CHAPTER 3

The Regional Scene: South Asia's Climate Vulnerability and Contribution to Greenhouse Gas Emissions

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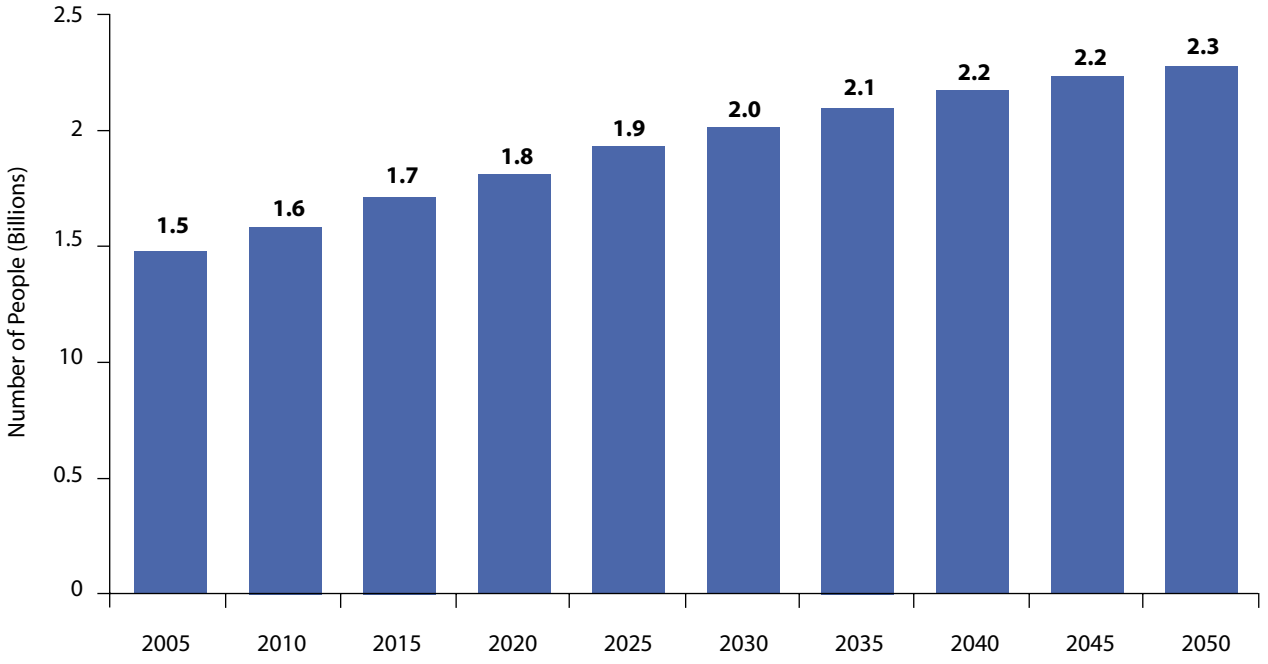
Why is South Asia Vulnerable to Climate Change?

Geography coupled with high levels of poverty and population density has rendered South Asia especially vulnerable to the impacts of climate change. The region faces daunting climate-related development challenges. The likely impacts of climate change in the form of higher temperatures, more variable precipitation, and more extreme weather events are already felt in South Asia. It has been projected that these will intensify. High population levels translate into increased resource demands on an already stressed natural resource base. By 2050, South Asia's population is likely to exceed 2.2 billion from the current level of 1.5 billion (Figure 3.1). With an estimated 600 million South Asians subsisting on less than US$1.25 a day, even

Figure 3.1 South Asia Population Projections



Source: World Bank 2009

small climate shocks can cause irreversible losses and tip a large number of people into destitution.

Through much of South Asia, poverty is still largely in the rural areas and closely intertwined with natural resource degradation. About 70 percent of South Asians live in rural areas and account for about 75 percent of the poor. Most of the rural poor depend on agriculture for their livelihoods. Agriculture employs about 60 percent of the labor force but contributes only 22 percent of regional GDP. With their rural economies closely tied to the natural resource base and climate-sensitive sectors such as agriculture, the poor in South Asian countries are likely to be disproportionately affected by climate change.

The region is already marked by climate variability and a high incidence of natural disasters. South Asia's climate is as diverse as its landscapes. The region's geographic expanse covers a variety of climate zones and ecosystems ranging from lush tropical forests to arid deserts and high-altitude forests and lakes. Climate risks in the region reflect these varying conditions with regular droughts, floods, wind storms, and tropical cyclones. The region is highly susceptible to natural disasters. More than 750 million people, about half of the region's population, have been affected by at least one natural disaster in the past two decades. The region shares common geological formations and river basins, and natural hazards frequently transcend national boundaries. With climate change the frequency and incidence of such natural disasters is projected to increase.

Compounding these risks is the region's heavy reliance on the monsoons. The monsoon is the most significant climate event in the region's economic calendar. It carries more than 70 percent of South Asia's annual precipitation in a brief four-month period. The monsoons also exhibit substantial annual variations. A buoyant and timely monsoon heralds bountiful harvests and financial security. However, when the monsoons fail or are excessive, suffering and economic loss are widespread. About 60 percent of the cultivated area is rain-fed, and hence the rural economy of South Asia critically depends on the timely arrival of the monsoons. The worst affected are the landless and the poor, whose primary source of income is agriculture. If climate projections are indicative of future trends, the risks associated with water-related climate variability are likely to worsen.

The Himalayas have a significant influence on the climate and economy of the region. The Himalayan system shapes the critical and often unpredictable monsoon dynamics. It acts as a natural reservoir for sustaining crops and providing groundwater recharge. In fact, it is home to a unique ecosystem. The Himalayan ecosystem sustains some 1.5 billion people who live directly in the floodplains of its many rivers (e.g., the Brahmaputra, Ganges, Indus, and Meghna). The Ganges River Basin alone is home to about 600 million people (see Figure 3.2). The retreating of some glaciers in the Himalayas could present the most far-reaching challenge to the region. The Himalayas are home to the region's glaciers, which are sensitive to increases in temperature. Some glaciers are receding more rapidly than the global average, leading to increased

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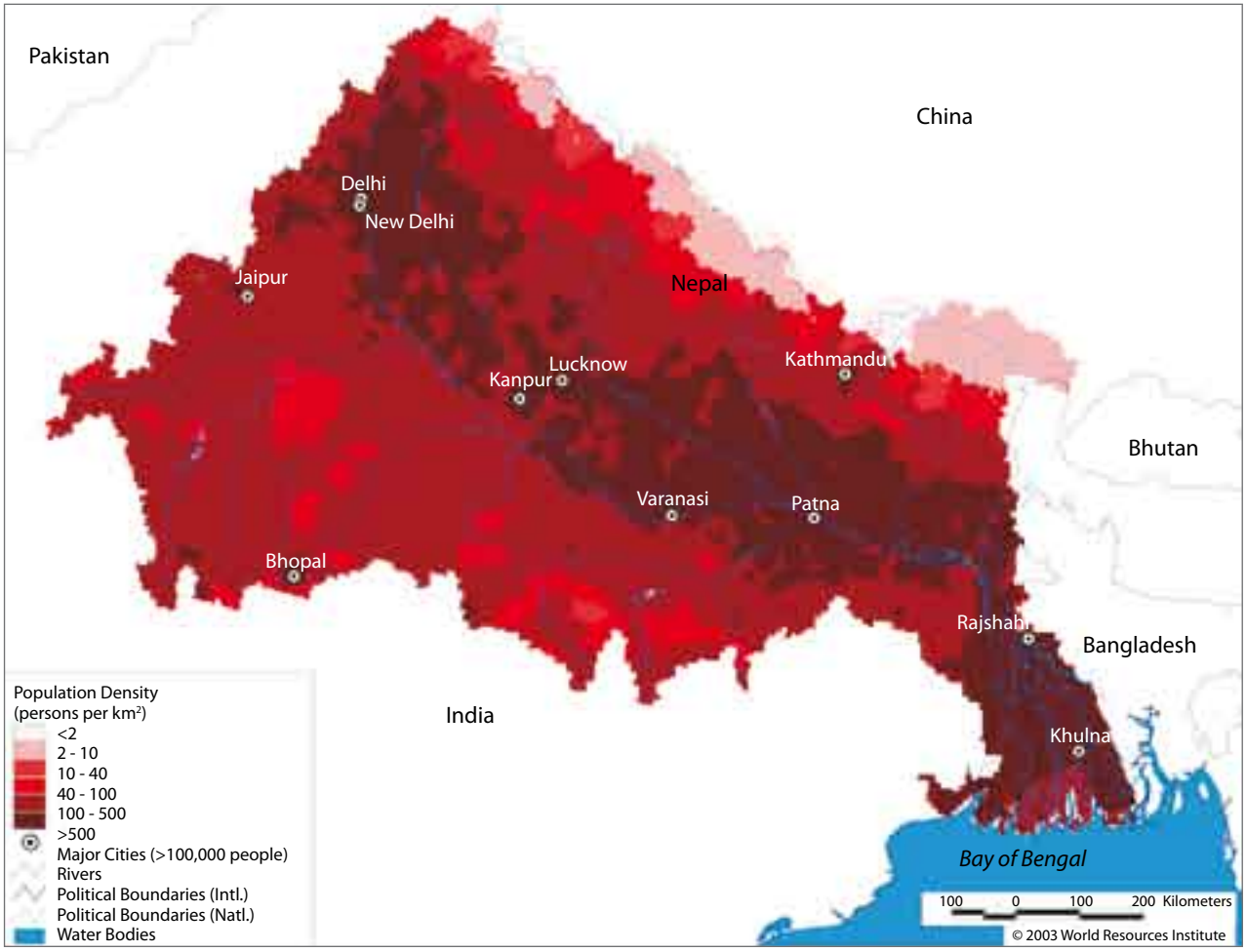
Figure 3.2 Ganges River Basin



Source: WRI, 2003

threats of glacial lake outburst floods in Bhutan and Nepal (see Figure 3.3). This poses an unprecedented threat to water supplies, lives, and the economy of the region. With melting of some glaciers, flood risks would increase in the near future. In the long term, there can be no replacement for the water provided by glaciers, and this could result in water shortages at an unparalleled scale. Such an occurrence could necessitate a shift in the economic activities away from water-intensive activities. A very important point to be noted is that the risks cut across borders and are regional. Possible glacier retreat in Nepal, for instance, can flood farms in distant Bangladesh, and climatic variations in, for example, China may impact some glacier retreat in South Asia. Addressing these problems calls for considerable regional cooperation.

The region has a long and densely populated coastline with low-lying islands that are vulnerable to sea-level rise. Sea-level rise is a major source of concern not only for coastal urban areas (e.g., Chennai, Cochin, Karachi, Kolkata, and Mumbai) but also for the fertile delta systems, which are threatened by both inundation and salinity intrusion (e.g., in Bangladesh and the river deltas of the Cauvery, Indus, Krishna, and Narmada). Saltwater intrusion in low-lying agricultural plains and water resources could lead to localized food insecurity, the spread of water-related diseases,

Figure 3.3 Glacial Lakes from Retreating Glaciers

This image from the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) instrument aboard NASA's Terra Satellite shows the termini (the ends) of the glaciers in the Bhutan-Himalaya. Glacial lakes have been rapidly forming on the surfaces of debris-covered glaciers worldwide during the last few decades.

Source: NASA, 2002

and the contamination of freshwater reserves. Parts of the east coast (Bangladesh and the Indian state of Orissa) are particularly vulnerable to cyclones and storm surges, and some projections suggest that these could become more devastating in the future. Low-lying islands (the Maldives, coastal areas of Sri Lanka, and the chars and islands of Bangladesh) stand most to lose from sea-level rise and the threat of coastal storms. The natural mangroves (Sundarbans) and coral reefs that have helped buffer some of these impacts would vanish if there is a significant climate change.

Urbanization poses an additional challenge in the region. South Asia is home to some of the fastest growing cities in the world. South Asia's burgeoning cities are seen as its icons of development, having fueled much of the investment and economic diversification that has underpinned rapid growth. The cities account for more than 25 percent of regional GDP, and their ability to attract and retain investment has a direct impact on overall economic performance. On the other hand, rapid urbanization has been accompanied by increased climate-related vulnerabilities and a steady deterioration in the quality of the urban environment. Projections indicate that in three decades about half the region's population will dwell in the cities. (See Figure 3.4.) By 2020, Mumbai will be the second largest city in the world, closely followed by Delhi and Dhaka. Together with Karachi and Kolkata, five of the world's 11 megacities will then be in South Asia. Dhaka is already the fastest growing megacity in the world, drawing an estimated 300,000 to 400,000 mostly poor migrants each year. In Mumbai, more than half the population is crowded into about 2,000 densely populated

slums that are at risk from flooding and where settlements lack basic protective infrastructure. There are particular challenges in making cities climate resilient. Building urban resilience requires improving infrastructure, governance, and finance. Without a substantial investment in basic amenities and infrastructure in these large cities, climate change will exacerbate existing vulnerabilities.

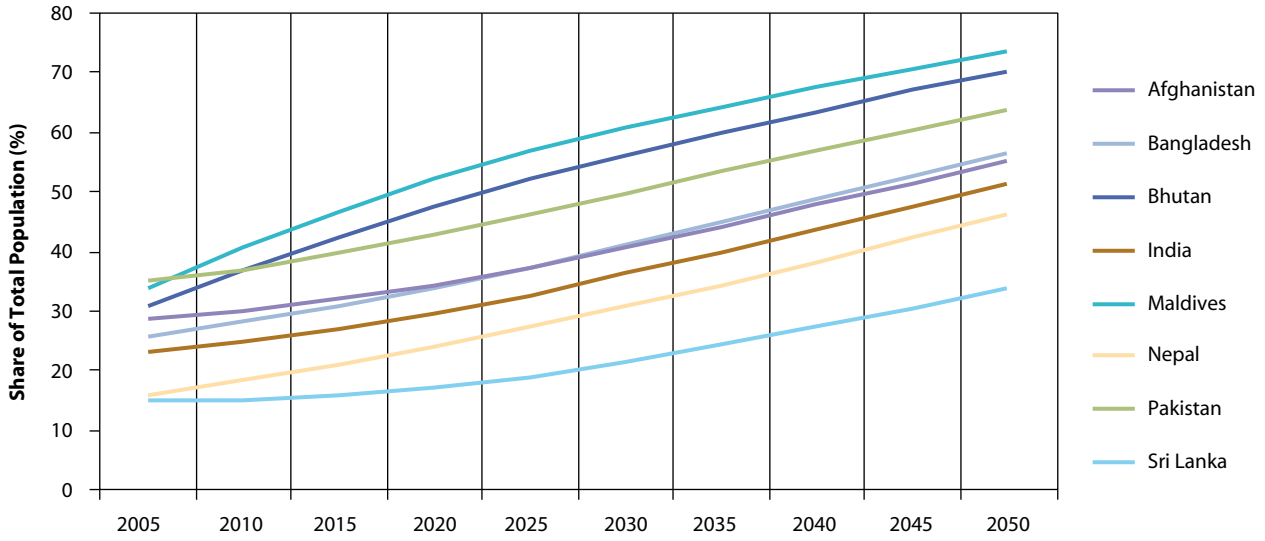
In sum, high population densities, a large concentration of poverty, and climate variability have all combined to make South Asia highly sensitive to the likely consequences of climate change. Climate change will likely compound the pressures on key resources associated with growth, urbanization, and industrialization. The appendix provides a snapshot of risks and climate profiles for each country in South Asia.

Rapid economic growth has been instrumental in reducing poverty in South Asia. During the 1990s, South Asia's economies grew rapidly at an average of 6 percent annually. Growth further accelerated to 6.5 percent during 2000–2007 and has lifted millions out of poverty. South Asia, however, is the least integrated region in the world and would grow further if its markets were more integrated. Regional cooperation can be a powerful tool for increasing growth, reducing inequality, increasing energy trade, and reducing vulnerabilities for the poor. Climate change will reinforce the need for greater levels of economic integration. For instance flood risks, population displacement, and the spread of climate-sensitive diseases are likely to transcend national boundaries. Regional cooperation can be helpful in addressing climate risks and lowering income inequality. Likewise, regional energy trade can contribute to the goal of low-carbon development. The challenge for South Asia is to maintain high growth rates while being climate resilient, environmentally sustainable, and inclusive.

What might the Future Hold for South Asia?

Projecting climate futures is a daunting task. Changes will depend on the unknown future path of GHG emissions, the response of physical systems to emission levels and, nonlinear feedback processes. While acknowledging the many uncertainties a broad consensus has emerged

Figure 3.4 South Asia Urban Population Projections



Source: UN 2007

about the likely risks and patterns of climate change under various scenarios developed by the IPCC. This section focuses on the primary climate variables: temperature; precipitation; runoff and the major consequences. The Appendix contains more scientific details.

Temperature

There is broad consensus that the world is warming. There is ample evidence that by mid-century temperature increases ranging from 1°C to 2°C are likely to occur. In South Asia, this warming is projected to vary regionally, with already warm areas such as Sri Lanka and the Maldives seeing the lowest rise (about 1°C) while the higher altitude areas of Afghanistan, Bhutan, and Nepal experiencing a rise of 1.5°C to 2.5°C in the moderate scenario put forward by the IPCC.[27]

Precipitation

The projections suggest that the wet regions will get wetter and the dry regions drier. Forecasts indicate higher but more variable and intense rainfall in South Asia, except in the relatively drier areas of Afghanistan, western India, and Pakistan, which could see even less rainfall. IPCC projections indicate that the number of days for which extreme events last (especially floods and droughts) would increase in duration and severity. This effect will be especially pronounced in South Asia with its reliance on the monsoons.[28]

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Runoff

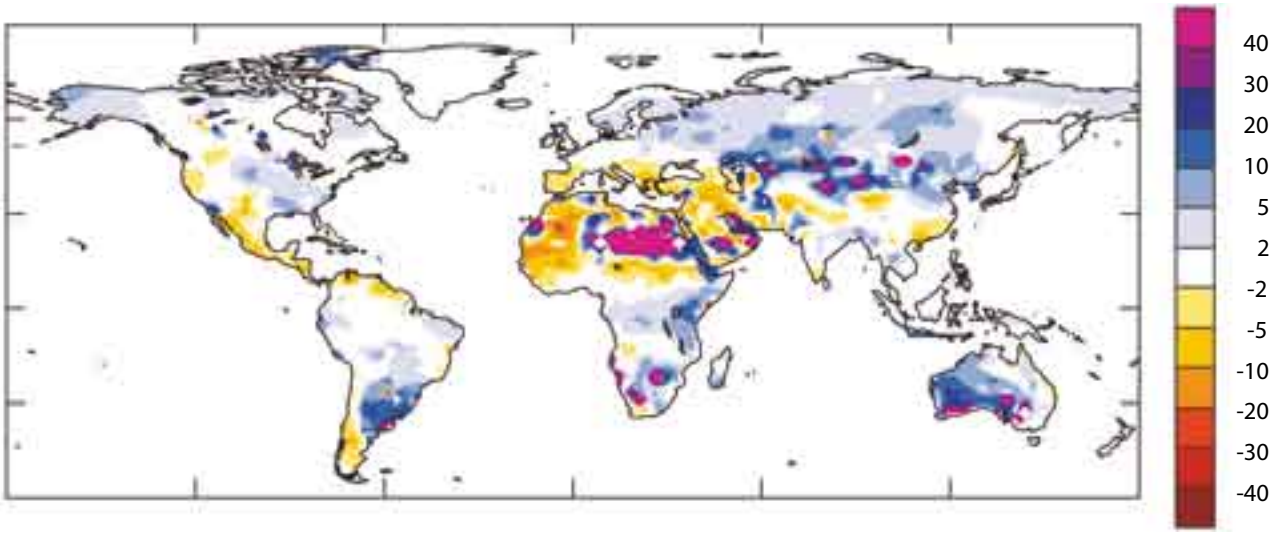
Changes in precipitation and temperature are expected to interact in complex ways to change the balance between "green" water and "blue" water. "Green" water is the water that is used or lost in catchments before it reaches the rivers, while "blue" water is the runoff that reaches the rivers. The runoff is expected to change significantly in the subcontinent (Figure 3.5), with implications for agriculture. The Indus and Ganges/Brahmaputra Basins are expected to experience increased runoff driven by precipitation changes and glacial melt. After the glacial melt, however, there could be significant declines in flows. By 2050, the annual runoff in the Brahmaputra is projected to decline by 14 percent and the Indus by 27 percent (IPCC 2001). Afghanistan is expected to be particularly impacted by a reduction in flows with considerable implications for storage, irrigation, and the development and reliability of hydropower systems. Such outcomes will be further complicated by changes in water use in the basins including diversions, groundwater-surface water interactions, and increased demands for irrigation, hydropower, industrial, and municipal water supplies by the increasing population.

[27] This is one of the scenarios used by the IPCC in its climate projections. It is moderate in its assumptions about the world and the pace at which it will change. For instance, it assumes low rates of population growth and land-use changes; medium availability of resources such as oil and gas; very high GDP and energy-use growth; and rapid technological change, among other things (Nakicenovic and Swart 2000).

[28] However, evidence presented in the India National Communications finds that there is no statistically discernible trend in the monsoons. This is because the monsoons have always exhibited high stochastic variation and a stable core remains. (Source: Government of India, Ministry of Environment and Forests 2004).

Figure 3.5 Relative Change in Runoff in the Twenty-first Century

Country	Mean runoff change (%)
Afghanistan	–20 to –10
Bangladesh	20 to 30
Bhutan	10 to 20
India	30 to 40
Maldives	20 to 30
Nepal	10 to 20
Pakistan	> 40



Ensemble (arithmetic) mean of relative change (percentage) in runoff for the period 2041–2060, computed as 100 times the difference between 2041–2060 runoff in the SRES A1B experiments and 1900–1970 runoff in the 20C3M experiments, divided by 1900–1970 runoff.

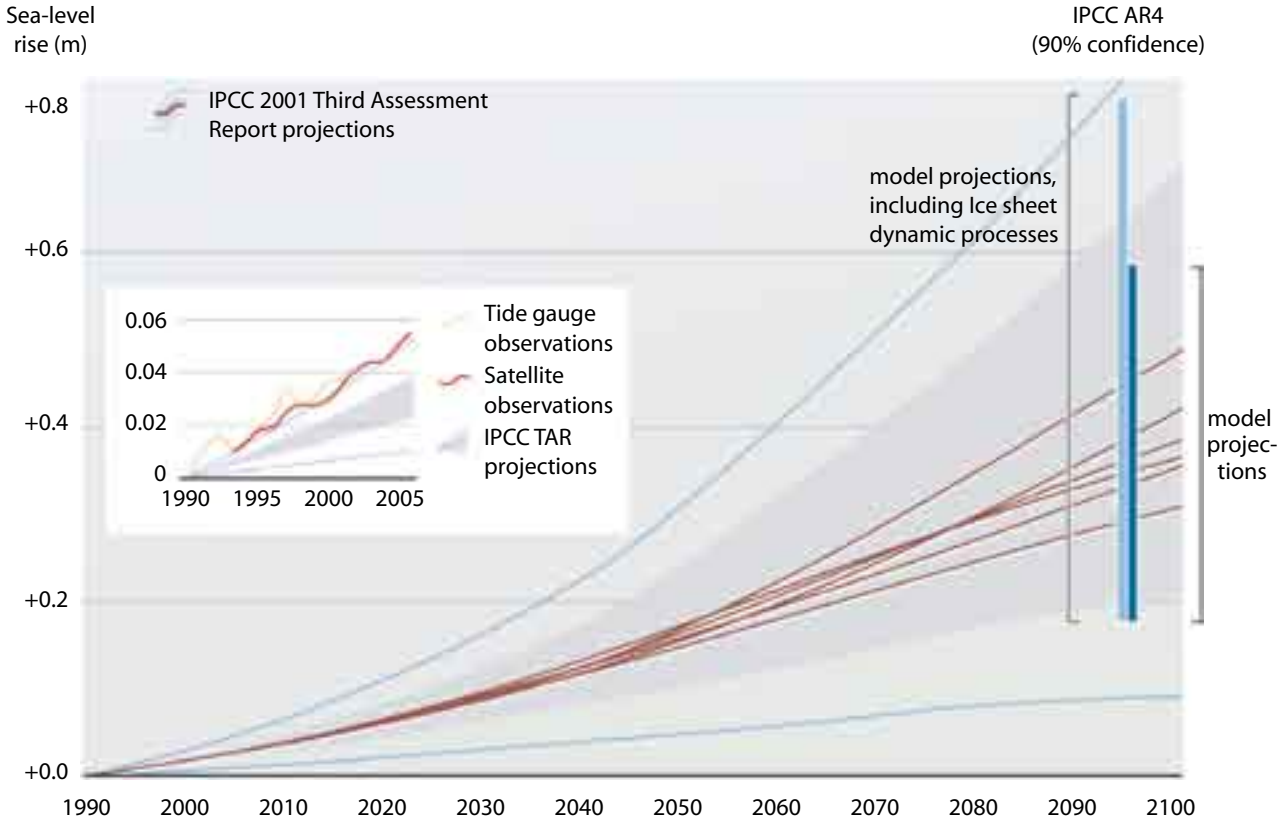
Source: Milly, Dunne, and Vecchia 2005 (reprinted by permission from Macmillan Publishers Ltd)

Sea-level Rise

Sea-level rise could have a significant impact on the low-lying coastal systems and islands. While there are uncertainties on the extent of change, the IPCC Fourth Assessment (Figure 3.6) projects a mean of about a 0.4 meter rise by the end of the century, excluding future changes in possible glacier melt.[29] In India and Pakistan the current rise in sea level is reported to be about 1.0 millimeter per year. Bangladesh is particularly vulnerable, with estimates of sea-level rise varying from 0.30 to 1.5 meters by 2050 under alternative scenarios (Broadus 1993). Whatever the magnitude, the rate of increase of sea-level rise is not a linear function of time. Sea-level changes have direct inundation impacts and indirect effects such as changes in salinity levels, enhanced storm surge effects, changing sedimentation patterns, and changes in ocean currents. The most vulnerable country in South Asia is the Maldives, which consists of low-lying islands scattered in the Indian Ocean. Most islands (96 percent) occupy less than 1 km^2 of land and 80 percent of the country lies below one meter sea level. Sea-level rise could pose an existential threat and is projected to submerge much of the country in the worst-case scenarios.

[29] There are numerous other projections of more severe sea-level rise that allow for greater melting of polar ice mass.

Figure 3.6 Projected Global Average Sea-level Rise at the end of the Twenty-first Century



Source: Ahlenius 2007 (reprinted with permission)

Climate-related Disasters

Climate change is likely to increase the intensity and incidence of many climate-related natural disasters. South Asia is subject to a range of climate-related disasters, including tropical cyclones, sand storms, floods, and droughts. Although it is difficult to predict the relationship between storms and climate change, it is expected that, around the world, there will be more storms, at higher intensity. Projections for cyclone intensity in the Bay of Bengal are mixed, with some studies suggesting higher intensities with lower frequency (Government of Bangladesh 2002, 2005). Floods and droughts are also expected to increase, given predictions of higher precipitation in fewer days. Floods are likely to continue being a major problem in Bangladesh, Bihar, and Uttar Pradesh in India and a significant problem in many other places vulnerable to flash floods. Vulnerability to natural disasters is of particular concern because of the region's high population density and poverty.

Coordination between the disaster-risk management and the climate-change agendas will become essential. Many of the impacts associated with climate change alter the risk profile of existing hazards, such as floods, droughts, cyclones, and other extreme weather-related events. Adaptation measures can benefit from the practical experience in disaster management. Enhancing the ability of local communities to manage current natural hazard risks will improve capacity to prepare for and respond to future climatic changes. In this context, the disaster-risk mitigation and climate adaptation agendas require an integrated approach.

Glacier Retreat

There is general agreement that widespread retreat of the global ice cover has been occurring since at least the early 1800s. With rising temperatures, the ice mass of the Himalayan-Hindu Kush is retreating more rapidly than the global average in some locations. The Gangotri glacier (see Figure 3.7) is the source of the Ganges and is one of the largest in the Himalayas. The Gangotri has been receding since 1780 and in recent years the pace of retreat has accelerated.[30] The receding trends of glacier masses threaten water supplies, livelihoods, and the economy of the region. Agriculture and the region's economic structure will need to undergo significant adjustment to cope with these changes.

Who will be most Affected by Climate Change?

The poor and marginalized are likely the most vulnerable to climate risks. Climate change

Figure 3.7 The Gangotri Glacier, India: Past 200 Years

This composite image from the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) instrument aboard NASA's Terra satellite shows how the Gangotri Glacier terminus has retracted since 1780.

Source: NASA 2001 (reprinted with permission)

[30] During the period 1975 to 1999, the glacier has retreated more than 850 meters, with a 7-meters loss from 1996 to 1999 alone. However, many scientists believe that it is premature to make a statement that some glaciers in the Himalayas are retreating abnormally because of the global warming.

affects women differently because of unequal and differential access to economic opportunities. In natural disasters female mortality outnumbers males. As an example, women accounted for 90 percent of the deaths in the 1991 cyclone in Bangladesh. Urban slum dwellers who subsist on the economic margins of cities have poor access to basic amenities and are usually the first to suffer from climate-related damages to assets and lives. Nearly half the indigenous peoples in the world, around 100 million, live in South Asia. Their dependence on forests makes them especially vulnerable to climate-induced changes in natural resource productivity.

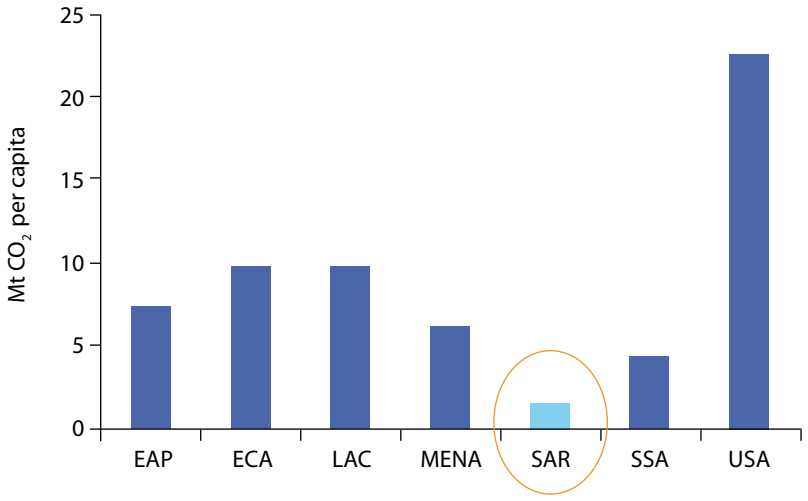
A further cause of concern is the likelihood of climate refugees. South Asia's population is large and growing rapidly; almost any perturbations to the environment will be cause for dislocation. Displacement may be the result of extreme weather events, such as the monsoon floods that displaced more than 20 million people in Bangladesh, India, and Nepal in the summer of 2007, or of sea-level rise. People displaced internally or across borders are vulnerable to poverty impacts that can be irreversible.

South Asia's GHG Footprint

While vulnerability to climate change is high in South Asia, the region has also emerged as a significant contributor to GHG emissions. High economic growth has fueled an insatiable thirst for energy. Rising energy demand is driven by urbanization, industrialization, and prosperity, all of which are part of a broader process of development that is lifting millions out of poverty. However, increased energy consumption has been accompanied by rising GHG emissions. On average, emissions have risen at about 3.3 percent annually since 1990—more rapidly than in any other region of the world, except the Middle East. Total emissions exceed 2.5 billion tons of CO_2 equivalents. However, per capita emissions of the region are still extremely low by international standards—less than one-fifth of the developed countries (Figure 3.8).

As the region strives to meet its development goals, the potential for further growth in emissions is enormous. More than 400 million people in India alone have no access to electricity. How South Asia meets the legitimate demands for energy and economic prosperity will have

Figure 3.8 Per Capita Greenhouse Gas Emissions by Region, 1995 and 2000



Key to abbreviations:

EAP: East Asia and Pacific

SAR: South Asia Region

MENA: Middle East and North Africa

SSA: Sub-Saharan Africa

ECA: Europe and Central Asia

LAC: Latin America and the Caribbean

USA: United States of America

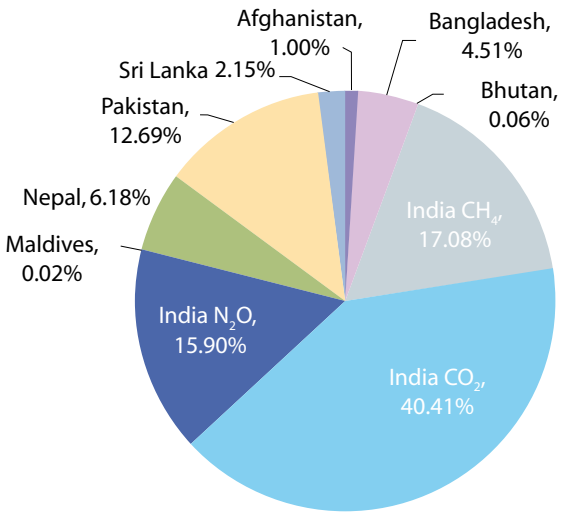
Source: WRI 2009 and World Bank 2009

far-reaching consequences on global GHG emissions. Growth typically spurs emissions in rough proportion to the income in generates.[31] Hence, South Asia like the rest of the world faces an enormous challenge to sustain its growth while addressing global warming.

Reflecting the size of its economy, population and territory, India remains the largest contributor to GHGs in the region. (See Figure 3.9.) However, in terms of emissions per unit of GDP (measured either by purchasing-power parity [PPP] or nominal exchange rates) India remains a low-intensity producer of CO_2 emissions. India's energy intensity of GDP has declined from 0.3 kilograms of oil equivalent (kgoe) in GDP PPP terms in 1972 to 0.19 kgoe in 2003—equivalent to Germany and other energy-efficient economies. This suggests considerable success in decoupling the energy-GDP link at an earlier stage of development than has been achieved in other economies.[32] A recent study suggests that India has successfully offset about 30 percent of its growth- and population-related emissions through improvements in efficiency and changes in economic structure and fuel mix.[33] Importantly, per capita emissions in India are among the lowest in the world, while per capita energy consumption stands at about half the developing country average.[34]

In South Asia energy, industry, agriculture, and to a lesser extent transport are the key contributors to GHGs. (See Table 3.1). The sources of emissions vary substantially across the region. In India, energy- related consumption and transformation accounts for the bulk of emissions, reflecting the economy's rapid industrialization. At the other end of the spectrum lie Nepal and Sri Lanka, where changes in land use (deforestation) and agriculture are the main sources of emissions.

Figure 3.9 Greenhouse Gas Contributions by Country in South Asia, 2000



Source: WRI 2009.

Note: Figure only provides contribution by gas for India in CO_2 equivalents

Transport-related emissions across the region are typically low but could rise rapidly with greater prosperity and sustained economic growth. In many other regions deforestation is an important driver of GHG emissions. By contrast, the forest boundaries in most other South Asian countries (with a few exceptions) have largely stabilized

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[31] Globally, a 1 percent increase in per capita income has induced—on average—a 1 percent increase in GHG emissions.

[32] Confederation of Indian Industry 2008.

[33] World Bank 2007a.

[34] IEA Electricity Access Index.

as a result of high rates of forest conversion to agricultural land in earlier decades. However, there remain concerns that the quality of forest stock (i.e., forest density) is declining and hence the carbon sequestration potential of forests could be falling due to unsustainable management practices.

a. **Energy:** Coal is the backbone of the energy sector and is expected to remain the dominant fuel that will power the economies of South Asia. India has the third-largest stock of proven coal reserves in the world, after the United States and China. Strategies to lower emissions by diversifying into cleaner sources of power are constrained by energy resources. India, the largest energy consumer in the region, is not well endowed with reserves of cleaner fuels such as oil, gas, and uranium.[35] Hydropower potential is significant and large in absolute terms (150,000 megawatts) but small compared to the country's future energy needs.[36] There are considerable and untapped possibilities for importing hydropower from Nepal and Bhutan and wind power from Sri Lanka, but there remain difficulties in establishing transboundary energy trade agreements. Based on oil prices during recent decades, the cost advantage of coal and the relative security of the fuel supply, Bangladesh, Pakistan, and Sri Lanka likely will find coal emerge as the front-running fuel for incremental power generation. For Pakistan, the alternative to coal is natural gas imported from its oil-rich neighbors in the Middle East and Central Asia. Pakistan shares a land border with the world's second-largest holder of gas reserves, Iran. In Sri Lanka, the alternative source of supply would be imported liquefied natural gas. However, plans for a massive expansion of coal-fired energy are well advanced, so the prospect of reversing that decision may not be feasible, though little consideration appears to have been given to the health and environmental implications.

b. **Industry:** Industry remains another major contributor, accounting for about 15 percent of GHG emissions. Much of the industrial output is from small- and medium-scale enterprises that utilize outdated and inefficient technologies and processes. There is enormous scope to improve the efficiency and reduce the intensity of energy systems, but there are also considerable challenges in reaching the sector because of the scale and diversity of enterprises and limited financial and technical capacity.

c. **Transport:** South Asia's emissions from transport currently are relatively low but likely to increase rapidly. With rising household incomes and the availability of cheaper vehicles, transport demand is projected to escalate. In India alone the total vehicle stock increased fourfold from 19 million in 1990 to 73 million in 2004.[37] There is every reason to expect this trend to continue with the domestic auto industry predicting car sales to increase by 10 percent per annum for the next two decades (Bose and Spurling 2005). There are policy and technology choices that could lower the emissions growth rate while increasing mobility, improving air quality, reducing traffic congestion, and lowering transport and energy costs.

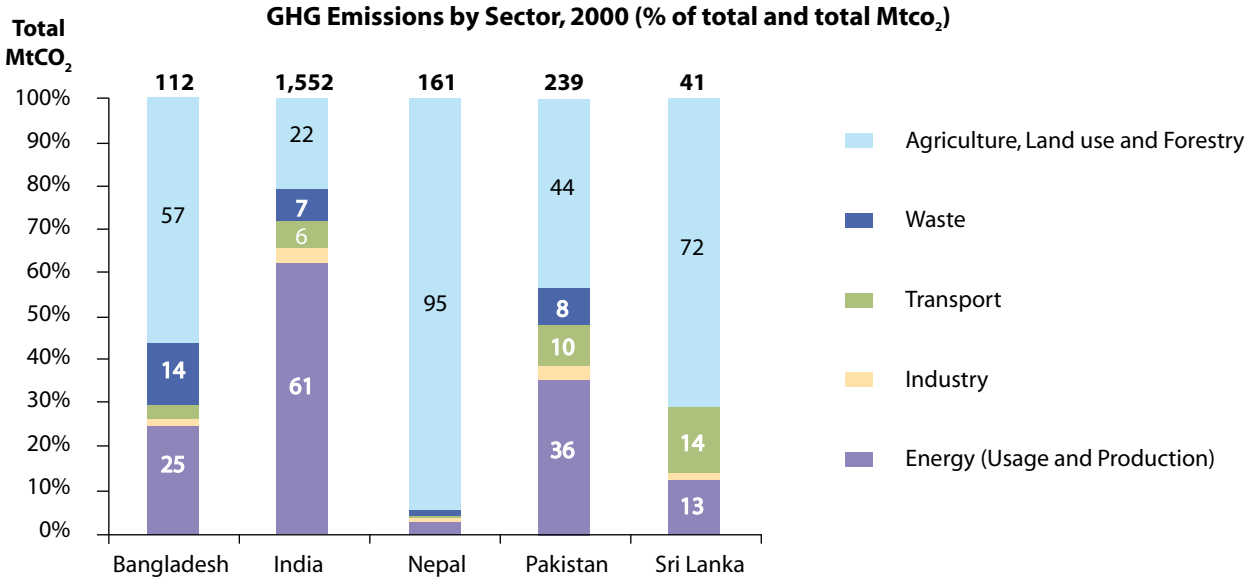
d. **Agriculture:** Methane emissions primarily from rice cultivation and livestock are the principal GHG emissions from agriculture

[35] Oil reserves are 789 million tones of oil equivalent and gas reserves are 1,101 million tones of oil equivalent. (Government of India, Planning Commission 2006).

[36] More precisely, the Government if India's *Integrated Energy Policy* (2006) indicates that with 8 percent growth 150,000 megawatts of hydropower would account for about 5 percent of the country's energy needs by 2030. (Government of India, Planning Commission 2006).

[37] Excluding two- and three-wheelers, there are currently 13 vehicles per 1,000 people in India, while in Japan the ratio is 600 vehicles per 1,000 population. The scope for expansion of the fleet size is thus enormous. The Energy and Resources Institute of India (TERI) cited in Bose and Spurling. 2005.

Figure 3.10 Contributions to Greenhouse Gas Emissions by Sector and Country in South Asia



Source: WRI 2009

in South Asia. Together these account for about 25 percent of GHG emissions in India and about 40 percent of emissions in Bangladesh and Pakistan. The major source of agricultural emissions is from flood irrigation of rice. It is important to note that the per hectare emissions from rice cultivation in India (and perhaps elsewhere in South Asia) are approximately 20–30 percent less than the global average. This reflects the special features of the South Asian agricultural landscape: poor soils, low levels of chemical application, the type of rice cultivars used, and the planting regimes.

The following chapter identifies the potential role of the World Bank in helping countries meet their development priorities under climate constraints.