early emphasis on adaptation followed by mitigation if this becomes necessary (Lomborg 2007).[25]

The economic approach: Economics have searched for strategies that balance the costs of intervention with the perils of inaction. Assessments compare the expected costs of reducing or stabilizing GHGs (mitigation) with the expected benefits of emission reductions (in terms of avoided climate damages). There is broad agreement on the likely costs of stabilizing emissions. These are typically estimated in the range of 3–5 percent of GDP (IPCC 2007a; Heal 2008).

However, there is little consensus on the benefits of mitigation, defined as the avoided costs and damages from climate change. Estimates of the avoided damage from climate change vary from a low figure of 1 percent of GDP (Nordhaus 2006) per annum to a dramatic 5–20 percent (Stern 2006; Sterner and Persson 2007). A damage estimate of 1 percent of GDP is within the margin of GDP accounting error, and suggests the need for a highly circumspect approach to mitigation. Conversely, high damages of 5–20 percent would justify early mitigation measures to avoid the high costs and possibly catastrophic outcomes. The large differences reflect the weight given to future impacts and the factors included in the calculation of climate damages. Low estimates are obtained when the damage assessments leave out nonpecuniary losses—in particular the loss of vital environmental services[26]—or place a low weight on damages in the distant future (termed the discount rate).

[25] The counter to this is that it would be too late to arrest the damage because of the long lags in climate systems. CO_2 endures in the atmosphere for about a century. Consequently, current climate impacts are a consequence of the atmospheric build-up of previous generations.

[26] Sterner and Perrson (2007) demonstrate this outcome in the Nordhaus model, which has typically produced low-end estimates.

Michael Foley/World Bank

Who is Right, the Climate Optimists or the Climate Pessimists?

The solution to the climate challenge lies not in impeding development and growth, but in finding strategies that weaken the link between economic activity and GHG emissions. Since growth spurs emissions in very rough proportion to the income it generates, there are legitimate concerns that mitigation would jeopardize other urgent development priorities, such as energy access, education, health, and nutrition. The ultimate solution to the climate challenge therefore lies in finding strategies that decouple economic activity and GHG emissions. New technology would need to play a pivotal role in finding longer term solutions to this far reaching problem.

An overarching challenge in addressing climate-related problems is the asymmetry in the cause of the problem and impacts across countries. The developed countries have contributed most to existing stocks of GHGs, but it is the developing countries, with their dependence on climate-sensitive sectors, who will be disproportionately affected. To address this problem will call for an unprecedented level of global cooperation and a substantial transfer of resources both to address the development challenges imposed by climate change and to slow the process of climate change. There is a governance challenge at the global level that requires collective action among nations and among groups within societies to ensure fair and equitable access to the global atmospheric commons. Global and regional cooperation will be crucial, given the potential damage that free riding can inflict by undermining mitigation by others. In the short term, this will mean making substantial resources available to ensure that developing countries do not have to suffer the costs of any chosen emission stabilization path. In the longer term, technology may provide the answers needed to sustain growth in a carbon-constrained world.

Chapter 3 identifies the broad impacts of climate change in South Asia and the region's contribution to the problem. It outlines the reasons why the region is highly vulnerable to the impacts of climate change, with a particular focus on the likely high impact sectors.

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