South Asia
Climate Change Strategy

January 27, 2009

South Asia Region
Climate Change Strategy for the South Asia Region

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Glossary

adaptation. A process by which strategies to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, and implemented. Types of adaptation include anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

adaptive measures or responses. Actions taken that result in building the capacity of communities and boosting their long-term resilience to climatic shocks or stress.

adaptation strategy. A broad plan of action that is implemented through policies and measures. Strategies can be comprehensive, focusing on national, cross-sectoral scales; or targeted, focusing on specific sectors, regions, or measures.

anemia. A condition that arises when the level of hemoglobin in the blood is less than 110 g/l in pregnant women, and less than 120 g/l in non-pregnant women.

analytical and advisory activities (AAA). These are non-lending services offered to client countries by the World Bank; they are aimed at providing a foundation for defining strategic priorities and informing policy dialogue and decisions on projects and programs. The outputs of such activities range from reports on key economic and social issues, to policy notes, to knowledge-sharing workshops and conferences. Economic Sector Work (ESW), knowledge management, and training and learning are some of the main types of AAA.

anthropogenic. Resulting from of produced by human beings.

basin. The drainage area of a stream, river, or lake.

C4 plant. A land plant that uses a so-called C4 fixation method to transform carbon dioxide into sugar. Chemically speaking, the method allows for binding the gaseous molecules to dissolved compounds inside the plant for sugar production through photosynthesis. C4 fixation is an improvement over the simpler and more ancient C3 carbon fixation strategy used by most plants. The intermediate compounds of the process contain four carbon atoms, hence the name C4.

carbon budget. (also called carbon balance) It is a way of tracking the amount of carbon in ecosystems for policy analysis. It shows the inventory of carbon in carbon pools and the balance of exchange between the pools. For forests, this generally involves multiplying inventory data collected at different times for trees, woody detritus, leaf litter, understory, and soil by conversion factors to express all units in terms of weight of carbon. Common units are million metric tons (MMT=Teragrams=1,012 grams), megagrams (Mg=106 grams), and billion metric tons (petagrams=1,015 grams). Carbon budgets or balances are often also calculated for individual plants in physiological terms, including photosynthesis, respiration, and allocation (which refers to the relative amount of carbon stored in specific organs) using time steps on the order of hours or daily. Generally, the models producing these budgets are called process models, as they describe the process underlying the system under study (Heath and Joyce 1997).
carbon dioxide equivalent. It is a quantity that describes the global warming potential (GWP), in terms of an equivalent amount of carbon dioxide, of a given mixture and amount of greenhouse gas over a specified time scale (generally, 100 years). The carbon dioxide equivalency for a gas is obtained by multiplying the mass and the GWP of the gas. For example, the GWP for methane (CH$_4$) over 100 years is 25. This means that 1 million metric tons of methane emissions is equivalent to 25 million metric tons of carbon dioxide emissions. While it is a standard and useful metric for comparing emissions of different greenhouse gases, it does not imply the same climate change responses. The following units are commonly used:

- By the Intergovernmental Panel on Climate Change (IPCC): billion metric tons (i.e. gigatons) of CO$_2$ equivalent (GtCO$_2$eq)
- In industry: million metric tons of carbon dioxide equivalents (MMTCDE)
- For vehicles: grams of carbon dioxide equivalents per kilometer (gCDE/km)

carbon fertilization. The enhancement of the growth of plants as a result of increased atmospheric carbon dioxide (CO$_2$) concentration. Depending on their mechanism of photosynthesis, certain types of plants are more sensitive to changes in atmospheric CO$_2$ concentration.

carbon finance. It is a branch of environmental finance that works on the premise that greenhouse gas emissions carry a monetary price. Through carbon finance, resources are provided to projects that generate (or are expected to generate) greenhouse gas (or carbon) emission reductions by way of purchasing such emission reductions at a price. The reductions in emissions are monitored and verified by an independent party. The selling of emission reductions has been shown to increase the bankability of projects, by adding an additional revenue stream in hard currency, which reduces the risks of commercial lending or grant finance. The World Bank has created the World Bank Carbon Finance Unit which uses money contributed by governments and companies in OECD countries to purchase project-based greenhouse gas emission reductions in developing countries and countries with economies in transition.

carbon intensity. The amount of emission of carbon dioxide per unit of Gross Domestic Product.

carbon sequestration. The process by which carbon sinks (see definition) remove carbon dioxide from the atmosphere.

carbon sink. A reservoir of carbon that accumulates and stores carbon for an indefinite period. The main natural sinks are oceans and plants/algae (via photosynthesis).

climate change. Any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” See also climate variability.

climatic prediction or climate forecast. The result of an attempt to produce a most likely description or estimate of the actual evolution of the climate in the future.

climate projection. A forecast of the response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios,
often based upon simulations by climate models. Climate projections differ from climate predictions in that they depend upon the emission, concentration, or radiative forcing scenario used, which are based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized and are therefore subject to substantial uncertainty.

**climate variability.** The variation in the mean state and other statistics (such as standard deviations and the occurrence of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or human-induced external forcing (external variability) (IPCC 2001).

**chikungunya fever.** A disease caused by a virus that is transmitted to humans by virus-carrying Aedes mosquitoes. In humans, the virus causes an illness with symptoms similar to dengue fever. Symptoms include fever up to 39°C (102.2°F), severe pain in the joints of the extremities, rash of the trunk and occasionally the limbs, headache, conjunctival injection, and slight photophobia. The acute febrile phase of the illness lasts only two to five days; joint pain may persist for weeks or months.

**coral bleaching.** The paling in color which results if a coral loses its symbiotic, energy-providing, organisms.

**coupling.** (Also known as “dependency”). It is the degree to which a program module relies on each one of the other modules that comprise the program.

**development policy loans/operations.** These are loans available to both IBRD and IDA borrowers not in arrears to the Bank Group. They are intended to provide rapid financial assistance to allow countries to deal with actual or anticipated development financing requirements of domestic or external origins. They typically support the achievement of a set of development results through a medium-term program of policy and institutional actions consistent with a country’s economic and sectoral policies. They can be stand-alone operations or, more frequently, be part of a programmatic series of operations. In programmatic operations, the Bank supports the implementation of a medium-term program of policy reforms through a series of annual operations, each of which is disbursed against a mutually agreed set of policy and institutional actions. Over Fiscal Years 2006 and 2007, IDA and IBRD development policy operations accounted for less than 30 percent of the World Bank’s total financial commitments.

**emission scenario.** A plausible representation of the future development of emissions of greenhouse gases and aerosols based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development and technological change) and their key relationships. In 1992, the IPCC presented a set of emission scenarios that were used as a basis for the climate projections in the Second Assessment Report (IPCC 1995). These emission scenarios are referred to as the IS92 scenarios. For the Third Assessment Report (IPCC 2001) new emission scenarios, namely the SRES scenarios (Special Report on Emission Scenarios of the IPCC), were published. These are known as the A1, A2, B1, and B2 family scenarios and were also utilized in the preparation of the Fourth Assessment Report (IPCC 2007a, 2007b, 2007c; final report in preparation). There are multiple variations of each family scenario.
**energy intensity.** It is the ratio of useful energy output of a system, conversion process or activity, to its energy input.

**equivalent carbon dioxide (CO\(_2\)e).** It is a measure for describing how much global warming a given type and amount of greenhouse gas may cause. Specifically, it is the concentration of \(\text{CO}_2\) that would cause the same level of radiative forcing (see definition) as a given type and concentration of another type of greenhouse gas. It is expressed as parts per million by volume (ppmv). It provides an instantaneous measurement rather than one over time.

**evapotranspiration.** The combined process of evaporation from the Earth’s surface and transpiration from vegetation.

**extreme weather event.** An event that is rare within its statistical reference distribution in a particular place. Definitions of “rare” vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place. An extreme climate event occurs when the same considerations apply to an average of a number of weather events over a certain period of time (e.g. rainfall over a season).

**greenhouse gas.** A gaseous constituent of the atmosphere which can be natural or made by man. These gases absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth’s surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H\(_2\)O), carbon dioxide (CO\(_2\)), nitrous oxide (N\(_2\)O), methane (CH\(_4\)) and ozone (O\(_3\)) are the primary natural greenhouse gases in the Earth’s atmosphere. Human-made greenhouse gases include halocarbons and other chlorine- and bromine-containing substances.

**irrigation efficiency.** The ratio between the estimated irrigation water requirements and the actual irrigation water withdrawal in a given location.

**leishmaniasis.** It is a disease caused by a parasite that is transmitted to humans by the bite of certain species of sand fly. The main symptoms are skin sores which erupt weeks to months after the person affected is bitten by sand flies. Likewise, fever, damage to the spleen and liver, and anaemia can also manifest themselves.

**lymphatic filariasis.** A disease caused by thread-like parasitic worms that are transmitted to humans by insect bites and lodge in the lymphatic system. The transmission agent is a certain type of mosquito. The main symptom is *elephantiasis* – the thickening of the skin and underlying tissues – that affects the lower extremities more commonly.

**mitigation.** Technological change and substitution that reduce resource inputs and emissions per unit of output. With respect to climate change, mitigation means implementing policies to reduce greenhouse gas emissions and enhance any process, activity or mechanism meant to remove from the atmosphere such emissions, as well as aerosols and precursors of greenhouse gases.

**morbidity.** Rate of occurrence of disease or other health disorders within a population, taking account of the age-specific morbidity rates.

**mortality.** Rate of occurrence of death within a population.
**Ocean Acidification.** A decrease in the pH of sea water due to the uptake of anthropogenic carbon dioxide.

**Onchocerciasis.** It is a disease transmitted to people through the bite of a black fly, which spreads parasitic worms (*Onchocerca volvulus*) throughout the body; when the worms die, they cause intense itching and a strong immune system response that can destroy nearby tissue, such as the eye. Thus, it is also known as “river blindness.”

**Permafrost.** Ground (soil or rock and included ice and organic material) that remains at or below 0°C (32°F) for at least two consecutive years (Van Everdingen 1998).

**Radiative Forcing.** It is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In keeping with the IPCC’s custom, in this report radiative forcing values are for changes relative to preindustrial conditions defined at the year 1750 and are expressed in watts per square metre (W/m²) (from IPCC’s *Climate Change 2007: Synthesis Report*).

**Risk (climate related).** The result of the interaction of physically defined hazards with the properties of the exposed systems in terms of their sensitivity or (social) vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences; that is, risk equals the probability of a climate hazard multiplied by a given system’s vulnerability (Lim *et al.* 2005).

**Runoff.** Surface flow occurring when the precipitation rate exceeds the infiltration rate of the soil or other surface material.

**Technical Assistance (TA).** It is a type of analytical and advisory activity (see above) offered by the World Bank. Its main objective is to facilitate the transfer of skills and knowledge for developmental purposes. Technical assistance is a key instrument for improving policies and project design, enhancing skills, and strengthening implementation capacity.

**Transmission and Distribution (T&D) Losses.** It refers to energy losses that occur within any given power network due to poor maintenance, malfunction of the network, or to the use of inadequate devices such as outdated transformers. The energy that escapes is wasted and not recovered. In South Asia, these losses are very high by international standards.

**Vector or Vector-Borne Disease.** (epidemiology). A vector is an organism that transmits infection by conveying pathogens from one host to another but which does not cause disease itself. A classic example is the anopheles mosquito which acts as a vector for the disease malaria by transmitting the malarial parasite *Plasmodium* to humans. In this case, *Plasmodium* is harmless to the mosquito (its intermediate host) but causes the disease malaria in humans (its definitive host).

**White Spot.** It is as an area where a lack of regional-scale data and information on climate, hydrology, and meteorology has hindered proper planning and decision-making.

**Zoonotic.** It refers to a disease that normally exists in animals but that can infect humans.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAA</td>
<td>analytic and advisory assistance</td>
</tr>
<tr>
<td>AOGCM</td>
<td>atmosphere-ocean global circulation model</td>
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<tr>
<td>CBO</td>
<td>community-based organization</td>
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<tr>
<td>CDM</td>
<td>Clean Development Mechanism</td>
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<tr>
<td>CF</td>
<td>carbon finance</td>
</tr>
<tr>
<td>CFU</td>
<td>Carbon Finance Unit</td>
</tr>
<tr>
<td>CH₄</td>
<td>methane</td>
</tr>
<tr>
<td>CNG</td>
<td>compressed natural gas</td>
</tr>
<tr>
<td>CO₂</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>CO₂ₑ</td>
<td>equivalent carbon dioxide</td>
</tr>
<tr>
<td>CO₂ₑq</td>
<td>carbon dioxide equivalent</td>
</tr>
<tr>
<td>CoP</td>
<td>Conference of the Parties</td>
</tr>
<tr>
<td>CSO</td>
<td>civil society organization</td>
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<tr>
<td>DPL</td>
<td>development policy loan</td>
</tr>
<tr>
<td>DRM</td>
<td>disaster risk management</td>
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<tr>
<td>DSM</td>
<td>demand-side management</td>
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<tr>
<td>ENSO</td>
<td>El Niño southern oscillation</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>FACE</td>
<td>free air concentration enrichment</td>
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<tr>
<td>GDP</td>
<td>gross domestic product</td>
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<tr>
<td>GEF</td>
<td>Global Environment Facility</td>
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<tr>
<td>GFDRR</td>
<td>Global Facility for Disaster Reduction and Recovery</td>
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<tr>
<td>GHG</td>
<td>greenhouse gas</td>
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<tr>
<td>GIS</td>
<td>geographic information system</td>
</tr>
<tr>
<td>GLOF</td>
<td>glacial lake outburst flood</td>
</tr>
<tr>
<td>IBRD</td>
<td>International Bank for Reconstruction and Development</td>
</tr>
<tr>
<td>IDA</td>
<td>International Development Association</td>
</tr>
<tr>
<td>IFC</td>
<td>International Finance Corporation</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>JI</td>
<td>Joint Implementation</td>
</tr>
<tr>
<td>kgoe</td>
<td>kilograms of oil equivalent</td>
</tr>
<tr>
<td>LDCF</td>
<td>Least Developed Countries Fund</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
</tr>
<tr>
<td>NAPA</td>
<td>National Adaptation Program of Action</td>
</tr>
<tr>
<td>NGO</td>
<td>nongovernmental organization</td>
</tr>
<tr>
<td>N₂O</td>
<td>nitrous oxide</td>
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</table>
OECD  Organisation for Economic Co-operation and Development
ppm  parts per million
PPP  purchasing power parity
SARCCS  South Asia Region Climate Change Strategy
SCCF  Special Climate Change Fund
SAR  South Asia region
SHG  self-help group
SPA  Strategic Priority on Adaptation
SRES  Special Report on Emissions Scenarios
TA  technical assistance
T&D  transmission and distribution
UNDP  United Nations Development Programme
UNFCCC  United Nations Framework Convention on Climate Change
VKT  vehicle-kilometers of travel
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1 Listed in alphabetical order.
Executive Summary

The Global Challenge

1. **The world is facing a prolonged period of planetary surface warming, which is unparalleled in human history.** The scientific consensus holds that this is largely a consequence of human-generated emissions of greenhouse gases (GHG). The impacts of higher temperatures are already being felt and are visible in melting glaciers, rising sea levels, more frequent storms and extreme weather events. The 1990s was the warmest decade and 2005 the warmest year on record since 1800. At current trends, scientists predict that the Arctic will be ice free within 100 years.

2. **Climate change has become central to the development and poverty reduction agenda.** Progress towards attaining the Millennium Development Goals (MDGs), such as eradicating poverty, combating communicable diseases, and ensuring environmental sustainability, could be in jeopardy. The effects of global warming certainly will be unfair and the impacts will not be evenly distributed across countries. Industrialized countries are responsible for the vast bulk of past and current greenhouse gas emissions. But the developing countries and the poorest people will suffer the most from climate change because of unfavorable geography, limited assets, and a greater dependence on climate-sensitive sources of income. Yet few developing countries are well adapted to even current climate variations. Climate change is predicted to increase the variability and frequency of extreme events in ways that are outside the realm of experience. Some of the impacts could be in the form of new challenges (such as sea level rise), others could emerge as old threats made more severe by climate change (such as flooding or drought).

The Strategy and Its Objectives

3. **The South Asia Region Climate Change Strategy (SARCCS) articulates the guiding principles for the World Bank’s climate-related work in the South Asia region (SAR).** It builds upon the World Bank’s Strategic Framework for Development and Climate Change that defines the pillars and priorities to the climate challenge. SARCCS recognizes that uncontrolled climate change threatens the development prospects of South Asian countries and that there is a need to develop an approach that addresses specific country risks and needs. Upon identifying key threats posed by climate change, the strategy explores the broad parameters involved in devising responses to the climate challenge consistent with the country assistance strategies that guide government-Bank partnerships. The strategy attempts to enhance the effectiveness of Bank assistance programs by building climate resilience and promoting sustainable growth. An effective response calls for adaptation, to address the inevitable; and mitigation, to prevent the avoidable.

4. **Climate policies in South Asia will need to be tailored to risks and country circumstances.** South Asia’s climate is as diverse as its landscape. The region spans a variety of climate zones, including arid deserts, parched rangelands, freezing alpine mountains, and humid tropical islands. The projected impacts of climate change will be heterogeneous, suggesting that there can be no one-size-fits-all approach for building climate resilience across South Asia.
Responses will need to be customized to specific risks. Accordingly the strategy sets out the broad principles of an evolutionary approach that can be tailored to fit individual circumstances.

Why Is South Asia So Vulnerable to Climate Change?

5. **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. High population levels translate into increased resource demands on an already stressed and largely degraded natural resource base. With an estimated 600 million people subsisting on less than US$1.25 a day, even small climate variations can cause irreversible losses and tip large numbers into destitution.

6. **The region is highly susceptible to natural disasters.** Over 50 percent of South Asians – more than 750 million people – have been affected by a natural disaster in the last two decades. The human and economic toll has been high with almost 230,000 deaths and about US$45 billion in damages. The region shares common geological formations and river basins, so that natural hazards frequently transcend national boundaries. With climate change the frequency and incidence of such natural disasters is projected to increase.

7. **Compounding these risks is the region’s heavy reliance on the monsoon.** The monsoon is the most significant climate event in the region’s economic calendar. It carries over 70 percent of South Asia’s annual precipitation in a brief four-month period. A buoyant monsoon heralds bountiful harvests and financial security, yet when the monsoons fail, or are excessive, suffering and economic loss is widespread. If climate projections are indicative of future trends, the risks associated with water-related climate variability are likely to worsen.

8. **The retreating glaciers of the Himalayas could present the most far-reaching challenge to the region.** The Himalayas are a vital life-sustaining resource for South Asia. The Himalayan ecosystem supports some 1.5 billion people who live directly in the floodplains of its many rivers (e.g. Indus, Ganges, Brahmaputra, and Meghna). The Himalayan system influences monsoon dynamics, acts as a natural reservoir to sustain crops, provides groundwater recharge, and is home to a unique ecosystem with an abundance of endemic species. But with rising temperatures the ice mass of the Himalayas and Hindu Kush is retreating more rapidly than the global average. This poses an unprecedented threat to water supplies, lives, and the economies of the region. With melting glaciers, flood risks would increase in the near future. In the long term, there can be no replacement for the water provided by glaciers, which could result in water shortages at an unparalleled scale. Agriculture and the region’s economic structure will need to undergo significant adjustment to cope with these changes.

9. **Sea level rise is a further concern in the region.** The region has long and densely populated coastlines with many low-lying islands. In the severe climate change scenarios sea level rise poses an existential threat that would submerge much of the Maldives and inundate 18 percent of Bangladesh’s total land, directly impacting 11 percent of the country’s population. Salt water intrusion from sea level rise in low-lying agricultural plains could lead to food

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2 Most of the region relies on the summer monsoon, which runs from June to September. In Sri Lanka and the Maldives, however, it is the winter northeast monsoon that delivers most of the precipitation, between November and January.

3 Reference here is to the Intergovernmental Panel on Climate Change (IPCC) A2 scenario.
insecurity, further spread of water-related diseases, and reduced freshwater supplies. Many of the region’s primary cities (e.g. Karachi, Mumbai, Kolkata, Chennai, Cochin) – the engines of its growth – are located on the coast and threatened by sea level rise. The immediate impact of sea level rise is on coastal communities and ecosystems. Ripple effects could be felt beyond borders if there is large-scale displacement of populations in densely inhabited coastal areas and erosion of protective coastal ecosystems.

10. **Many of the most severe impacts of climate change are likely to be regional and will call for coordinated regional responses.** Bangladesh has 54 shared rivers with India, so that changes in upstream runoff and demand due to climate change, could significantly impact future water availability across all these rivers. Likewise sea level rise could displace much of the population along the coastal zone and induce cross-border migration. Climate sensitive diseases could spread rapidly across borders in a globalized world. The last decade saw dengue fever, cholera and Rift Valley fever spread across and between continents. Adaptation to climate change might therefore require not just local action but, also cross-boundary cooperative arrangements. Partnerships and coordinated approaches provide a cost effective way of adapting to the impending regional climate related risks.

11. **The cascading effects of more variable rainfall and higher temperatures will impact most aspects of life and the economy.** Weather extremes and greater fluctuations in rainfall have the capacity to refashion the region’s comparative advantage. Food security, health, livelihoods, and access to basic services of water, sanitation, energy, and shelter could all be compromised. Expected impacts of climate change include the following:

- Reduction of yields of major crops by as much as 20 percent and an even sharper decline in agricultural incomes in the worst-case climate scenarios.
- Growing scarcity of water, with a need to balance more variable water supplies with the accelerating demand for water.
- Economic losses and damage to high-value infrastructure, particularly in the cities and vulnerable coastal belt.
- An increase in the incidence of diseases, with some ailments, such as heatstroke and vector- and water-borne diseases, becoming more widespread with higher temperatures or less reliable water supplies.
- The possibility that climate change could exacerbate prevailing social disparities among vulnerable groups such as women, children, the poor and indigenous people.
- Irreversible loss of ecosystems and ecological services, particularly in fragile and unique biomes covering terrestrial and marine ecosystems (such as the Himalayas, the Western Ghat biosphere encompassing India and Sri Lanka, and the fragmented coral reefs).

12. In sum, high population densities, a large concentration of poverty, and the region’s climate variability have all combined to make South Asia especially sensitive to the consequences of climate change. Climate change has the potential to compound existing development problems and increase pressures on key resources needed to sustain future growth, urbanization and industrialization.
13. **While vulnerability to climate change is high, the region has also recently emerged as a significant contributor to greenhouse gas emissions.** High economic growth has fueled an insatiable thirst for energy in South Asia. 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 of South Asians out of poverty. Increased energy consumption has been accompanied by rising greenhouse gas emissions. On average, emissions have risen at about 3.3 percent annually in the region since 1990 – more rapidly than in any other region, except the Middle East. Total emissions exceed 2.5 billion metric tons of carbon dioxide equivalent. However, per capita emissions of the region are still extremely low by international standards – less than one-fifth of the developed countries.

14. **As the region strives to meet its development goals, the potential for further growth in emissions is enormous.** Over 500 million people in South Asia have no access to electricity. How the region meets the legitimate demands for energy and economic prosperity will have far-reaching consequences on global greenhouse gas emissions. Growth typically spurs emissions in rough proportion to the income it generates. Hence, South Asia, like the rest of the world, faces an enormous challenge to sustain its growth while addressing global warming.

15. **Coal is the backbone of the energy sector and is expected to remain the dominant fuel that will power the Indian economy.** 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. Hydropower potential is significant and large in absolute terms (150,000 megawatts), but small compared to the country’s future energy needs. 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. Because of the cost advantage of coal, Bangladesh, Pakistan and Sri Lanka will increasingly find coal emerge as the front-runner for incremental power generation. Cleaner coal technologies are likely to play a pivotal role in addressing the global climate challenge at least in the short term.

16. **There are large gains to be had from promoting energy efficiency and reducing power losses.** Much of the industrial output in the region is from small- and medium-scale enterprises that utilize outdated and inefficient technologies and processes. Cost-effective energy efficiency opportunities exist across the entire chain of energy production, distribution, and consumption in all South Asian countries. In addition there is scope for reducing emissions from existing thermal power plants. Many of the plants in the region are aged, inefficient, and highly polluting. Rehabilitation of these with cleaner technology can generate substantial emission

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4 Globally, a 1 percent increase in per capita income has induced, on average, a 1 percent increase in greenhouse gas emissions.

5 In 2005-6 oil reserves were estimated at 786 metric tons and gas reserves are 1,101 million cubic meters (Government of India, Planning Commission 2006).

6 According to the Government of India’s Integrated Energy Policy (2006), with 8 percent growth, 150,000 megawatts of hydropower would supply about 5 percent of total energy needs in the best case scenarios by 2030.
reductions. Such measures would be in line with the countries’ needs for more energy to sustain their growth as well as with global mitigation objectives.

17. **Cities are major contributors to greenhouse gas emissions.** Rapid urbanization has been accompanied by increased demands for transportation, energy, water supply, and sanitation and increased generation of wastewater and solid waste, all of which contribute to greenhouse gas emissions. Fortunately there remain large and untapped opportunities for South Asia to simultaneously improve services (waste treatment, public transport, etc.) and quality of life while reducing the greenhouse gas footprint of the urban landscape.

18. **Agriculture is also a major significant to greenhouse gases.** Rice and livestock are the primary sources of agricultural emissions in South Asia and account for over 20 percent of emissions from South Asia. However, the per-hectare emissions from rice in South Asia are lower than the global average reflecting the special features of the agricultural landscape: poor soils, low levels of chemical application and the planting regimes. The most promising area for emission reductions is likely to be in the livestock sector, where changes in diet can simultaneously increase productivity and lower methane emissions. In addition in some countries a significant proportion of under-priced electricity is used for groundwater extraction and lift irrigation.

**World Bank’s Role**

19. **The main objective of the World Bank is to support the development priorities of countries in South Asia by addressing climate change related risks and harnessing development opportunities that promote low-carbon growth.** The World Bank’s (the Bank) current portfolio of activities in South Asia is already structured to promote growth under climate constraints. The adaptation dimension is closely linked to the Bank’s core development mission and includes a well-targeted package of interventions aimed at reducing exposure to climate risks, promoting integrated coastal zone management, and building climate-resilient rural economies. There is also a growing engagement in understanding and addressing the risks in the large coastal cities of South Asia, which generate much of the region’s investment and growth but where climate vulnerabilities are high. The Bank’s energy portfolio in the region has been moving towards promoting energy efficiency, renewable energy and institutional reforms aimed at improving energy service and efficiency. The strategy envisions that the World Bank will continue to play a key role in facilitating South Asia’s transition to a low-carbon-growth trajectory while promoting climate-resilient development.

20. **Building country ownership, capacity and awareness is the key to tackling the climate change problem.** Funds available for addressing climate change are limited. So expanding the many climate-friendly interventions in the Bank’s portfolio will not be sufficient to tackle the climate challenge in South Asia. To leverage limited resources effectively the solution lies in promoting country ownership of climate change issues. This calls for selectivity with a focus on outcomes that build institutional capacity and deepen knowledge so that climate change risks are incorporated in country development policies, plans and programs. It also requires high-impact investments that could have catalytic effects.
Broad Principles of a Development Strategy for Climate Change

21. **Effective adaptation poses significant policy challenges.** Countries need to devise responses in the face of uncertainties on the timing, location and severity of climate impacts. The scale of these impacts will be contingent upon global mitigation efforts undertaken in the next few decades. Delayed or limited emission stabilization will necessitate considerably greater investment in risk management and climate change adaptation. These uncertainties need to be factored into the development of adaptation strategies and financing plans. The policies and institutions that enable South Asian countries to cope with these risks today, will build resilience in addressing future risks. Climate change is also predicted to bring new and unprecedented problems, such as those associated with sea level rise and melting glaciers. This will call for building new policies to prepare for the potential adverse impacts. However, given the large uncertainties a rational first-response is to invest in greater knowledge to better understand the scale and magnitude of these threats and to build institutional capacity to adequately respond to the challenge of climate change. In many cases, institutions will be considerably challenged by the crisis of climate change, in particular where structures and responsibilities are fragmented and technical capacity is limited.

22. To promote climate resilient development and growth in South Asia, adaptation activities will be guided by five pillars:

- **A “no-regrets” approach.** No-regrets approaches build resilience to climate risks and also generate co-benefits. Faced with uncertainty about future climate outcomes, no-regrets policies provide a strategy for hedging against climate risks. Irrigation supplies, health care, infrastructure, agriculture technology, disaster preparedness, habitat protection, and equitable and environmentally sensitive growth lend themselves to no-regrets interventions that simultaneously deliver climate resilience and development benefits.

- **Focus on the poor.** The most vulnerable are the poor in the developing countries, who have limited resources and whose assets and livelihoods are tied to climate-sensitive factors of production. Building resilience of these groups to current climate risks would generate immediate development dividends and reduce future climate vulnerability.

- **Investment in knowledge.** Climate science is imperfect and it is not possible to predict with certainty the path of future climate risks and the likely damages. Under uncertainty, knowledge has high value, and this will require vigorous investment in information and building awareness in the relevant policy agencies.

- **Regional Cooperation.** The most severe climate threats (such as glacier retreat and sea level rise) transcend national boundaries. Likewise in an increasingly globalized world, climate sensitive diseases spread rapidly beyond their origins. Finding effective solutions will require cooperation between countries to jointly address shared problems.

- **Maintaining the integrity of environmental services.** Recognizing that climate change is a consequence of damaged and diminished eco-services, the remedial measures need to be aimed at protecting and restoring ecosystem integrity. Indeed, maintaining ecosystem integrity can provide a cost-effective way of building climate resilience and a buffer against climate impacts.

23. With a large proportion of South Asia’s population living below the poverty line, any low-carbon growth initiative must be consistent with the development objectives of improving
living standards and incomes. This is the principle that guides the Bank’s programs. Fortunately opportunities do exist to harness win-wins by focusing on measures that generate significant co-benefits such as improvements in energy and economic efficiency, reduction in local pollutants and improvements in natural resource management. The South Asia region has initiated a strong dialogue and a work program that includes knowledge sharing, and investments to realize these multiple benefits.

24. Recognizing the need for approaches to be informed and led by country development priorities there are three key pillars that guide the low-carbon development and growth agenda:

- **Win-win policies.** Such policies not only provide global benefits in reducing greenhouse gases but also pay for themselves in local benefits such as reduced fuel expenditure, improved air quality, and natural resource management.

- **Compensation.** South Asian countries would need to be compensated for the additional costs of mitigation actions that go beyond their development objectives. This approach underlies the United Nations Framework Convention on Climate Change (UNFCCC) principle of “common but differentiated responsibilities”. It recognizes that current climate risks are the consequence of past actions by developed countries and there is a need for assuring equal and fair access to the global atmospheric commons.

- **Technology transfer.** A third pillar is to promote research and the wider adoption of clean technologies. Developing new technologies are expensive and risky, but with continued research and early adoption, they can become more economical and accessible. Development, deployment, and diffusion of new technology are critical to enabling developing countries to meet the challenges of climate change. The Bank can play a supportive and catalytic role in this process.

25. Most South Asian countries already spend a significant proportion of their development budgets on disaster relief and programs that address climate related risks to welfare and development. Climate change is expected to increase the frequency of adverse climate events in ways that are outside the realm of current experience and could compromise the effectiveness of development efforts in climate sensitive sectors of the economy. To meet the additional costs of climate change South Asian countries will need to be well positioned to utilize the new funds that are being made available to address climate related problems. These include the Climate Investment Funds and its various sub-components, as well as mobilizing additional global resources (for example from bilateral donors). The Bank can play an important role in helping South Asian countries leverage resources to meet the additional costs of development under climate constraints.

26. Table E.1 provides a summary of the main climate risks and Table E.2 outlines the priority responses across the South Asia region. The risks and responses do imply the need for the development of a more climate-sensitive approach, which builds on many aspects of the current South Asia region portfolio that already contain dimensions related to both adaptation and mitigation. The region will need to make greater use of the existing range of instruments – knowledge partnerships and capacity building (including climate risk assessments, assistance with global negotiations where required, reports and technical support), as well as priority investments. In a resource constrained environment there will be a need to leverage funds effectively to achieve transformational impacts that could have significant effects in building climate resilient and low-carbon growth economies in the near to medium term.
Table E.1 Summary of Climate Risks by Country

<table>
<thead>
<tr>
<th></th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Maldives</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level rise</td>
<td>-</td>
<td>Very High</td>
<td>-</td>
<td>Modest</td>
<td>-</td>
<td>Modest</td>
<td>Very</td>
<td>High</td>
</tr>
<tr>
<td>Glacier retreat</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Temperature increase</td>
<td>High</td>
<td>High (?)</td>
<td>High</td>
<td>Very</td>
<td>High</td>
<td>Modest</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Floods more frequent</td>
<td>?</td>
<td>Likely</td>
<td>High</td>
<td>High</td>
<td>Likely</td>
<td>High</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Drought more frequent</td>
<td>Likely</td>
<td>High</td>
<td>?</td>
<td>High</td>
<td>?</td>
<td>Likely</td>
<td>-</td>
<td>?</td>
</tr>
</tbody>
</table>
Table E.2 Summary of Regional and Sector Impacts in the Context of Climate Change and Priority Responses

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
</tr>
</thead>
</table>
| Regional and Cross-sectoral | • Information gaps  
• Limited coordination between sectors and countries  
• Funding gaps for both adaptation and low-carbon growth | • Knowledge products  
• Institutional coordination and strengthening  
• Resource mobilization | • Climate policy support targeted to needs  
• Low-carbon growth studies (India, Pakistan, Sri Lanka)  
• Trade barriers to clean technology adoption  
• Poverty-climate linkages  
• Build knowledge partnerships between countries and sectors  
• Assist with resource mobilization |
| Water                | • Glacier melting in the Himalayas, including lake outburst  
• Floods  
• Droughts  
• Saline intrusion in coastal aquifers (due to sea level rise) | • Regional cooperation on international rivers and river basins  
• Improved water resources management  
• Climate sensitive infrastructure “packages” to build climate resilience  
• Knowledge investments, e.g. to assess risks in Himalayas and the region’s large river basins  
• Increased research on new water efficient technologies and (drought resistant) crop varieties | • Convening power/leadership role to catalyze regional cooperation  
• Honest broker role without footprint  
• Technical assistance  
• Lending and financing for hydropower and storage |
| Agriculture          | • Declining yields of major crops  
• Agriculture unviable in marginal areas e.g. arid, semi-arid, coastal (saline intrusion affected zones due to sea level rise)  
• Crop destruction by extreme events | • Promotion of climate resilient cropping patterns and techniques  
• Agricultural research and extension for promoting climate resilient crop varieties  
• Improvements in risk management (e.g. climate insurance, contingent credit schemes)  
• Irrigation development and increased investment in water harvesting infrastructure at required scales that take account of climate risks | • Technical assistance (TA) to help in dissemination of climate-resilient crop varieties and cropping systems  
• Investments in agriculture research, improved extension services, irrigation and livelihood diversification  
• Sector work to identify innovative financing mechanisms (e.g. climate insurance, carbon credits) |
<table>
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<tr>
<th>Sectors</th>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
</tr>
</thead>
</table>
| **Natural Disasters** | Higher probability of extreme climate events (cyclones, storms, floods, heat waves)  
Higher probability of slow onset disasters (prolonged droughts, sea level rise) | - Emergency preparedness and information (early warning systems)  
- Risk mitigation: structural and nonstructural measures  
- Catastrophe risk financing or transfers (where needed) | - Strengthening institutional capacity for disaster reduction management (DRM) and emergency response  
- Technical assistance  
- Funding support for disaster preparedness and adaptation  
- Donor mobilization |
| **Health** | Increased incidence of water related diseases (malaria)  
Heatstroke  
Direct health risks; e.g. injury and death caused by extreme events | - Awareness of the health implications of climate change  
- Monitoring and surveillance of disease and improved health sector response and training for new disease risk profiles  
- Improved water supply and sanitation | - Analytical and advisory activities (AAA) and TA for impact assessments and review of the evidence base  
- Lending and financing  
- Convening role facilitating national and regional policy dialogues to prevent spread of climate sensitive diseases |
| **Social** | Increased poverty, vulnerability and nutrition insecurity  
Social conflict  
Aggravation of social exclusion and inequity  
Indebtedness in climate vulnerable areas  
Migration  
Increased urban slum population | - Awareness raising, social mobilization and capacity building  
- Education and skill training for women, indigenous populations (IPs) and other vulnerable groups for reducing agricultural dependence  
- Promotion of self-help groups (SHGs); and enhancing access to microfinance and banking services  
- Strengthening public-private partnerships and social capital of vulnerable groups, their access and decision making  
- Promotion of community-based asset building and sharing of natural resources | - Financial and technical support for promoting equity, inclusion, rights and livelihoods through targeting vulnerable groups and enhancing voice, decision making and capacity of the vulnerable to adapt  
- Partnership with community-based organizations (CBOs), coastal state organizations (CSOs), non-governmental organizations (NGOs) and private sector for capacity building.  
- Governance, strengthening institutions and social capital by initiating parallel capacity building and social accountability initiatives |
<table>
<thead>
<tr>
<th>Sectors</th>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
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</thead>
<tbody>
<tr>
<td><strong>Ecosystems and Biodiversity</strong></td>
<td>Quantitative and qualitative damage upon freshwater, coastal, marine and terrestrial ecosystems with consequences upon livelihoods</td>
<td>Expansion of protected area networks and promotion of ecosystem-based approach in biodiversity conservation</td>
<td>Financing for arresting and reversing ecosystem degradation, especially in <em>biodiversity hotspots</em></td>
</tr>
<tr>
<td></td>
<td>Loss of habitats, dependent species and important ecological goods and services</td>
<td>Mainstreaming of biodiversity and ecosystem management in development projects, climate mitigation, adaptation and risk management</td>
<td>Pilot new approaches for protecting, upgrading, restoring, sustaining and expanding ecosystems–Payment for Ecosystem Services, Debt for Nature Swap</td>
</tr>
<tr>
<td></td>
<td>Biodiversity loss in the Himalayas, glacier-fed ecosystems, forests and coral reefs</td>
<td>Designing and building biodiversity friendly and climate resilient infrastructure</td>
<td>Increasing the AAA and TA portfolio for building knowledge and capacity, particularly of the regulatory agencies</td>
</tr>
<tr>
<td></td>
<td>Shifts in vegetation regimes in forests, grasslands and semi-arid deserts resulting in altered community structures and climate feedbacks</td>
<td>Generation of knowledge and capacity</td>
<td></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>Political economy (non-climate) barriers to developing regional energy trade</td>
<td>Regional energy trade from power surplus countries (Bhutan, Nepal for hydro and Sri Lanka for wind) to energy-deficient economies (India and Pakistan)</td>
<td>Scale-up transmission &amp; distribution (T&amp;D) loss reduction investments in India, Pakistan and Bangladesh, including selected Indian state-level T&amp;D companies</td>
</tr>
<tr>
<td></td>
<td>Poor quality local coal</td>
<td>Cleaner coal – through rehabilitation and replacement of inefficient generation units</td>
<td>Expand renewable energy support through leveraging climate investment funds and advancing investments in hydropower (India, Nepal, Pakistan), coal (India), gas-fired (Bangladesh)</td>
</tr>
<tr>
<td></td>
<td>Aging and inefficient thermal power generation, high transmission and distribution losses</td>
<td>Harness hydropower potential</td>
<td>Operationalize energy efficiency possibilities in India, Pakistan and Bangladesh</td>
</tr>
<tr>
<td></td>
<td>Inefficient energy use</td>
<td>Energy efficiency and reduction of system losses.</td>
<td>Low-carbon growth studies for Pakistan, Bangladesh, and Sri Lanka</td>
</tr>
<tr>
<td></td>
<td>Poor energy pricing frameworks including under-priced electricity for lift irrigation which can consume up to 20 percent of supplies in some countries</td>
<td>Investment in (non-polluting) renewable energy</td>
<td>Advance energy pricing reform dialogue</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwork and dialog for investments in regional energy trade infrastructure</td>
</tr>
<tr>
<td>Sectors</td>
<td>Risks</td>
<td>Priority Response</td>
<td>World Bank’s Potential Role</td>
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</tr>
</tbody>
</table>
| Transport | • Increase in number of private vehicles and usage per vehicle  
• Increase in age and efficiency of vehicle fleet  
• Ongoing deterioration of public transport in cities  
• Expansion of low-density urban land development which is not friendly to public transport and non-motorized transport  
• Rail freight competitiveness and efficiency | • Sustainable and energy efficient public transport, and aggressive transport demand management, particularly in mega-cities  
• Reorienting urban growth patterns and practices so as to create networks of walkable neighborhoods, particularly in high growth, medium-sized cities  
• Slowing the modal shift to rail transport  
• Fuel efficiency standards for road vehicles | • Financial and technical support for the development of more energy efficient transport modes, such as public transport, non-motorized transport and clean transport  
• Transitioning traffic management priorities from private transport to public transport and non-motorized transport  
• Long-term land-use and transport planning  
• Greater weight given to assessment of transport impacts (particularly on energy use and climate change) in the project appraisal process  
• Institutional support to  
  - Capacity development for transport planning, operation and management at national and local level  
  - Regional or national initiatives that help develop and disseminate information on fuel efficiency standards and best-practices in vehicle maintenance  
  - National or local initiatives that advance the adoption of transport CO2 emission targets and monitoring mechanisms |}

| Urban | • Climate related damage upon urban settlements, lives, assets and basic water and sanitation services,  
• Increase in urban vector and water-borne diseases, (associated with urban poverty mainly in slums).  
• Growth of GHG emissions of future urbanization | • Integration of climate adaptation and disaster risk management within the urban climate change strategy.  
• Harnessing mitigation potential in industries such as solid waste, wastewater treatment, energy efficient buildings and infrastructure.  
• Improving energy efficient buildings | • Technical, financial and capacity-building support on adaptation and risk management in urban areas  
• Building knowledge and capacity of cities to adopt mitigation strategies and in developing urban climate change agenda  
• Assist cities in integrating urban transport, energy and construction within urban climate change strategy  
• Supporting the improvement of urban water infrastructure and sanitation services and demand management |
PART I. General Context and Strategy
Chapter 1. Introduction

The Context

27. A broad scientific consensus holds that climate change is already occurring and is bound to continue, even under the most optimistic scenarios. The current pace of change in the world’s climate is unprecedented in recent human history. The 1990s was the warmest decade, and 2005 the warmest year, on record since 1800. The impacts of higher temperatures are already being felt and will continue to intensify. Although mitigation of greenhouse gas emissions is crucial to alter dramatic long-term impacts, most of the changes projected for the coming decades can no longer be avoided. Climate change is a problem that the world will have to confront.

28. Addressing climate change presents a daunting policy problem. At the most fundamental level, climate change is a global issue, necessitating an international response. But not all countries are equally affected; nor do they all have an equal capacity to respond. The benefits of addressing the problem accrue in the uncertain and distant future, while the costs weigh upon current generations. Developing countries, and particularly the poorest among these, are most vulnerable, with likely impacts that would implicate crucial development needs and food security goals. Collectively these features create unrivaled challenges, of unmatched complexity.

29. Recognizing the risks to development from climate change, the World Bank (the Bank) has recently articulated a Strategic Framework for Development and Climate Change. The Framework views climate change through a development prism with an emphasis on growth and poverty reduction and defines the Bank’s overarching response to the development challenge under climate constraints (Box 1.1). The South Asia Region Climate Change Strategy (SARCCS) builds upon the World Bank’s Framework and identifies the guiding principles to address the challenges of climate change in South Asia. The SARCCS recognizes that South Asia is highly vulnerable to the impacts of climate change and there is a need for responses to be calibrated to government priorities and socio-economic conditions in the region. With its focus on poverty and development SARCCS is also closely linked to the South Asia Regional Strategy which emphasizes the need for growth in the lagging regions.

30. The main objective of the SARCCS is to support the development priorities of countries in South Asia by addressing climate-change related risks and opportunities. Adaptation to climate change lies at the heart of the strategy, because it is critical in reducing climate-related threats to development. With rapid economic progress in recent decades, there also remain wide opportunities for catalyzing low-carbon growth across the region in ways that contribute to the overall development objectives of South Asian countries. SARCCS identifies the broad parameters that will guide the Bank’s engagement in countries. The SARCCS emphasizes the need for approaches that are aligned with country priorities and demands. It attempts to inform and support country programs by deepening knowledge of the climate change challenge to development, expanding the policy toolkit to address climate challenges and facilitating access to additional financial resources. The focus is on the consequences of climate change on economic growth, poverty reduction and achieving the MDGs.
Report Structure

31. The strategy is in two parts. The first defines the broad parameters, directions and principles for addressing the climate change challenge in South Asia. It begins with an assessment of the global dimension of the problem. It then 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 and the key principles that would guide a response to the climate challenge in ways that are sensitive to country needs. Many of the far reaching climate impacts are projected to cut across sectors and national boundaries, necessitating regional responses and integrated approaches.

32. Reflecting the multi-sector scope of the challenge, the second part of the strategy provides a detailed assessment of the potential risks and responses in sectors where climate risks and consequences are high – water resources, agriculture, energy, transport, the urban space, biodiversity, and the social impacts of climate change. The links are often complex, interconnected and run both ways – many sectors are threatened by climate change, but also have an impact on future climate outcomes. Likewise, climate impacts in one sector – such as water availability – can have cascading effects in other segments of the economy – such as agriculture and industry. A common theme that emerges is the need for better information and knowledge of these links to define well articulated responses to the climate challenge.

<table>
<thead>
<tr>
<th>Box 1.1 The Strategic Framework on Development and Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Strategic Framework on Development and Climate Change defines the World Bank Group response to the development impacts of climate change. It identifies six broad priority areas of action for both adaptation and mitigation:</td>
</tr>
<tr>
<td>- Support climate actions in country-led development processes</td>
</tr>
<tr>
<td>- Mobilize concessional finance</td>
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<tr>
<td>- Facilitate the development of market-based financing mechanisms</td>
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<tr>
<td>- Leverage private sector resources</td>
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<tr>
<td>- Support accelerated development of new technology</td>
</tr>
<tr>
<td>- Policy research, capacity building and knowledge</td>
</tr>
</tbody>
</table>

Process and Consultation Strategy

33. SARCCS is the product a joint effort with inputs from all sectors in the South Asia Region of the Bank and collaboration with many networks. This structure has encouraged an effective exchange of information that has promoted learning and the integration of climate issues in sectoral programs. The document has also benefited from consultations held in Bangladesh, India and Sri Lanka for the Strategic Framework for
34. Following a management review of this draft document a wider country based consultation process will be undertaken. There will be multi-stakeholder consultations and workshops in most SAR countries. The document will be posted on the Bank website to solicit comments from a wide range of constituencies. Discussions and consultations are intended to promote awareness of climate change challenges in South Asia and ensure that the final strategy document reflects country priorities.

*Development and Climate Change.* It incorporates the views and concerns of the many stakeholders that emerged during these discussions.
Chapter 2. Climate Change: The Global Scene

35. 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?

36. The Earth is warming and its climate is changing. Indeed, measurements show that the Earth has warmed by 0.74°C over the last 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.

37. Climate change is about more than just rising temperatures. There are cascading effects, with some areas becoming drier due to more heat and evaporation, such as the Sahel, the Mediterranean basin, Southern Africa, and parts of Southern Asia. 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 impacts of higher temperatures, more variable precipitation, more extreme weather events, and sea level rise will likely continue to intensify. These changes are already having 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?

38. 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 (CO₂), methane (CH₄), and nitrous oxide (NO₂) are the main greenhouse gases 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).
39. 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 over 380 ppm in 2005. 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, ).

**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 [Figure FAQ 1.3].*

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7 Data on other GHGs in the 18th and 19th centuries are unavailable.
40. 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. This conclusion has been reached through numerous sources of scientific information. First, climate models show that observed temperature changes can only be predicted 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 show that current CO₂ levels are higher than they have been in 440,000 years, and variations in CO₂ levels closely correlate with surface temperatures.

**Box 2.2 Role of Anthropogenic GHGs in Global Warming**

Human activities have changed the climate of the Earth. The figures below have been used by IPCC to conclude that natural factors alone cannot explain the recent temperature changes. In the left panel 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.

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8 This assertion is made by the IPCC with 90 percent confidence probability.
What Might the Future Hold?

41. **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 Intergovernmental Panel on Climate Change (IPCC) developed a variety of emission scenarios (Nakicenovic, N., and R. Swart, eds. 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.

**Figure 2.1 Projected GHG Emissions and Global Surface Warming**

![Graph of projected GHG emissions and global surface warming](image)

*Source:* IPCC 2007a. ([Figure SPM5](#))

*Note:* The solid 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 Emission Scenarios.

42. **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 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$_2$)$_e$ 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 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.

**Figure 2.2 Projected Warming 2020–2099**

![Figure showing projected warming 2020-2099 for A2, A1B, and B1 scenarios.](image)

*Source: IPCC 2007b*. [Figure 3.2]. Reproduced/modified with permission by IPCC.

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9 See glossary for definition.

10 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.

11 Atmosphere-Ocean General Circulation Model 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 (top), A1B (middle) and B1 (bottom) SRES scenarios averaged over decades 2020-2029 (left) and 2090-2099 (right).
What Are the Main Impacts of Climate Change?

43. **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. 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 may be unavoidable or even accentuated by practices that increase exposure to climate risks (mal-adaptation). 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.

44. **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. Rainfed agriculture and rangeland-based pastoralism remain especially vulnerable to more variable climate patterns.

45. **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 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.

46. **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 over 2 billion people in developing nations, representing about 40 percent of the total population in the affected countries. Although forecasts are uncertain, projections indicate that with warmer surface temperatures the seas will fuel more violent tropical cyclones and winds, 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.

47. **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.

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48. **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.

49. **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 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.

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**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, 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.

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13 Local sea level change (meters) due to ocean density and circulation change relative to the global average (i.e., positive values indicate greater local sea level change than global) during the 21st century, calculated as the difference between averages for 2080 to 2099 and 1980 to 1999, as an assemble mean over 16 AOGCMs forced with the SRES A1B scenario. Stippling denotes regions where the magnitude of the multi-model ensemble mean divided by the multi-model standard deviation exceeds 1.0.
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 points 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 be less 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.

Confronting Climate Risks: The Need for Adaptation

50. 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 climate shocks can
cause irreversible loss. Hence, climate change poses a risk to development and could potentially delay or reverse the attainment of many of the Millennium Development Goals (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?**

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

52. **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 approach to developing a climate risk management strategy. Any strategy 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.

53. **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 disaster preparedness 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. Nevertheless the provision of new and additional financial resources is essential to meet global development aspirations when faced with the

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14 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.
burdens of climate change. Indeed, it was commitment to such extra resources that provided the common ground to bind diverse parties to the Bali Action Plan in 2007.\textsuperscript{15}

\textit{Are there limits to “Climate-Proofing”?}

54. 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.

\textbf{The Global Emission Footprint}

\textit{What Are the Main Sources of GHGs?}

55. 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 over 65 percent of GHGs, followed by deforestation, which contributes about 18 percent, with the remainder from agriculture and wasteland use (Figure 2.4). Deforestation and fossil fuel consumption primarily produce CO\textsubscript{2}, while agriculture and waste are the main sources of methane emissions. Methane is a highly potent GHG.

\textbf{Figure 2.4 Sources of GHG Emissions}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure2.4.png}
\caption{Sources of GHG Emissions}
\end{figure}

\textit{Source:} World Resources Institute 2005.

Which Countries Are Responsible for Emitting GHGs?

56. **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.

57. **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 CO2 emissions (with a share of 29 percent), followed by the countries of the present European Union (26 percent) and Russia (8 percent).16 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 commitment that developed countries should take the lead in combating climate change.17

58. **Current emissions.** A relatively small number of countries, 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 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 over 80 percent of global emissions. The distribution of emissions is therefore highly skewed, but this also reflects the distribution of global GDP and population.

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

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

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

*Source:* World Resources Institute Climate Analysis Indicators Tool (CAIT) (http://www.wri.org/project/cait).
Figure 2.6 Countries with the Highest Per Capita CO₂eq Emissions¹⁸, 2000

<table>
<thead>
<tr>
<th>Country</th>
<th>CO₂eq (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belize</td>
<td>93.9</td>
</tr>
<tr>
<td>Qatar</td>
<td>54.7</td>
</tr>
<tr>
<td>Guyana</td>
<td>52.5</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>49.4</td>
</tr>
<tr>
<td>Malaysia</td>
<td>37.4</td>
</tr>
<tr>
<td>Brunei</td>
<td>33.2</td>
</tr>
<tr>
<td>Kuwait</td>
<td>31.6</td>
</tr>
<tr>
<td>Singapore</td>
<td>30.5</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>29.3</td>
</tr>
<tr>
<td>Australia</td>
<td>26.6</td>
</tr>
</tbody>
</table>

Source: World Resources Institute Climate Analysis Indicators Tool (CAIT) (http://www.wri.org/project/cait).

**What Determines Per Capita Emission Levels?**

60. **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.

61. **Emission intensity.** Emission intensity measures the amount of GHG emitted per unit of output (GDP). It varies widely across countries at all levels of development and income (Figure 1.8). 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.¹⁹ 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

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¹⁸ See glossary for definition.
¹⁹ 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.
insurance). Finally, emission intensity also depends on the mix of fuels used to generate electricity, and the efficiency of energy use.20

Figure 2.7 CO₂ Intensity: Main Emitters, 2000


At What Level Should the World Stabilize GHG Emissions?

62. 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 CO₂e and is rising at about 2 ppm each year.21 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.

63. 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 UNDP Human Development Report (UNDP 2007), which calls for stabilization at 450 ppm CO₂e, an emission level that will likely produce a 2°C to 3°C 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

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20 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.

21 The implication is that the Earth is likely committed to a 2°C warming.
large unknowns the risks of wasteful expenditure on mitigation could outweigh the potential costs of climate change. The suggested strategy involves a wait-and-see approach, with an early emphasis on adaptation followed by mitigation if this becomes necessary (Lomborg 2007).22

64. **The economics of climate change.** Economic assessments have searched for strategies that balance the costs of intervention, with the perils of inaction. These 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).

65. 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 services23 – or place a low weight on damages in the distant future (termed the discount rate).

**Who Is Right – The Climate Optimists or the Climate Pessimists?**

66. **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.

67. **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 to address both the development challenges imposed by climate change and to slow the process of climate change.

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22 The counter to this is that it would be too late to arrest the damage because of the long lags in climate systems. CO₂ endures in the atmosphere for about a century. Consequently, current climate impacts are a consequence of the atmospheric build-up of previous generations.

23 Sterner and Persson (2007) demonstrate this outcome in the Nordhaus model, which has typically produced low-end estimates.
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 available substantial resources 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.

68. The following chapter 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.
Chapter 3. The Regional Scene: South Asia’s Climate Vulnerability and Contribution to Greenhouse Gas Emissions

Why is South Asia Vulnerable to Climate Change?

69. 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 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, the South Asia’s population is likely to exceed 2.2 billion from the current level of 1.5 billion. With an estimated 600 million South Asians subsisting on less than US$1.25 a day, even small climate shocks can cause irreversible losses and tip a large number of people into destitution.

Figure 3.1 South Asia Population Projections

![South Asia Population Projection](image)

Source: World Bank’s Human Development Network.24

70. 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

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24 Note: The input data used for the projections include a Base year (mid-2000) population estimate by age and sex, and base period (2000–2005) estimates of mortality, fertility and migration. The Population projection tables are produced by the World Bank's Human Development Network in consultation with operational staff and country offices and provide population projections and other demographic data for nearly 200 economies. Available at [http://go.worldbank.org/H4UN4D5K10](http://go.worldbank.org/H4UN4D5K10).
agriculture, the poor in South Asian countries are likely to be disproportionately affected by climate change.

71. **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 last two decades. The region shares common geological formations and river basins; natural hazards frequently transcend national boundaries. With climate change the frequency and incidence of such natural disasters is projected to increase.

72. **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 over 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 three-fifth 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.

73. **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. Brahmaputra, Ganges, Indus, and Meghna). The Ganges river basin alone is home to about 600 million people (see Figure 3.2). The retreating glaciers of 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 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 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. Glacier retreat in Nepal for instance can flood farms in distant Bangladesh. Addressing these problems calls for considerable regional cooperation.
Figure 3.2 Ganges River Basin

- Basin Area (sq. km): 1,016,124
- Large Cities (100,000 or more): 82
- Water Supply per Person (1995)(m³/year): 1,700–4,000


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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, Karachi, Kolkata, Mumbai, and Cochin) 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 Indus, Krishna, Cauvery, and Narmada). Salt water intrusion in low-lying agricultural plains and water resources could lead to localized food insecurity, spread of water-related diseases 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 these are expected to 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 over 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. By 2020, Mumbai will be the second largest city in the world, closely followed by Delhi, and Dhaka. With Karachi and Kolkata – five of the world’s 11 megacities will then be in South Asia. Dhaka is already the fastest growing mega-city in the world, drawing an estimated 300,000 to 400,000 mostly poor migrants each year. In Mumbai, more than half the population are 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.

Figure 3.4 South Asia Urban Population Projections

![South Asia Urban Population Projections](image)


76. **In sum, high population densities, a large concentration of poverty, and climate variability have all combined to make South Asia highly sensitive to the 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.

77. 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 six percent annually. Growth further accelerated to 6.5 percent during 2000–2007 and has lifted millions out of poverty. South Asia is the least integrated region in the world but would grow further if it 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, displacement and 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?

78. 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, non-linear feedback processes. While acknowledging the many uncertainties a broad consensus has emerged 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

79. 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 will 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 IPCC26.

Precipitation

80. The wet regions will get wetter and the dry regions drier. Forecasts suggest 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 – more so than in many other parts of the world.

Runoff

81. 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

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26 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, N., and R. Swart, eds. 2000).
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.

**Figure 3.5 Relative Change in Runoff in the Twenty-First Century**

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean runoff change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>−20 to −10</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>20 to 30</td>
</tr>
<tr>
<td>Bhutan</td>
<td>10 to 20</td>
</tr>
<tr>
<td>India</td>
<td>30 to 40</td>
</tr>
<tr>
<td>Maldives</td>
<td>20 to 30</td>
</tr>
<tr>
<td>Nepal</td>
<td>10 to 20</td>
</tr>
<tr>
<td>Pakistan</td>
<td>&gt; 40</td>
</tr>
</tbody>
</table>


Ensemble (arithmetic) mean of relative change (percentage) in runoff for the period 2041–60, computed as 100 times the difference between 2041–60 runoff in the SRESA1B experiments and 1900–70 runoff in the 20C3M experiments, divided by 1900–70 runoff.
Sea Level Rise

82. 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 glacier melt.\textsuperscript{27} 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\textsuperscript{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.

Figure 3.6 Projected Global Average Sea Level Rise at the End of the Twenty-First Century

\textsuperscript{27} There are numerous other projections of more severe sea level rise that allow for greater melting of polar ice mass.

Climate-Related Disasters

83. 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, globally, that there will be more storms, at higher intensity. Likewise, 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.

84. 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

85. 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.28 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.

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28 During the period of 1975 to 1999, the glacier has retreated more than 850 meters, with a 76 meters loss from 1996 to 1999 alone.
Who Will be Most Affected by Climate Change?

86. **Women, the poor, and indigenous peoples are most vulnerable to climate risks.** Climate change affects women differently because of unequal power relations 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. Social exclusion makes women more vulnerable to natural disasters, so that effective adaptation strategies would need to address these fundamental gender disparities. Livelihoods of the poor are based on agriculture and will be directly impacted by climate change. 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 live, around 100 million, in South Asia. Their dependence on forests makes them especially vulnerable to climate induced changes in natural resource productivity.

87. **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 disease (St. Louis, Campbell-Lendrum, and Hess 2008) and suffer poverty impacts can be irreversible.

South Asia’s GHG Footprint

88. While vulnerability to climate change is high in South Asia, the region has also emerged as a significant contributor to greenhouse gas 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, except the Middle East. Total emissions exceed 2.5 billion tons of CO₂ 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).

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; ROW, Rest of the World.

Source: World Resources Institute Climate Analysis Indicators Tool (CAIT) (http://www.wri.org/project/cait).

89. As the region strives to meet its development goals, the potential for further growth in emissions is enormous. Over 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 far-reaching consequences on global GHG emissions. Growth typically spurs emissions in rough proportion to the income in generates.²⁹ Hence, South Asia like the rest of the world faces an enormous challenge to sustain its growth while addressing global warming.

²⁹ Globally, a 1 percent increase in per capita income has induced – on average – a 1 percent increase in GHG emissions.
Figure 3.8 Greenhouse Gas Contributions by Country in South Asia, 2000

<table>
<thead>
<tr>
<th>Country</th>
<th>CO2 Contribution</th>
<th>CH4 Contribution</th>
<th>N2O Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>40.41%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bhutan</td>
<td>0.06%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maldives</td>
<td>0.02%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>6.18%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afghanistan</td>
<td>1.00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakistan</td>
<td>12.69%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangladesh</td>
<td>4.51%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India N2O</td>
<td>15.90%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India CH4</td>
<td>17.08%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: World Resources Institute Climate Analysis Indicators Tool (CAIT) (http://www.wri.org/project/cait).

90. Reflecting the size of its economy, population and territory, **India remains the largest contributor to GHGs in the region**. However, in terms of emissions per unit of GDP (measured either by PPP or nominal exchange rates) India remains a low-intensity producer of CO2 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. Simultaneously, 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.

91. In South Asia energy, industry, agriculture, and to a lesser extent transport are the key contributors to GHGs (see Table 3.1). In many other regions deforestation is an important driver of GHG emissions. By contrast the forest boundaries in most South Asian countries (with a few exceptions) have largely stabilized as a result of high rates of forest conversion to agricultural land in earlier decades. Consequently, the contribution of deforestation to GHGs is relatively small. 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

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30 Note: Figure only provides contribution by gas for India in CO2 equivalents.
32 IEA Electricity Access Index.
region, is not well endowed with reserves of cleaner fuels such as oil, gas, and uranium.\footnote{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).} Hydropower potential is significant and large in absolute terms (150,000 megawatts), but small compared to the country’s future energy needs.\footnote{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.} 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. Because of the cost advantage of coal and the relative security of the fuel supply, Bangladesh, Pakistan, and Sri Lanka will likely increasingly 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 \textbf{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.

\begin{table}[h]
\centering
\begin{tabular}{lrrrrrr}
\hline
 & Afghanistan & Bangladesh & Bhutan & India & Nepal & Pakistan & Sri Lanka \\
\hline
Energy Transformation & -- & 32 & -- & 1068 & 5 & 112 & 11 \\
& & & & & & & \\
Electricity & -- & 9 & -- & 558 & 0 & 34 & 3 \\
& & & & & & & \\
& & & & & & & \\
Heat & & & & & & & \\
Manufacturing & -- & 10 & -- & 231 & 1 & 27 & 1 \\
& & & & & & & \\
& & & & & & & \\
Construction & & & & & & & \\
Transportation & -- & 3 & -- & 92 & 1 & 25 & 6 \\
& & & & & & & \\
Other Fuel Combination & -- & 10 & -- & 147 & 3 & 17 & 1 \\
& & & & & & & \\
Fugitive Emissions & -- & 0 & -- & 40 & 0 & 9 & -- \\
& & & & & & & \\
Industrial & -- & 2 & 0.1 & 71 & 0 & 5 & 1 \\
\hline
\end{tabular}
\caption{Contributions to Greenhouse Gas Emissions by Sector and Country in South Asia}
\end{table}
c. **Transport.** South Asia’s emissions from transport are currently 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 four-fold from 19 million in 1990 to 73 million in 2004.\(^{35}\) 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 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.

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

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\(^{35}\) 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 (*op cit*).
Chapter 4. The Way Forward – Strategic Priorities

93. **Climate change is already a development reality in South Asia.** Existing concerns about food security, water scarcity and energy are made all the more difficult by climate risks that will challenge the goals of inclusive and environmentally sustainable economic growth. Development under climate constraints demands a dual approach. Adaptation is necessary to limit the damage caused by climate change. It enables communities to preempt and manage climate risks and allows governments to protect and “climate-proof” high value assets and infrastructure. Mitigation is also vital since no amount of adaptation planning can protect economies from the potentially catastrophic impacts of climate change. A key to a sound climate change strategy will be to strengthen the knowledge and capacity of institutions that currently manage climate-sensitive assets and natural resources. Recognizing that industrialized countries have contributed most to the existing stock of emissions, there is a broad consensus that developed countries would need to take the lead and shoulder the financial burden of mitigation actions in the near term.\(^{36}\) However, there also remain wide opportunities for developing countries to participate in emission stabilization in ways that generate win-wins and benefit national development goals.

**Role of the World Bank and the Pillars of Engagement**

94. **The World Bank, with its development mandate, has an important role to play in supporting South Asian countries to develop under climate constraints.** Agreements on global climate strategies to stabilize emissions lie in the jurisdiction of the Parties to the UNFCCC, at which the World Bank is a neutral observer and does not participate. However, the Bank recognizes that climate change has become a significant development challenge that threatens growth prospects.

95. Addressing the climate change challenge must include adaptation, to address the inevitable; and mitigation, to prevent the avoidable. The adaptation dimension is closely linked to the development mission of the Bank. The Bank is therefore well positioned to assist its partners in building economic resilience in order to protect development from climate risks. The Bank also has a large presence in renewable energy, energy efficiency, the water sector and institutional reform. The Bank can therefore play a key role in facilitating a global transition to low-carbon-growth economies in ways that promote sustainable development and economic progress. There are a suite of instruments available to address the climate challenge. These include knowledge products, technical assistance, policy advice, as well as investments. Subsequent chapters address this issue in greater detail.

96. **Building country ownership, capacity and awareness is the key to tackling the climate change problem.** The resources available for climate change are limited, while the region is a large player whose performance (on both emission stabilization and adaptation) will have an important bearing on global outcomes. Simply strengthening or scaling-up the many climate-friendly investments in the Bank’s portfolio will not be

\(^{36}\) At the time of writing the turbulence in financial markets remains a major concern and source of uncertainty.
sufficient to tackle the problem. For the Bank’s interventions to be effective the solution lies in building partnerships to promote country ownership of climate change challenges. This calls for tailored approaches to deepen knowledge and institutional awareness so that climate risks are incorporated in country development policies, plans and programs. It also requires high-impact investments that would have catalytic effects. Strengthening the knowledge base and institutional capacity is especially significant in this context given that most measures must be guided by government policies.

**Adaptation in South Asia**

97. **Effective adaptation poses many policy challenges.** Responses have to be developed in the face of uncertainties on the timing, location and severity of climate impacts. Looking to the future the scale of these impacts will be contingent upon global mitigation efforts undertaken in the next few decades. Delayed or limited emission stabilization will necessitate considerably greater investment in risk management and climate change adaptation. These uncertainties need to be factored into the development of adaptation strategies and financing plans. In some respects the risks posed by climate change are one of degree – more intense floods, or more frequent droughts, or a greater incidence of climate-sensitive diseases. The policies and institutions that enable South Asian countries to cope with these risks today, will build resilience in addressing future risks. Simultaneously, climate change is also predicted to bring new and unprecedented problems, such as those associated with sea level rise and melting glaciers. This will call for building new policies to prepare for the potential adverse impacts. However, given the large uncertainties, a rational first response is to invest in greater knowledge to better understand the scale and magnitude of these threats and to build institutional capacity and knowledge to adequately respond to the challenge of climate change. In many cases institutions will be considerable challenged by the crisis of climate change, in particular where structures are highly fragmented, such as for water resources, and where technical capacity is limited. In all South Asian countries institutional responsibility for climate change is vested in the environment sector, but the actions and responses that are needed are typically cross-sectoral. There is often limited understanding of climate change related problems in sectoral ministries and public sector companies, so an investment in knowledge is crucial.

98. **Climate policies in South Asia will need to be tailored to specific risks and country development priorities.** The projected impacts of climate change in South Asia will be varied and heterogeneous, suggesting that there are no simple blueprints for successful climate change adaptation. Responses will need to be customized to specific risks. Accordingly, the South Asia region climate change strategy sets out the broad principles of an evolutionary approach that can be tailored to fit individual circumstances. The focus would need to vary depending on country risks, needs, demands and institutional structures. Recognizing the need for flexibility, the South Asia adaptation priorities are guided by five pillars:

   a. **Investment in knowledge.** In a situation of uncertainty, knowledge has high value, and this makes the case for vigorous investment in information and better understanding. Adaptation to climate change is analogous to many other forms of risk management. It requires an assessment of possible threats and opportunities
arising from climate variability; and incorporation of the outcomes of such assessments into policy through the appropriate mechanisms. The challenge is that climate science is imperfect and there is often little reliable information on the path of future climate risks and the likely damages in particular if these are regional or local in nature.

b. **“No-regrets” approach.** No-regrets approaches build resilience to climate risks while generating additional co-benefits. Faced with uncertainty about future risks, no-regrets policies provide a strategy for hedging against climate risks. Issues such as irrigation supplies, health care, infrastructure, agriculture technology, disaster preparedness, and habitat protection lend themselves to no-regrets adaptation interventions that simultaneously deliver climate resilience and address current development needs.

c. **Focus on the poor.** The most vulnerable are the poor in the developing countries who have limited resources and whose assets and livelihoods are exposed to climate-sensitive factors. The poor are also most often employed in sectors, such as agriculture, that are exposed to high climate risks. Building resilience of these groups to current climate risks is a difficult challenge given their general lack of representation in various institutions, but one that would generate immediate development dividends as well as reducing future climate vulnerability.

d. **Promoting regional cooperation to address common threats.** The most severe climate threats (such as glacier retreat and sea level rise) transcend national boundaries. Finding effective solutions for flood control, irrigation and river transport will require cooperation between upper and lower riparian countries. This calls for coordinated solutions to jointly address shared problems. Simultaneously effective regional cooperation through energy trade can also assist in lowering emissions.

e. **Maintaining the integrity of environmental services.** Recognizing that climate change is a consequence of damaged and diminished ecoservices, remedial measures need to be aimed at protecting and restoring ecosystem integrity. Indeed, maintaining ecosystem integrity can provide a cost-effective way of building climate resilience and providing a buffer against climate impacts.

**Low-Carbon Development in South Asia**

99. With a large proportion of South Asia’s population living below the poverty line, any low-carbon growth strategy must be consistent with the region’s development objectives of improving living standards and incomes. This is the overarching principle that guides the Bank’s operations. Fortunately, opportunities do exist to harness win-wins by focusing on measures that generate significant co-benefits such as improvements in energy and economic efficiency, reduction in local pollutants and improvements in natural resource management. The South Asia region has initiated a strong dialogue and a work program to realize these multiple benefits and to expand its interventions. There are three key pillars that guide the South Asia region in promoting low-carbon development and growth:

a. **Win-win policies.** Such policies not only provide global benefits in reducing GHGs but also pay for themselves in domestic benefits such as reduced fuel
expenditure, energy efficiency, greater energy security, improved air quality. If win-win policies were easy to implement, they would have long since been put in place. But they are often impeded by regulatory barriers, financial constraints, coordination problems, institutional bottlenecks, or market failures. Some (IEA 2006; Farrell et al. 2008) see tremendous untapped opportunities for win-win policies and argue that the mitigation challenges can be largely achieved with such structural realignments. But others are skeptical, emphasizing the formidable policy and political economy obstacles that would need to be overcome. The Bank, with its long global experience in addressing institutional and policy hurdles, is well positioned to assist countries harness these opportunities.

b. **Compensation.** All South Asian countries would need to be compensated for the additional costs of mitigation actions that go beyond their development objectives. This approach underlies the UNFCCC principle of “common but differentiated responsibilities.” It recognizes that current climate risks are the consequence of past actions by developing countries and there is a need for assuring equal and fair access to the global atmospheric commons.

c. **Technology transfer.** A third pillar is to promote the wider adoption of clean technologies. New technologies are expensive and risky, but with further research and adoption, they can become more economical and accessible. Development, deployment, and diffusion of affordable technology are critical to enabling developing countries to meet the challenges of climate change. Hence the transfer of technology and intellectual property rights regimes will be pivotal in determining the success of any global measures to stabilize GHGs. The World Bank can play a supportive and catalytic role in this process.

100. Tables 4.5 and 4.6 (located at the end of this chapter) provide a summary of the main climate risks and priority responses across the South Asia region – by sector and country. The Bank has at its disposal a wide range of instruments that include knowledge partnerships and capacity building (including climate risk assessments, assistance with global negotiations where required, reports and technical support) and investments. Consistent with its mandate the focus will be on the development impacts of climate change. The risks and responses suggest the need for the development of a climate sensitive approach, which builds on many aspects of the current portfolio of activities that already contain dimensions related to both adaptation and mitigation. Some existing activities would need to be further enhanced to address climate challenges, demands and needs. To be effective the strategy must aim to build country capacity and ownership of the climate change challenge.

101. In a resource constrained environment there will be a need to leverage funds effectively to achieve transformational impacts. Full use will need to be made of the evolving financial instruments, such as the Climate Investment Funds, and its components, in addition to other global resources such as special financial vehicles established by bilateral donors (such as climate change trust funds), and any international financing mechanism to be agreed under the second commitment period of the Kyoto Protocol (post-2012) and other agreements. The following section provides an overview of available financial resources.
Box 4.1 Can Regional Cooperation Reduce Climate Vulnerabilities of South Asia?

During the 1990s, South Asia’s economies grew rapidly at an average of 6 percent annually. The growth further accelerated to 6.5 percent during 2000-2007. Rapid growth has been instrumental in reducing poverty in South Asia. Progress has also improved human development and social indicators. South Asia is the least integrated region in the world and has the potential to grow further if the region is integrated.

South Asia would probably gain most from regional cooperation in water, energy, and climate. Regional Cooperation can be a powerful tool for increasing growth, reducing inequality, increasing energy trade, and reducing vulnerabilities for the poor. By reducing vulnerability, regional cooperation can be helpful in lowering income inequality.

The melting of Himalayan glaciers leading to the disastrous prospect of reduced water availability in the South Asian rivers, the frequency of floods and cyclones, and the evidence of rising sea level necessitates a collective action for managing and reducing the vulnerability to climate change.

Actions at the national level cannot provide sustainable solutions since upstream flows from Afghanistan, Nepal, and parts of India impact Bangladesh, most of India and Pakistan. Finding solutions for flood control, irrigation and river transport will require cooperation with upstream countries. Thus, cross-border cooperation on water between India, Bangladesh, and Nepal offers a long-term solution to flood mitigation. There are similar benefits of water cooperation between India and Pakistan and between Pakistan and Afghanistan. The success of the Indus Water Treaty between Pakistan and India has already demonstrated that cooperation that benefits people can withstand all political obstacles.

What are the key constraining factors? First and foremost is the prevalence of a number of regional differences and priorities. Closer cooperation in climate related issues and trade could be a catalyst for resolving political and social differences. Given the magnitude of climate related events, it is critical that the regional countries move toward meaningful cooperation rather waiting for all differences to be resolved.

Financing Climate Adaptation and Mitigation

Climate change represents an unprecedented development challenge and the resources needed to tackle the problem vastly exceed available funds. Cost estimates point to a deficit in the order of hundreds of billions of US dollars per annum for several decades. Responding to the climate challenge will require additional financing that should complement rather than compete with investments required for development. The global financial architecture would likely be negotiated in a forum such as the UNFCCC, and until this occurs it will be difficult to cover the financial gap.

Most South Asian countries already spend a significant proportion of their development budgets to address climate related risks. In India for instance, the direct losses from natural disasters are about 2 percent of GDP and perhaps as much as 12 percent of government revenues (World Bank 2003). Climate change is expected to increase the frequency of adverse climate events and raise the costs of development.

37 A recent review conducted by the Bank suggests that the available funds for both climate mitigation and adaptation are of the order of US$10 billion pointing to a deficit in the order of hundreds of billions of US dollars per annum (World Bank 2008).
Though the resources that are currently available to meet the additional costs of climate change are insufficient, South Asian countries will need to prepare to utilize the new funds that are being developed to address climate risks in developing countries. There are also a number of financial instruments that are available to promote low-carbon development. These provide an opportunity to leverage the many untapped opportunities for investment in mitigation that simultaneously deliver other development benefits. The Bank can play an important role in helping South Asian countries access these resources.

**Box 4.2 Lagging Regions and Climate Change**

Recent rapid economic growth has been accompanied by rising regional inequality in South Asia. Growing income inequality and imbalance between regions within countries and among the countries could present social and economic problems to more prosperous neighbors as would imbalances within the countries.

India’s southern and western states, taking advantage of the global economy, are growing faster than the northern and eastern states. Sri Lanka’s western province now contributes more than 50 percent of national GDP. Poverty rates in Pakistan’s southern Punjab are twice those in northern Punjab. The disparities are seen even within fast growing state like Andhra Pradesh in India. The dismal prospects of rural economies that depend on agriculture remain the primary factor behind this rising inequality in South Asia. Unless the lagging regions participate in the growth, not much will change for millions of poor people.

The problem of inequality is, however, a more complex challenge. Growth acceleration in the lagging regions might help reduce inequality. But this is only a part of the larger task of making growth more inclusive. The large concentration of poor in the lagging regions suggest public policy must focus on raising growth and improving human development in these lagging regions. The lagging regions share a number of common vulnerabilities, including a high dependence on natural resources and climate-sensitive sectors of the economy. First and foremost is their vulnerability to natural disasters. South Asia has lost a significant amount of its GDP because of natural disasters and this impact is particularly harmful because of the region’s high population density. This loss has been especially significant in many of the lagging regions of Bangladesh, India and Pakistan. A second and related vulnerability is resource degradation and, in particular, access to water. Many of the lagging regions are arid and depend on groundwater for irrigation. Unsustainable irrigation will take more of a toll if droughts become more frequent because of climate change. Frequent water shortages and intermittent floods create serious challenges to maintaining the income level of these large numbers of poor people. With melting glaciers, flood risks would increase in the near future and it is lagging states such as Bihar and Jharkand in India, and Nepal and Bangladesh that will bear the burnt of these major climatic changes. All of this suggests that building climate resilience is an important part of a strategy for igniting growth in the lagging regions of South Asia.

**Financing the Transition to Low-Carbon Economies**

104. The World Bank has pioneered numerous initiatives to ensure that developing countries and economies in transition benefit from international efforts to address climate change. The expansion of the carbon market in recent years has promoted the implementation of climate-friendly technologies in numerous developing countries and transition economies. The volume of carbon emission reduction reached
2.98 billion metric tons of carbon dioxide equivalent in 2007 amounting to trades of US$64 billion. About one-fifth of these carbon reductions were generated from developing countries through the Clean Development Mechanism (CDM) under the Kyoto Protocol mainly from China, India and Brazil, and in projects involving renewable energy development and energy efficiency. A similar mechanism focused on transitional economies, termed Joint Implementation (JI), has focused on emission reductions in economies in transition, with Russia, Ukraine and Bulgaria being the most important suppliers. Under current projections, the market-based mechanisms (CDM and JI) would contribute 20 percent of the total demand for emission reductions by 2012. Since their inception, the carbon markets have mobilized thousands of entrepreneurs in the private and public sectors, as well as in communities throughout the developing world.

105. The Carbon Finance Unit (CFU) in the Bank has developed numerous funds to assist project-based emission reductions in developing countries. The CFU has been an important catalyst in the formation of the carbon markets, by benchmarking carbon assets, and developing projects in new sectors. Funds are generated from the contributions of governments and companies in Organisation for Economic Co-operation and Development (OECD) countries and are used to purchase project-based GHG reductions in developing countries and economies in transitions. Carbon finance provides a stream of revenue for these countries, raising the bankability of projects and reducing the risks of commercial lending and grant finance. Hence, it enables the leveraging of new private and public investments into projects that mitigate climate change at the same time contributing to sustainable development. Table 4.1 lists the various sources of carbon finance that have been supported by the Bank for mitigation initiatives in energy, forestry, land-use change, agro-ecosystems and industry. These are currently being used to purchase emission reductions in developing countries.

Figure 4.1 Clean Development Mechanism Projects by Country, Beneficiary, and Sector

Source: Capoor and Ambrosi 2008.
A number of recent developments are expected to contribute to the evolution and transformation of the carbon markets over the next few years, in particular for emission reductions originating in developing countries. These include: (i) the second commitment period under the Kyoto Protocol (post-2012) which will likely include mechanisms to scale up the CDM and JI and provide more flexible operational procedures and eligibility requirements; (ii) the European Union is likely to extend the European Union Emissions Trading Scheme beyond 2012, and could include linkages to the CDM and JI, thereby expanding the size and scope of the market; and (iii) the growing demand for carbon offsets from the voluntary market.

Under these rapidly evolving conditions, the World Bank’s Board of Directors has approved the launch of two new carbon facilities in September 2007. The first is the Carbon Partnership Facility, which will purchase emissions reductions for at least 10 years beyond 2012 in an effort to promote a shift towards investments in long-term, low-carbon technologies where otherwise greenhouse gas emissions would be locked in for decades to come. Recognizing the importance of forests as a carbon sink, a Forest Carbon Partnership Facility is dedicated to reducing emissions from deforestation and degradation. This initiative is aimed at setting the stage for future systems for performance-based payments that would provide incentives to slow deforestation and degradation. Consistent with the Bank’s role to further develop the carbon market, these two facilities are based on the need to support long-term investments in an uncertain market environment, possibly spanning several market cycles. “Learning by doing” approaches will be an essential aspect of these facilities, as the carbon market moves from individual projects to programmatic approaches, including methodologies needed for such approaches.

Table 4.1 Available Carbon Financing for South Asia

<table>
<thead>
<tr>
<th>Carbon Finance Fund</th>
<th>Description</th>
<th>Funds (US$ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototype Carbon Fund</td>
<td>Pioneers the market for project based greenhouse gas emission reductions while promoting sustainable development and offering a learning by doing opportunity to its stakeholders</td>
<td>180</td>
</tr>
<tr>
<td>Bio-Carbon Fund</td>
<td>Funds projects that sequester or conserve carbon in forest and agro-ecosystems. The fund aims to deliver cost-effective emission reductions, while promoting biodiversity conservation and poverty alleviation.</td>
<td>53.8</td>
</tr>
<tr>
<td>Community Development Carbon Fund</td>
<td>A public/private initiative designed in cooperation with the International Emission Trading Association and the UNFCCC that supports projects that combine community development attributes with emission reductions to create development plus carbon credits and improve the lives of the poor and local environment.</td>
<td>128.6</td>
</tr>
<tr>
<td>Fund</td>
<td>Description</td>
<td>Amount</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Italian Carbon Fund</td>
<td>A fund that purchases greenhouse gas emission reductions from projects in developing countries and countries in economies in transition that may be recognized under CDM and JI. It is open for Italian private and public sector entities.</td>
<td>155.6</td>
</tr>
<tr>
<td>Danish Carbon Fund</td>
<td>The fund supports mitigation initiatives by Danish public and private entities in wind, combined heat and power, hydropower, biomass use for energy and landfill.</td>
<td>68.5</td>
</tr>
<tr>
<td>Spanish Carbon Fund</td>
<td>Purchases GHG emission reduction from projects under Kyoto protocol to mitigate climate change while promoting the use of cleaner technologies and sustainable development in developing countries and economies in transition.</td>
<td>278.6</td>
</tr>
<tr>
<td>Umbrella Carbon Facility</td>
<td>A facility that pool funds from existing International Bank for Reconstruction and Development-(IBRD-) managed carbon funds and other participants for the purchase of emission reductions from large projects.</td>
<td>719</td>
</tr>
<tr>
<td>Forest Carbon Facility</td>
<td>Assists developing countries in their efforts to reduce emissions from deforestation and degradation by providing value to standing forests.</td>
<td>300</td>
</tr>
<tr>
<td>Carbon Partnership Facility</td>
<td>It is designed to develop emission reductions and support their purchase over long periods after 2012. This facility is prepared for large-scale, potentially risky investments with long lead times, which require durable partnerships between buyers and sellers.</td>
<td></td>
</tr>
</tbody>
</table>

108. A capacity building and technical assistance program has been established to enhance capacity and expertise of developing countries in engaging in greenhouse gas market. The CF-Assist is a capacity building and technical assistance program that supports project identification and preparation for greenhouse gas emission reduction and sequestration. The program is undertaken in three phases with clearly defined objectives. The first phase is aimed at establishing focal points, identifying potential CDM and JI opportunities and training. In the second phase, technical assistance is provided for development of project design documents, marketing of projects to carbon buyers, identification of industry association or intermediary, integration of carbon finance into investment promotion strategies, and engagement of financial sector to promote integration of carbon finance in lending strategies.

109. The Global Environment Facility (GEF) has also provided some assistance for development of clean renewable energy and improving energy efficiency in developing countries. The GEF-financed energy projects in renewable energy and energy efficiency approved in 2003-2006 are expected to directly reduce emissions of greenhouse gases by 388 million tons over the project lifetime.
The Climate Investment Funds (CIF) are the most recent source of funding that provide an opportunity for increased assistance to developing countries for promoting climate resilience and low-carbon growth. When they signed the UNFCCC, governments agreed to help developing countries meet the climate change challenge through additional resources for both adaptation and mitigation. The Climate Investment Funds represent a major global effort for financing mitigation and adaptation efforts in developing countries in advance of the global financial architecture to be developed under the UNFCCC. Two trust funds have been established under the Climate Investment Funds: the Clean Technology Fund and the Strategic Climate Fund (Figure 4.2). The Clean Technology Fund is designed to support projects and programs in developing countries which contribute to the demonstration, deployment, and transfer of low-carbon technologies that can have significant potential for long-term greenhouse gas savings. The Strategic Climate Fund, on the other hand, is broader in scope and serves as an overarching fund for various programs to test innovative approaches to climate change, with an emphasis on adaptation. In September 2008, about US$6.1 billion had

Box 4.3. Carbon Partnership Facility

The Carbon Partnership Facility (“CPF” or “the Facility”) promotes greenhouse gas emission reductions (“ERs”) on a larger scale through the provision of carbon finance for long-term investments that is designed to scale up the delivery of carbon finance through programmatic and sectoral initiatives and methodologies. Moving to programmatic and sectoral and country-wide approaches is a response to the limitations of the project-based Clean Development Mechanism and Joint Implementation initiatives that have high transaction costs. Ultimately, the Facility aims to contribute to a transformation of economic activities in energy, energy efficiency, waste management, oil and gas, transportation and urban sectors of Bank client countries in the direction of less carbon-intensive activities.

The CPF will establish partnerships to sell and purchase ERs from long-term programs beyond 2012 and support greenhouse gas emissions mitigation programs (“ER Programs”). Unlike the traditional carbon funds administered by the Bank whereby the Bank acts as trustee, the governance structure and trustee role of the CPF will include developing country governments and companies as sellers. This partnership approach reflects the sharing of risk between potential sellers and buyers of ER Programs during a period when the regulatory environment beyond the first Kyoto Protocol is uncertain and the global carbon market remains fragmented.

The CPF will be comprised of two trust funds, the Carbon Asset Development Fund (CADF) and the Carbon Fund. The CADF will hold funds generated from fee payments from buyer participants, donor contributions as well as investment income. The second trust fund, or Carbon Fund, will use financial contributions from buyer participants (governments or public and eligible private entities) to pay for ERs as they are received. The Carbon Fund will have funding tranches, with a discrete set of buyer participants and portfolio criteria. The portfolio criteria may cover several sectors and technologies or be more narrowly focused. Seller participants can participate in the facility by putting forward ER Programs allocated by the Trustee to one or more of the Carbon Fund tranches.

The proposed CPF is an important and integral part of the Bank’s strategic framework on climate change that is currently under preparation and is expected to complement the Climate Investment Funds, notably the Clean Technology Fund (CTF).

Source: Partnership Review Note: Carbon Partnership Facility, The World Bank, Carbon Finance Unit

110. **The Climate Investment Funds (CIF) are the most recent source of funding that provide an opportunity for increased assistance to developing countries for promoting climate resilience and low-carbon growth.** When they signed the UNFCCC, governments agreed to help developing countries meet the climate change challenge through additional resources for both adaptation and mitigation. The Climate Investment Funds represent a major global effort for financing mitigation and adaptation efforts in developing countries in advance of the global financial architecture to be developed under the UNFCCC. Two trust funds have been established under the Climate Investment Funds: the Clean Technology Fund and the Strategic Climate Fund (Figure 4.2). The Clean Technology Fund is designed to support projects and programs in developing countries which contribute to the demonstration, deployment, and transfer of low-carbon technologies that can have significant potential for long-term greenhouse gas savings. The Strategic Climate Fund, on the other hand, is broader in scope and serves as an overarching fund for various programs to test innovative approaches to climate change, with an emphasis on adaptation. In September 2008, about US$6.1 billion had
been pledged for this investment. There are also plans to establish a Forest Investment Program and a Scaling-Up Renewable Energy Program under the Strategic Climate Fund in the coming months. Designed as an interim measure, the Climate Investment Funds include specific sunset clauses.

**Figure 4.2 Structure of the Climate Investment Funds**

Financing Options for Climate Adaptation

111. **The Global Environmental Facility has been the main source of grant and concessional funding for adaptation projects.** The initial phases of GEF financing covered vulnerability and adaptation assessments and capacity building projects. Pilot adaptation projects are funded through the Strategic Priority on Adaptation (SPA), a US$ 50 million GEF trust fund. Other GEF resources include the Least Developed Countries Fund (LDCF) which is targeted to 49 least developing countries and the Special Climate Change Fund (SCCF) which is accessible to all developing countries (Table 4.2). These funds integrate adaptation measures into development practices. Since its inception, the GEF has disbursed about US$120 million for “National Communications”, of which a significant amount has been allocated to vulnerability and adaptation assessments. In addition, about US$28 million has been provided to support capacity-building and about US$78 Million worth of projects have been approved under SPA, LDCF and SCCF. While these funds have delivered resources for filling information gaps and capacity building their magnitude has been insufficient to catalyze robust adaptation initiatives on the ground. South Asia’s share in these resources has been limited with only three projects approved amounting to about US$8 million (Table 4.3).
<table>
<thead>
<tr>
<th>Name of the Fund</th>
<th>Funding Source</th>
<th>Total Funds Mobilized (US$ million)</th>
<th>Operational Criteria</th>
<th>Main Activities of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Environment Facility (GEF) Trust Fund</td>
<td>GEF</td>
<td></td>
<td>Incremental cost to achieve global environmental benefits</td>
<td>Vulnerability and adaptation assessments as part of national communications and enabling activities</td>
</tr>
<tr>
<td>Strategic Priority on Adaptation (SPA)</td>
<td>GEF</td>
<td>50</td>
<td>Incremental cost guidance with some flexibility, especially for Small Grants Programme</td>
<td>Pilot and demonstration projects on adaptation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Small Grants Programme (US$5 million) to support community-based adaptation</td>
</tr>
<tr>
<td>Special Climate Change Fund</td>
<td>Voluntary contributions from 11 developed countries</td>
<td>45.4 (Contributions: 36.7; pledged 8.7)</td>
<td>Additional cost of adaptation measures Sliding scale for co-financing</td>
<td>Addresses adaptation as one of the four funding priorities</td>
</tr>
<tr>
<td>Least Developed Countries Fund</td>
<td>Voluntary contributions from 13 developed countries</td>
<td>75.7 (Previous contributions: 29.9; pledged: 45.8; GEF allocation to date: 11.8)</td>
<td>Guiding principles: country-driven approach, equitable access by LDCs, expedited support and prioritization of activities Provision of full cost funding for adaptation increment as identified and prioritized in NAPAs Sliding scale for co-financing</td>
<td>Implementation of NAPAs (all projects for the preparation of NAPAs in 44 countries approved with a budget of US$9.6 million)</td>
</tr>
<tr>
<td>Adaptation Fund</td>
<td>2 percent share of proceeds from CDM</td>
<td>Under negotiation</td>
<td>Guiding principles country-driven and a learning by doing approach, sound financial management and transparency, separation from other funding sources</td>
<td>Concrete adaptation projects and programs identified in decision</td>
</tr>
</tbody>
</table>

Future funding for adaptation is also being established through a special Adaptation Fund. The structure, governance and management of this fund are still under negotiation. The Fund is to be managed by an independent board with representation from the five UN regions. It is to be financed through a 2 percent levy on CDM projects. Estimates of the size of this fund vary and suggest that the levy could translate from about US$100 million to US$5 billion depending upon the demand for emission reduction credits. The sustainability of this fund clearly depends on the continuity of the CDM and the development of the carbon market. Existing estimates of adaptation needs
suggest that the expected level of funding will be insufficient to cover future costs of adaptation.\textsuperscript{38}

Table 4.3 GEF Projects under the New Climate Change Funds

<table>
<thead>
<tr>
<th>Country</th>
<th>Project Title</th>
<th>Agency/ Fund</th>
<th>Project Grant (US$ approved)</th>
<th>Co-financing Total (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sri Lanka</td>
<td>Participatory Coastal Zone Restoration and Sustainable Management in Eastern Province of Post Tsunami Sri Lanka</td>
<td>IFAD\textsuperscript{39}/ Strategic Priority on Adaptation</td>
<td>1,919,000</td>
<td>7,569,000</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Community Based Adaptation to Climate Change through Coastal Afforestation</td>
<td>UNDP/ Least Developed Countries Fund</td>
<td>3,000,000</td>
<td>6,080,000</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Reduce Climate Change Induced Risks and Vulnerabilities from Glacial Lake Outbursts in Punakha-Wangdi and Chamkhar Valley</td>
<td>UNDP/ Least Developed Countries Fund</td>
<td>3,455,000</td>
<td>3,469,000</td>
</tr>
</tbody>
</table>

113. The Global Facility for Disaster Reduction and Recovery (GFDRR), is an additional instrument that can finance development projects and programs that enhance local capacities for disaster prevention and emergency preparedness and adaptation to climate change. The GFDRR aims to mainstream disaster reduction and climate change adaptation in country development strategies to reduce vulnerabilities to natural hazards. It funds disaster risk assessments, risk mitigation policies and strategies, preparation of disaster prevention projects and additional financing for recovery. Its program is undertaken in three tracks representing global, regional and country-level engagements. Track I supports annual work program of the International Strategy for Disaster Reduction (ISDR) to enhance global and regional advocacy, partnerships and knowledge management in disaster risk reduction. Track II provides ex ante support through 3 year technical assistance program to improve investments in risk reduction, institutional development, risk transfer mechanisms and adaptation to climate change. Track III is geared towards enhancing the mobilization of international assistance for disaster recovery and towards supporting the accelerated disaster recovery of low-income

\textsuperscript{38} Financing adaptation through a tax on CDM implies that adaptation is being encouraged by making mitigation more expensive and hence less attractive. The extent of substitution this would promote is unclear in the absence of data on the relevant elasticities. A more consistent strategy would involve a levy on emissions (the cause of the problem) rather than mitigation (a solution to the problem).

\textsuperscript{39} International Fund for Agricultural Development.
countries. Activities supported by GFDRR in South Asia amounted to US$4.3 million (Table 4.4).

Table 4.4 GFDRR Projects in South Asia under Track II

<table>
<thead>
<tr>
<th>Proposal Title</th>
<th>Country</th>
<th>Total Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Asian Conference on Disaster Reduction</td>
<td>India</td>
<td>75,000</td>
</tr>
<tr>
<td>Development of Lessons Learned Reports from Gujarat Emergency Reconstruction Project</td>
<td>India</td>
<td>350,000</td>
</tr>
<tr>
<td>Implementation Support for High Priority Disaster Risk Mitigation Program in India</td>
<td>India</td>
<td>400,000</td>
</tr>
<tr>
<td>India Crop Insurance: Developing Market-based Products</td>
<td>India</td>
<td>668,250</td>
</tr>
<tr>
<td>Bangladesh: Agricultural Risk Insurance Feasibility Study</td>
<td>Bangladesh</td>
<td>296,000</td>
</tr>
<tr>
<td>Climate change and future flood risks</td>
<td>Bangladesh</td>
<td>370,000</td>
</tr>
<tr>
<td>Improving Bangladesh’s Response and Recovery Activities</td>
<td>Bangladesh</td>
<td>230,000</td>
</tr>
<tr>
<td>Building capacity to effectively deliver Safety Nets in post-disaster situations in Pakistan</td>
<td>Pakistan</td>
<td>290,000</td>
</tr>
<tr>
<td>Communicating Results Achieved and Lessons Learnt in the Bank-funded</td>
<td>Pakistan</td>
<td>250,000</td>
</tr>
<tr>
<td>Improving Sri Lanka’s response and recovery in the aftermath of natural disaster</td>
<td>Sri Lanka</td>
<td>230,000</td>
</tr>
<tr>
<td>Hazard Risk Management Program: Nepal</td>
<td>Nepal</td>
<td>914,000</td>
</tr>
<tr>
<td>Nepal: Agricultural Insurance Feasibility Study</td>
<td>Nepal</td>
<td>188,000</td>
</tr>
</tbody>
</table>

114. Recognizing the need to address the funding gap the Bank has been working with bilateral donors and other groups to establish country partnerships to mobilize additional resources. The most recent example is the DFID\(^{40}\)-financed Bangladesh Climate Change Trust Fund that provides grant resources for urgent adaptation needs. In the short term greater effort will need to be devoted to build partnerships with donors and other groups.

115. What is clear is that the current framework for climate change financing is provisional and the funds available are not commensurate to country needs for either adaptation or emission stabilization. The financial instruments to address the climate change challenge in developing countries are still evolving. There is a need for

\(^{40}\) United Kingdom Department for International Development.
considerably greater international commitment, cooperation and coordination on funding if the world is to successfully address the development challenges brought about by climate change.

116. The International Finance Corporation also supports the private sector in transitioning to a lower-carbon growth path and in adapting their business operations to climate risks.

Box 4.4. IFC’s support to Climate Mitigation and Adaptation in South

Sustainable Energy Finance and Energy Efficiency

A key impediment to the large scale adoption of energy efficiency is financing of energy saving improvements, renewable energy. IFC has two projects under development – one in Sri Lanka and one in Nepal – which have a high level of replication potential.

The Portfolio Approach to Distributed Generation Opportunities (PADGO) in Sri Lanka aims to improve access to cleaner and more reliable sources of energy for underserved populations. The model will develop a framework under which various parties (manufacturers, developers, operating companies, banks, rural communities, etc.) are provided tools (template agreements and contracts, performance standards for equipment, and financing opportunities) to encourage entry into the market while maintaining quality of service provided, so as to lower transaction costs. The framework is designed to be flexible to address the various local constraints and available energy resources to allow for replication in other countries/regions.

In Nepal, IFC will support three commercial banks to develop a portfolio of energy efficiency finance projects that they will offer to Nepalese industry. Energy intensive industries such as rolling mills, cement, sugar, paper, structural clay, distillery, bakery, rubber, leather, noodle, wool dyeing, jute, would be targeted with tailored financial products for energy efficiency that would enable the companies to reduce their energy consumption, costs, and emissions of greenhouse gases. This effort is also intended to serve as demonstration case in Nepal (and potentially for the region) that will improve awareness and understanding of energy efficiency and build technical capacity among financial institutions to provide energy efficiency lending services.

Investing in Renewable Energy

While climate change presents a considerable challenge, it also provides the private sector with the opportunity to expand its activities and grow while helping mitigate the risks of climate change and adapt to its impacts. In this context, IFC has a growing portfolio of renewable energy investments that are helping displace coal power generation and reduce greenhouse gas emissions that includes: four hydropower projects (two in Nepal and two in India); a bagasse cogeneration plant at two mills for a large sugar producer in India for a total of 40 megawatts; wind energy investments in two wind farms in India totaling 37 megawatts; and a potential investment in a photo-voltaic plant in Tamil Nadu (India).

IFC has supported Indian manufacturer Moser Baer expand into solar photovoltaic (PV) cell and module production. Solar PV is a renewable energy source that is used for electricity production in stand-alone and grid-connected applications. IFC is also supporting Jain Irrigation, one of the major agribusiness companies in India, in setting up an agricultural waste-based power project as well as help them define a strategy to become a renewable power sector player in India.

Carbon Finance

IFC’s role in the carbon finance market is to help create a level playing field between emerging
market projects and developed country buyers without distorting the market. In South Asia, IFC has successfully concluded emissions reduction purchase agreements (ERPAs) with Eco Power, a private developer of small hydropower plants in Sri Lanka with more than 30 megawatts in seven projects and with Indian Hydropower Development Company (IHDC) for small-scale “bundled” projects owned and operated by the latter.

IFC has also recently provided a Carbon Delivery Guarantee for credits from a waste heat recovery project done by Rain CCII Carnon India Limited that reduces the company’s dependence on fossil fuels.

As part of the World Bank Group’s effort to deepen access to Carbon Finance, IFC also expects to offer carbon market-related advisory services to its clients, especially municipalities and financial institutions through wholesale aggregation arrangements for energy efficiency savings in lighting, water pumps, etc.

Cleaner Production Assessments

IFC’s work in Cleaner Production Assessments supports the adoption of profitable cleaner production initiatives – such as energy efficiency and water conservation and recycling – among IFC’s clients, thus setting an example and promoting demand for cleaner technologies. Typically, IFC provides technical assistance to companies in the form of clean production (CP) audits that help identify energy, water, and other type of resource savings, which reduce GHG emissions for client operations as well as improve profitability.

In South Asia, IFC has targeted a high-carbon footprint sector in India (paper and pulp) to conduct CP audits in three companies that will focus on energy and water audits, resource conservation, and GHG estimation. These audits are currently underway and another 7 – 10 companies have expressed interest in undertaking CP audits. IFC has also set up a global fast-tracking financing facility called “Cleaner production Lending Pilot” (CPLP) that will enable existing IFC clients to access loans up to US$5 million to implement some of the recommendations from the CP audits.

Cleaner Technologies Program

IFC’s Cleaner Technologies investing focuses mainly on supporting small, high-risk ventures with accelerated technology transfer and commercialization of intellectual property. IFC has directly invested in areas of increasing strategic interest, such as the water sector, and it will play a major role in guiding the World Bank Group’s work on accelerating clean energy technology innovation. The Cleaner Technologies program typically provides funding ranging from US$200,000 to US$2,000,000 for innovative business initiatives that produce goods and services with environmental benefits. The program’s strategy going forward is to focus on Asia and on India, in particular.

Conclusions

117. The aim of this strategy is to catalyze a process that would build climate-resilient economies that grow along a low-carbon trajectory. To achieve this it will be necessary to promote country ownership, knowledge and institutional and financial capacity. The challenges are wide ranging suggesting the need for integrated approaches that transcend sectors and countries. As an example, in the water sector synergies can be built between approaches to flood prevention that promote adaptation, energy trade to facilitate low-carbon growth and water transport to stimulate economic integration. But this will require
a level of coordination and cooperation far beyond what is commonly observed in the region. More importantly, unilateral actions can often worsen underlying climate vulnerabilities. The introduction of export restrictions and bans of basic food staples (such as rice) may have alleviated shortages within countries, but this has had the unintended consequence of restricting global supply that has aggravated food price inflation.

118. The Bank is one of many players in the global arena of climate change. It sees its comparative advantage in addressing the development implications of climate change and stands ready to assist countries in South Asia across the many dimensions of the development challenges of climate change – local, national, sectoral and regional. With its convening power and presence across all countries in South Asia, the Bank can promote regional dialog and cooperation. The following section of the report provides a detailed assessment of the climate challenges and impacts in a sectoral context.
Table 4.5 Summary of Sector Impacts in the Context of Climate Change and Priority Responses

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
</tr>
</thead>
</table>
| Regional and Cross-sectoral | · Information gaps  
· Limited coordination between sectors and countries  
· Funding gaps for both adaptation and low-carbon growth | · Knowledge products  
· Institutional coordination and strengthening  
· Resource mobilization | · Climate policy support targeted to needs  
· Low-carbon growth studies (India, Pakistan, Sri Lanka)  
· Trade barriers to clean technology adoption  
· Poverty-climate linkages  
· Build knowledge partnerships between countries and sectors  
· Assist with resource mobilization |
| Water                    | · Glacier melting in the Himalayas, including lake outburst  
· Floods  
· Droughts  
· Saline intrusion in coastal aquifers (due to sea level rise) | · Regional cooperation on international rivers and river basins  
· Improved water resources management  
· Climate sensitive infrastructure “packages” to build climate resilience  
· Knowledge investments, e.g. to assess risks in Himalayas and the region’s large river basins  
· Increased research on new water efficient technologies and (drought resistant) crop varieties. | · Convening power/leadership role to catalyze regional cooperation  
· Honest broker role without footprint  
· Technical assistance  
· Lending and financing for hydropower and storage |
| Agriculture              | · Declining yields of major crops  
· Agriculture unviable in marginal areas e.g. arid, semi-arid, coastal (saline intrusion affected zones due to sea level rise)  
· Crop destruction by extreme events | · Promotion of climate resilient cropping patterns and techniques  
· Agricultural research and extension for promoting climate resilient crop varieties  
· Improvements in risk management (e.g. climate insurance, contingent credit schemes)  
· Irrigation development and increased investment in water harvesting infrastructure at required scales that take account of climate risks | · Technical assistance (TA) to help in dissemination of climate-resilient crop varieties and cropping systems  
· Investments in agriculture research, improved extension services, irrigation and livelihood diversification  
· Sector work to identify innovative financing mechanisms (e.g. climate insurance, carbon credits) |
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<tr>
<th>Sectors</th>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
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</table>
| Natural Disasters | • Higher probability of extreme climate events (cyclones, storms, floods, heat waves)  
                   • Higher probability of slow onset disasters (prolonged droughts, sea level rise) | • Development of incentives and innovative approaches for rural development to diversify income and buttress against climatic risks | • Strengthening institutional capacity for disaster reduction management (DRM) and emergency response  
                   • Technical assistance  
                   • Funding support for disaster preparedness and adaptation  
                   • Donor mobilization |
| Health      | • Increased incidence of water related diseases (malaria)  
                   • Heatstroke  
                   • Direct health risks; e.g. injury and death caused by extreme events | • Awareness of the health implications of climate change  
                   • Monitoring and surveillance of disease and improved health sector response and training for new disease risk profiles  
                   • Improved water supply and sanitation | • Analytical and advisory activities (AAA) and TA for impact assessments and review of the evidence base  
                   • Lending and financing  
                   • Convening role facilitating national and regional policy dialogues to prevent spread of climate sensitive diseases |
| Social      | • Increased poverty, vulnerability and nutrition insecurity  
                   • Social conflict  
                   • Aggravation of social exclusion and inequity  
                   • Indebtedness in climate vulnerable areas  
                   • Migration  
                   • Increased urban slum population | • Awareness raising, social mobilization and capacity building  
                   • Education and skill training for women, indigenous populations (IPs) and other vulnerable groups for reducing agricultural dependence  
                   • Promotion of self-help groups (SHGs); and enhancing access to microfinance and banking services  
                   • Strengthening public-private partnerships and social capital of vulnerable groups, their access and decision making  
                   • Promotion of community-based asset building and sharing of natural resources | • Financial and technical support for promoting equity, inclusion, rights and livelihoods through targeting vulnerable groups and enhancing voice, decision making and capacity of the vulnerable to adapt  
                   • Partnership with community-based organizations (CBOs), coastal state organizations (CSOs), non-governmental organizations (NGOs) and private sector for capacity building.  
                   • Governance, strengthening institutions and social capital by initiating parallel capacity building and social accountability initiatives |
<table>
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<tr>
<th>Sectors</th>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
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<tbody>
<tr>
<td><strong>Ecosystems and Biodiversity</strong></td>
<td>- Quantitative and qualitative damage upon freshwater, coastal, marine and terrestrial ecosystems with consequences upon livelihoods&lt;br&gt; - Loss of habitats, dependent species and important ecological goods and services&lt;br&gt; - Biodiversity loss in the Himalayas, glacier-fed ecosystems, forests and coral reefs&lt;br&gt; - Shifts in vegetation regimes in forests, grasslands and semi-arid deserts resulting in altered community structures and climate feedbacks</td>
<td>- Expansion of protected area networks and promotion of ecosystem-based approach in biodiversity conservation&lt;br&gt; - Mainstreaming of biodiversity and ecosystem management in development projects, climate mitigation, adaptation and risk management&lt;br&gt; - Designing and building biodiversity friendly and climate resilient infrastructure&lt;br&gt; - Generation of knowledge and capacity</td>
<td>- Financing for arresting and reversing ecosystem degradation, especially in biodiversity hotspots&lt;br&gt; - Pilot new approaches for protecting, upgrading, restoring, sustaining and expanding ecosystems–Payment for Ecosystem Services, Debt for Nature Swap&lt;br&gt; - Increasing the AAA and TA portfolio for building knowledge and capacity, particularly of the regulatory agencies</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>- Political economy (non-climate) barriers to developing regional energy trade&lt;br&gt; - Poor quality local coal&lt;br&gt; - Aging and inefficient thermal power generation, high transmission and distribution losses&lt;br&gt; - Inefficient energy use&lt;br&gt; - Poor energy pricing frameworks</td>
<td>- Regional energy trade from power surplus countries (Bhutan, Nepal for hydro and Sri Lanka for wind) to energy-deficient economies (India and Pakistan)&lt;br&gt; - Cleaner coal – through rehabilitation and replacement of inefficient generation units&lt;br&gt; - Harness hydropower potential&lt;br&gt; - Energy efficiency and reduction of system losses.&lt;br&gt; - Investment in (non-polluting) renewable energy</td>
<td>- Scale-up transmission &amp;distribution (T&amp;D) loss reduction investments in India, Pakistan and Bangladesh, including selected Indian state-level T&amp;D companies&lt;br&gt; - Expand renewable energy support through leveraging climate investment funds and advancing investments in hydropower (India, Nepal, Pakistan), coal (India), gas-fired (Bangladesh)&lt;br&gt; - Operationalize energy efficiency possibilities in India, Pakistan and Bangladesh&lt;br&gt; - Low-carbon growth studies for Pakistan, Bangladesh, and Sri Lanka&lt;br&gt; - Advance energy pricing reform dialogue&lt;br&gt; - Groundwork and dialog for investments in regional energy trade infrastructure</td>
</tr>
<tr>
<td>Sectors</td>
<td>Risks</td>
<td>Priority Response</td>
<td>World Bank’s Potential Role</td>
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</tbody>
</table>
| **Transport** | - Increase in number of private vehicles and usage per vehicle  
- Increase in age and efficiency of vehicle fleet  
- Ongoing deterioration of public transport in cities  
- Expansion of low-density urban land development which is not friendly to public transport and non-motorized transport | - Sustainable and energy efficient public transport, and aggressive transport demand management, particularly in mega-cities  
- Reorienting urban growth patterns and practices so as to create networks of walkable neighborhoods, particularly in high growth, medium-sized cities  
- Slowing the modal shift to rail transport  
- Fuel efficiency standards for road vehicles | - Financial and technical support for the development of more energy efficient transport modes, such as public transport, non-motorized transport and clean transport  
- Transitioning traffic management priorities from private transport to public transport and non-motorized transport  
- Long-term land-use and transport planning  
- Greater weight given to assessment of transport impacts (particularly on energy use and climate change) in the project appraisal process  
- Institutional support to capacity development for transport planning, operation and management at national and local level  
- Regional or national initiatives that help develop and disseminate information on fuel efficiency standards and best-practices in vehicle maintenance  
- National or local initiatives that advance the adoption of transport CO₂ emission targets and monitoring mechanisms |
| **Urban** | - Climate related damage upon urban settlements, lives, assets and basic water and sanitation services  
- Increase in urban vector and water-borne diseases, (associated with urban poverty mainly in slums).  
- Growth of GHG emissions of future urbanization | - Integration of climate adaptation and disaster risk management within the urban climate change strategy  
- Harnessing mitigation potential in industries such as solid waste, wastewater treatment, energy efficient buildings and infrastructure.  
- Improving energy efficient buildings | - Technical, financial and capacity-building support on adaptation and risk management in urban areas  
- Building knowledge and capacity of cities to adopt mitigation strategies and in developing urban climate change agenda  
- Assist cities in integrating urban transport, energy and construction within urban climate change strategy  
- Supporting the improvement of urban water infrastructure and sanitation services and demand management |
Table 4.6 Priority Response and Potential World Bank Country Engagement

<table>
<thead>
<tr>
<th>Country</th>
<th>Climate Change Impacts:</th>
<th>Risks</th>
<th>Current Initiatives and Potential Role</th>
</tr>
</thead>
</table>
| Afghanistan | - Exposure of agriculture (pasture), ecosystems and water resources to drought and desertification  
- Flooding from glacial melt and long run vulnerability of depletion of water supplies of glacial-fed rivers  
- Water and food insecurity, malnutrition and possible migration and conflict | Adaptation | - TA on impact assessment and benefits of mainstreaming adaptation responses  
- Scaling up of existing developmental investments that promote economic, social and ecosystem resilience to climate change  
- Regional dialogues on international/river basin water resources |
| Bangladesh | - Combined impacts of sea level rise and glacial melt lead to increased incidence of flooding and land loss  
- Drought in some areas  
- More intense cyclones  
- Lower agricultural output through diminished yields and loss of land  
- Increased incidence of heat-related illnesses, water-borne diseases, poverty, child and infant mortality; lower access to safe water and sanitation and possible migration  
- Loss of biodiversity in coastal ecosystems – Sunderbans at high risk  
- Mitigation Issues: Increased coal dependence (risks of early transition to coal) | Adaptation | - Development Policy Loan (DPL) (under preparation): (i) TA on coastal risks and defenses; hard and soft engineering; (ii) planning and zoning policies for climate resilience; (iii) infrastructure design; (iv) institutional strengthening*41  
- AAA work on agricultural adaptation (including groundwater issues)*  
- Flood forecasting, early warning system, public awareness*  
- Food security support by developing of climate resilient cropping systems  
- Water and sanitation program in climate vulnerable areas  
- Building livelihood resilience in ecologically fragile areas  
- Strengthen human resources and institutional capacity  
Mitigation | - Improve energy efficiency, gas exploration, reservoir management; renewable energy development  
- Scale up carbon finance in industry |
| Bhutan | - Damages from glacial melt  
- Impact of increased temperature on rangelands and agriculture.  
- Potential loss of forest biodiversity due to vegetation shift and increased incidence of forest fire due to temperature increase | Adaptation | - TA or AAA focus on filling gaps in the official “National Communications” to IPCC and identifying vulnerabilities  
- Support for hydro developments (flood risks downstream and energy trade) |

* denotes current or in preparation.
India

**Climate Change Impacts:**
- Exposure of agriculture, water resources, and ecosystems to extreme weather events and more variable precipitation
- Impact of glacial melt on water resources quantity, biodiversity and low-lying agriculture
- Increased heat-related illnesses and water-borne diseases and changes in epidemiological patterns
- Impacts on urban infrastructure including drainage, water and sanitation
- Vegetation shift in forests and biodiversity, regime shifts in rangelands, decreased agricultural yields in tropics and subtropics
- Increased exposure to sea level rise

**Mitigation Issues:**
- Increased emissions from energy production and transformation, transport, urban, agriculture, industrial and residential sectors due to economic growth and urbanization
- Impact of climate change upon carbon sequestration capacity of forest ecosystems, other biomass and soils

**Current Initiatives and Potential Role**

**Adaptation**
- AAA: Towards New Groundwater Strategies in India: Investing in Groundwater Management for Responsible Growth*
- TA: AP Pilot Drought Adaptation Initiative*
- AAA: Coastal Cities and Adaptation to Climate Change*
- TA: Sundarban Biodiversity and Sustainable Development*
- AAA: India 2030: Vision for an Environmentally Sustainable Future*
- AAA on agricultural adaptation
- Agriculture and rural sector adaptation: storage to address rainfall variability
  (strengthening climate change considerations in portfolio)
- Climate insurance, livelihoods diversification (in marginal areas)

**Mitigation**
- AAA: Low-carbon Growth Strategy for India *
- AAA: Operations and Maintenance Best Practices of Coal-fired Power Plant Rehabilitation*
- TA: Biomass for Sustainable Development*
- AAA: Capacity Building in Hydro and Renewable Energy*
- AAA: Improving Rural Electricity Services through Renewable Energy-based Distribution *
- Strengthening Investment Climate for renewable energy*, energy efficiency and clean technologies, including through the use of grants, concessional lending and carbon finance
- Regional cooperation on water resources management*
- State-level capacity building
- Coal Thermal Rehabilitation Project*
- Accelerated Chiller Replacement Project*
- Financing Energy Efficiency Measures in Small and Medium Enterprises*
- Sustainable Transport Project *
- Energy efficiency in industry - opportunities for Carbon Finance (CF)
- Energy trade
<table>
<thead>
<tr>
<th>Country</th>
<th>Climate Change Impacts</th>
<th>Current Initiatives and Potential Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maldives</td>
<td>- Ecosystem damages and loss of protection afforded by coral reefs</td>
<td>- Island level risk assessments to identify safe and vulnerable islands</td>
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<tr>
<td></td>
<td>- Inundation of islands due to sea level rise and physical damages from flooding</td>
<td>- Institutional capacity building for implementing National Adaptation Plan of Action</td>
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<tr>
<td></td>
<td>- Increased salinity of groundwater resources</td>
<td>- Promote better stewardship of protective reefs and natural defenses</td>
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<td></td>
<td>- Possible migration and large scale relocation</td>
<td>- Maldives Environmental Project – (under implementation - builds capacity, addresses waste problems and knowledge gaps)* - with potential mitigation component</td>
</tr>
<tr>
<td>Nepal</td>
<td>- Decline in agricultural production in some areas</td>
<td>- TA Glacier retreat dynamics, impacts on Himalayan rivers and ecosystems and economics of climate change*</td>
</tr>
<tr>
<td></td>
<td>- Glacial lake outburst floods (GLOF) and future desiccation of water resources due to rapid glacial melt and impact on dependent ecosystems and agriculture</td>
<td>- TA River basin-level hydrological and economic dynamics of climate change*</td>
</tr>
<tr>
<td></td>
<td>- Impact of vegetation shift to forest biodiversity</td>
<td>- AAA Assessment of impacts on agricultural with adaptation pilots</td>
</tr>
<tr>
<td></td>
<td>- Likely outbreak of malaria and similar diseases</td>
<td>- Assist with capacity building global negotiations at Conferences of the Parties (CoPs)</td>
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<tr>
<td></td>
<td>Mitigation Issues:</td>
<td>- Community –level coping strategies and capacities</td>
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<tr>
<td></td>
<td>- Impacts on carbon sequestration of vegetation shifts and forest productivity changes</td>
<td>- River basin management: river regulation, flood control, water allocation and land use planning</td>
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<td></td>
<td>- Land-use changes due to future development</td>
<td>- Disaster management systems: GLOFs including weather and hydromet monitoring</td>
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<td></td>
<td>- Slash-burn agricultural practices</td>
<td>Mitigation</td>
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<tr>
<td></td>
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<td>- Hydro developments, micro to large scale*</td>
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<td></td>
<td></td>
<td>- Energy (hydropower) trade with India</td>
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<td></td>
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<td>- Deforestation/ avoided deforestation (CF)</td>
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<td></td>
<td>- Enhance knowledge/capacity for carbon and climate finance</td>
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<tr>
<td>Country</td>
<td>Climate Change Impacts:</td>
<td>Adaptation</td>
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<tr>
<td>Pakistan</td>
<td>- Increased intensity and frequency of drought and effects on agriculture (pasture),</td>
<td>- TA filling gaps in “National Communications” for IPCC and assist in preparation for global negotiations at COPs</td>
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<tr>
<td></td>
<td>water resources and ecosystems (wetlands)</td>
<td>- AAA on agricultural adaptation*</td>
</tr>
<tr>
<td></td>
<td>- Initial flooding and future drying of water resources due to glacial melt and impact on water consumption</td>
<td>- TA for Shudd (sea level rise, water resource, coastal adaptation)</td>
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<tr>
<td></td>
<td>- Damages of sea level rise</td>
<td>- TA for programmatic Clean Development Mechanism (CDM) opportunities</td>
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<td></td>
<td>- Outbreak of heat related and insect-transmitted diseases, malnutrition, food and</td>
<td>- Investment in Indus 21</td>
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<tr>
<td></td>
<td>water insecurity, migration and conflict</td>
<td>- TA on the Implementation of the National Environment Policy*</td>
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<tr>
<td></td>
<td><strong>Mitigation Issues:</strong></td>
<td></td>
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<tr>
<td></td>
<td>- Increased emissions from energy, transport and urban sectors</td>
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<td></td>
<td>- Emissions from agriculture and rangeland degradation</td>
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<tr>
<td>Sri Lanka</td>
<td>Climate Change Impacts</td>
<td><strong>Mitigation</strong></td>
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<tr>
<td></td>
<td>- Reduced crop yields due to temperature increase</td>
<td>- TA for promoting carbon finance units for CF in industry*</td>
</tr>
<tr>
<td></td>
<td>- Sea level rise - damages upon settlements, industries and livelihoods in coastal areas</td>
<td>- Carbon-assist Japan Policy and Human Resources Development Fund (PHRD)</td>
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<tr>
<td></td>
<td>- Salt water intrusion in agriculture, freshwater and groundwater</td>
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<td></td>
<td>- Ecosystem degradation and biodiversity loss in coastal and marine ecosystems</td>
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<tr>
<td></td>
<td><strong>Mitigation Issues:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Release of stored forest carbon due to land-use changes</td>
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<td></td>
<td>- Increase in thermal power</td>
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PART II. Sectoral Context and Strategies
Chapter 5. The Sector Outlook

119. **Climate change will have wide-ranging environmental, social, and economic implications in South Asia.** The cascading effects of more variable rainfall and higher temperatures will touch most aspects of life in the region. Weather extremes and greater fluctuations in rainfall have the capacity to adversely dent the region's productive areas and comparative advantage. Food security, health, livelihoods, access to basic services, energy, and shelter could all be affected. Climate change has the potential to reverse the development gains that have been achieved by South Asia over the past decades.

120. **However, there are differences among and within South Asian countries in the ability to adapt to the impacts of climate change.** The capacity to adapt to climate change depends on a wide range of factors that include social, economic and political dimensions. How these factors interact differs between and within countries and determines vulnerabilities and coping capacities. Within any sector or social group, some may be more vulnerable than others depending on their economic status and exposure to climate risks. Reflecting the diverse nature of the challenge, this section of the SARCCS addresses activities in key sectors ranging from agriculture, biodiversity, energy, transport, urban development, and water to social development. It recognizes that changing climate affects development through many lenses and an effective response must combine both mitigation and adaptation. The strategy advocates an integrated approach to address the impact of climate change on agriculture, ecological resources, health, infrastructure, livelihoods, and natural disasters. South Asia’s heavy reliance on agriculture provides an important lesson. The impact of climate change on agriculture cannot be decoupled from water resources, floods, drought, and economic structure. These interact in ways that determine vulnerabilities, impacts and adaptation opportunities. The subsequent chapters identify the many cross-sectoral and regional linkages.

121. **Chapter 6 on the impact of climate change on water tackles the fundamental challenge to balance more variable water supplies with accelerating water demands.** The potential adverse impacts of climate change could be alleviated through enhanced cooperation and dialogue between and within regional counties. India and Bangladesh have 54 transnational rivers. Many important tributaries originate in Nepal, Bhutan, and China and supply water to Bangladesh, India, and Pakistan. Although there are agreements between some countries in the South Asia region, further regional cooperation will be required to address these future climate challenges.

122. **Chapter 7 highlights the urgency for implementing measures that are needed to revive agricultural growth in the region and address rural poverty.** With their economies closely tied to the natural resource base and climate sensitive sectors such as agriculture, South Asian countries are expected to suffer significant losses from climate change. In this context, the impact of climate change on agriculture is an issue of great significance to the lives of millions of poor people in South Asia who depend on agriculture.

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42 Suresh Ramalingam.
South Asia is highly vulnerable to natural disasters and the risks from climate change and the responses are articulated in Chapter 8. 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. When dealing with climate change risks, it is important to recognize the existing vulnerability to climate variability. Enhancing the ability of local communities to manage current natural hazard risks will help improve their 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.

Though the relationship between climate change and human illness is complex and difficult to assess, Chapter 9 provides a broad qualitative overview of its likely impacts. In South Asia, heat waves, flooding, and increased intensity of tropical cyclones and storm surges all pose threats to human well being and health. Possibly the greatest health impacts could be those associated with population dislocation and displacement. People displaced internally or across borders are vulnerable to disease. Mental health impacts of extreme climate events and disasters present another public health challenge. The most common consequences of severe weather events, such as floods and cyclones, include anxiety, depression, and post-traumatic stress disorder.

Chapter 10 highlights the social dimensions of climate change and identifies three particularly vulnerable groups – women, indigenous people and the rural poor. In natural disasters female mortality vastly outnumbers that of males. Indigenous people, with their dependence on forests and natural resources are also sensitive to climate variations, while the rural poor whose livelihoods are based on agriculture are another group that will be directly impacted by climate change. The Chapter then argues that climate change could exacerbate prevailing disparities unless the root causes of the problems are addressed. Effective adaptation strategies would need to address these fundamental disparities.

Chapter 11 looks into how climate change will increase the damage from current risks and present new challenges to the sustainability of ecosystems and their services. The region’s natural resource base is currently facing tremendous pressure from rapid population and economic growth. The chapter suggests that better environmental stewardship can help build greater resilience to future climate risks and also assist with stabilizing emissions.

Chapter 12 draws attention to the opportunities for harnessing low-carbon growth in the region by addressing substantial loss of energy due to poor transmission infrastructure and inefficiencies in power generation. Rising energy demand is driven by urbanization, industrialization, and prosperity, all of which are parts of a broader process of development that is lifting millions out of poverty. However, increased energy consumption has been accompanied by rising greenhouse gas emissions. The energy that does not have to be generated due to loss reduction or efficiency gains is attractive from both the cost and the climate change standpoints. Chapter 11 suggests that there is a need for more active and extensive interventions to tilt the balance in favor of cleaner technologies.
128. **Chapter 13 explores the policy measures and initiatives needed to address the impending increase in transport carbon emissions.** While the transport sector has been a relatively small contributor to South Asia’s CO₂ emissions the rapid pace of urbanization and likely acceleration of motorization trends present a threat to mitigation efforts in the future.

129. **Chapter 14 investigates the vulnerability of cities to climate change and their contribution to GHG emissions.** It suggests that the threats are likely to grow as cities expand in a largely unplanned manner. In general the concentration of people and assets in cities increases its vulnerability to climate change. But South Asian cities are uniquely vulnerable to climate change impacts. This is due to a combination of non-climatic and climatic risks. Factors such as high levels of urbanization and concentration of poor people, and poor infrastructure increase the vulnerability of South Asian cities.
Chapter 6. Climate Change and the Water Sector

Water Resource Supply, Demand and Management: Why South Asia Is Vulnerable

130. **Extreme variability of rainfall is the defining feature of South Asia’s climate.** The monsoon is the most significant climate event: it carries over 70 percent of the region’s annual precipitation in only four months. Because of the dominance of the monsoons, the region’s climate exhibits the highest seasonal concentration and variability of rainfall in the world. If climate projections are indicative of future trends, the risks associated with water-related climate variability are likely to intensify and worsen.

131. **The region is highly vulnerable to droughts and floods.** Droughts vary in their intensity, duration, and spatial coverage. Climate change might exacerbate damage caused by such events. Monsoonal rainfall over India has decreased by approximately 5 to 8 percent since the 1950s, which might contribute to more intense, longer, or more widespread droughts (Chung and Ramanathan 2006). The region’s river systems are also highly flood prone. Floods are a natural and necessary feature of river systems with variable seasonal flows; however, when floods are excessive, they cause extensive damage. Flood-affected areas in South Asia might increase as a result of climate change. In India, the area affected by floods more than doubled between 1953 (19 million hectares) and 2003 (40 million hectares) and currently represents about 11 percent of that country’s geographic area (World Bank 2007). In Bangladesh, 60 percent of the country is flood prone. In addition, farmers in northeastern Bangladesh have observed that the first flash flood has been arriving earlier in the year. The effect has become more marked in recent years, with particular impact in 2003 and 2004.

132. **Water scarcity is another challenge.** Although annual water availability appears to meet current consumption (see Figure 6.1), the data conceal extreme seasonal distributional patterns. In fact, water availability has declined and this trend is projected to continue in many places. In India, for instance, per capita water availability has steadily been decreasing as a result of decreased water availability combined with increased population.

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Authors in alphabetical order: Ousmane Dione, Nagaraja Rao Harshadeep and Siet Meijer.

Most of the region relies on the summer monsoon, which runs from June to September. In Sri Lanka and the Maldives, however, it is the winter northeast monsoon that delivers most of the precipitation, between November and January.

The region is endowed with great rivers that are the lifelines of the regional economy. These rivers include the Ganges, Brahmaputra, and Indus, all of which rise in the Himalayan Hindu Kush “water towers”, fed by both rain and snowfall. The ice mass covering the Hindu Kush mountain range is the third largest in the world, after the polar icecaps. It is also the source of the nine largest rivers of Asia (Figure 6.2). These glacial masses store precipitation in the form of snow and ice, regulating water distribution and providing continuous flows during the dry months. Table 6.1 summarizes the major characteristics of the major South Asian river systems. These river basins are home to more than 700 million people, and their rivers are thus vital to the development and growth of the six South Asian countries through which they flow: Afghanistan, Bangladesh, Bhutan, India, Nepal, and Pakistan as well as China.
Table 6.1 Major River Systems in the South Asia Region

<table>
<thead>
<tr>
<th>Name of river system</th>
<th>Watershed area (sq. km)</th>
<th>Length (km)</th>
<th>Average population density (per sq. km)</th>
<th>Countries within watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brahmaputra</td>
<td>651,335</td>
<td>2,900</td>
<td>182</td>
<td>4</td>
</tr>
<tr>
<td>Ganges</td>
<td>1,016,124</td>
<td>2,525</td>
<td>401</td>
<td>4</td>
</tr>
<tr>
<td>Indus</td>
<td>1,081,718</td>
<td>2,880</td>
<td>165</td>
<td>4</td>
</tr>
<tr>
<td>Godavari</td>
<td>319,810</td>
<td>1,465</td>
<td>202</td>
<td>1</td>
</tr>
<tr>
<td>Mahanadi</td>
<td>145,816</td>
<td>851</td>
<td>201</td>
<td>1</td>
</tr>
<tr>
<td>Narmada</td>
<td>96,271</td>
<td>1,312</td>
<td>178</td>
<td>1</td>
</tr>
</tbody>
</table>


Projected Impacts of Climate Change

With its heavy reliance on the monsoons and snow-fed rivers, water availability in the region is highly sensitive to climate change. Increases in...
temperature are predicted to result in changes in evapotranspiration, soil moisture, and infiltration. Combined with predicted changes in precipitation, this could affect water availability in soils, rivers, and lakes, which would have implications for domestic and industrial water supplies, hydropower generation, and agricultural productivity (see also Box 6.1). Several recent studies suggest that monsoons could become more variable and unreliable, with possible consequences including an increase in the intensity of rainfall and a reduction in the duration of the monsoon (Hu et al. 2000; Lal et al. 2000). Climate change is also predicted to increase the likelihood of both coastal and inland flooding, especially in Bangladesh and Sri Lanka. However, the magnitude and precise timing of these changes is unknown, as global circulation models lack accuracy at finer spatial resolutions and there remain large uncertainties in projecting local changes in climate.

Box 6.1 Changes in Runoff Due to Climate Change

The quantity and nature of runoff is expected to change substantially in South Asia as a result of climate change. Changes in the spatial and temporal distribution of precipitation and temperature are expected to interact in complex ways that alter the balance and characteristics of “green” water (used or lost in catchments before it reaches rivers) and “blue” water (runoff that reaches rivers). By 2050, increased runoff, primarily fed by precipitation changes and glacial melt, is expected in the basins of the Indus, Ganges, and Brahmaputra rivers. Some models show significant declines in flow in rivers such as the Indus after glacial melt has run its course and the evapotranspiration impacts of increasing temperature begins to dominate. Afghanistan is expected to be particularly impacted, with flows reducing by almost 20-40 percent throughout the country, posing significant 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, and domestic, industrial, and municipal water supplies from increasingly populous countries with increasingly high development expectations.

Mean Runoff Change (%): 2041–2060 vs. 1900–1970 Scenario

The retreating glaciers of the Hindu Kush could pose the most far-reaching threat to the region. Due to increasing temperatures, in the past two decades the ice mass in the region has retreated at a rate of 0.3 to 1 meter per year, faster than the world average (Barnett, Adam, and Lettenmaier 2005). Figure 6.3 depicts this reduction in the glacial cover. The few analytical studies that exist suggest that climate change will alter the timing and rate of snow melt, with an increase in annual runoff in the initial years, followed by a steep decrease in annual river flows compared to the current baseline. The uncertainty in water supplies will be exacerbated by increased incidence of extreme events, such as glacial lake outburst floods.

Figure 6.3 Changes in Glacier Cover in the Western Himalayas


The precise consequences of these changes are hard to predict, but they will be significant. Reduced freshwater availability during low-flow periods will become a serious problem, with considerable implications for economic activity and livelihoods. Agriculture (including irrigation and livestock farming) and fisheries will be negatively impacted by a reduction in freshwater availability. As a result, rural economies and livelihoods stand at significant risk. Other water-dependent sectors, such as navigation, energy production, and household water use, are also likely to be affected.

Changes in water availability will also need to be measured against the changes in demand associated with population growth. Agricultural and industrial growth will be additional determinants of future water demand. On the supply side, agriculture in South Asia have come to critically rely on groundwater, with the region now accounting for a third of the total groundwater used in the world. With the semi-arid regions in South Asia predicted to expand, groundwater replenishment will be affected. Yet its role as a buffer resource will become even more important to the lives and livelihoods of people in the arid and semi-arid areas. Finally, as many of the rivers in the region are shared transboundary systems, regional coordination and cooperation will inevitably be required to allow both an increased understanding of the nature of climate challenges and the formulation of approaches to address such changes effectively.
Future Challenges and Opportunities

138. **Looking ahead, a fundamental challenge will be the need to better balance more variable water supplies with accelerating water demands.** Climate change projections show that floods and droughts will become more common. With more rainfall expected to fall in fewer days, the region will need to tackle the increasing incidence of both droughts and floods. On the supply side, this will call for a considerable investment in infrastructure, maintenance, and water management. There will be a need to “climate-proof” high-value and long-lived water assets to withstand extreme events. A major challenge in this regard is that existing climate models lack the precision needed to guide engineering design, so there is much uncertainty about what the future climate might hold. Moreover, in a region with scarce water supplies, there is considerable wastage in both urban and rural sectors. Irrigation efficiency is low throughout the region. Deteriorating water quality is another concern. Sewage and industrial effluents have turned many rivers, including major ones, into fetid waste canals. Institutional capacity to address these issues is weak throughout the region. Climate change could worsen these problems if, as a result of more frequent and more intense flooding, sedimentation, siltation, and erosion increase. In sum, large investments in both policy and infrastructure are needed to protect scarce water resources and people’s livelihoods and health.

139. **The retreating glaciers of the Hindu Kush add to the complexity of addressing the climate change challenge.** With melting glaciers in the near term, flood risks could increase, particularly in Bangladesh and Northeast India, if peak flows from the Ganges, Brahmaputra, and Meghna coincide more frequently. In the long term, there can be no replacement for the water provided by glaciers and their increasing retreat could result in water shortages at an unprecedented scale. Better water management techniques will help, but they alone cannot solve the problem. Agriculture and the region’s economic structure will also need to undergo significant changes. Since change is a gradual process, long-term anticipatory measures are needed to minimize the human and economic impacts. This will, in turn, require considerably greater cooperation and dialogue between and among countries.

140. **The potential impacts of climate change could be ameliorated through enhanced cooperation and dialogue between and within jurisdictions.** In the past, water has been a source of discontent for countries that share transboundary rivers. India and Bangladesh have 54 transnational rivers. Many important tributaries originate in Nepal, Bhutan, and China and supply water to Bangladesh, India, and Pakistan. The implications of variable water supply in these shared transboundary rivers will be twofold. First, intracountry issues may arise. Examples include the often acrimonious disputes between Sindh and Punjab provinces in Pakistan over the Indus, and those between the states of Karnataka and Tamil Nadu in India over the Cauvery River. More challenging are the intercountry disputes that could be further exacerbated by the increased demand for water, which would collide with diminishing supplies. Although there currently exist agreements between some countries in the South Asia region (e.g.
further cooperation will be required to address these future climate challenges.

Managing a common problem suggests the need for a cooperative solution that would include data collection and exchange, analysis, and exploration of shared responses. Despite the fact that the challenge is of regional dimensions, water diplomacy between the countries involved has stagnated, partially due to perceptions that water allocation is a “zero-sum game”, based on water rights and allocations rather than on benefit sharing. A strategy for achieving progress and building joint adaptive capacity would involve shifting the debate from its current narrow focus on water rights to one that seeks to address common challenges and create positive benefits, “expanding the pie” rather than simply dividing it. In this sense, building trust and relationships through patient dialogue and the creation of a knowledge-based cooperative partnership of states will be very important. Despite the magnitude of the problem, the impacts of climate change on the Himalayas remain poorly understood, leading the Intergovernmental Panel on Climate Change (IPCC) to define the region as a data-deficient “white spot”. There is an urgent need for the Himalayan countries to better understand the science of climate change, and its social, environmental, and economic consequences. Data sharing and scientific cooperation among countries in the region could be a realistic first step towards the creation of an institutional framework for regional cooperation.

**Strategy for the Future**

“Climate-proofing” water resources – in other words, building more resilience to climate change – is critical to maintaining and expanding South Asia’s growth. The way forward for the region requires a focus on four cross-cutting priorities:

a. **Knowledge base.** Widening the knowledge base will involve promoting national and regional initiatives that foster research, develop knowledge and data sharing among institutions, and establish a cooperative framework to advance a regional agenda aimed at increasing the exchange of knowledge and best practices. Technological components of a knowledge base approach would include greater use of geographic information systems (GIS), remote sensing and telemetry upgrading, wider application of satellite-based weather forecasting and monitoring of snow melt, and a regional early warning system for natural disasters.

b. **Policy and governance.** An adequate policy and governance structure would be required to further develop social constituencies who can advocate reforms, and to help build an enabling environment in which institutions can effectively grow and cooperate on sensitive issues. While it might be premature to move towards harmonization of policies across countries, setting the basis for such harmonization might be within reach, and could be encouraged by, for example,

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48 See glossary.
regional governance schemes aimed at stimulating data exchange and promoting a transboundary approach to knowledge sharing in facing the region’s challenges.

c. **Investment.** Key to the overall climate change agenda is the availability of and access to financing to address, in a timely and comprehensive fashion, the challenges associated with water resources and climate change. There is a crucial need to undertake, at an early stage, massive investment in specific areas to increase and improve the region’s preparedness. The critical areas that require immediate investment are the following:

- **Water resource management** needs to be improved through measures such as adequate training; laying out comprehensive strategies and action plans for extreme events, such as drought and floods; developing new tools, such as modeling, data collection, water allocation schemes, and financing mechanisms; strengthening institutions; and developing a transboundary conscience and regional cooperative framework that leads to actions at that level.

- **Water infrastructure packages** that can increase water storage capacity require consideration, particularly multipurpose water infrastructure schemes associated with modernization in specific areas such as agriculture, hydropower, and transport.

- **Water-efficient technologies** that can better address the adaptation agenda include the latest technologies in water treatment, irrigation dripping, weather forecasting, and monitoring of snow melting and its related impacts.

- **Crop research** is needed to identify and promote adaptative and water efficient crop varieties and to further the innovative use of (possibly organic) fertilizers to increase agricultural production.

- **Education** can build and enhance awareness, and can also build constituencies for required behavioral changes in short- and long-term sustainable water resource management.

d. **Leveling and enhancement of skills.** There is large gap between skills available and skills required, both within countries in the region and across them. A fundamental outcome of this agenda will be to address these shortcomings through training and capacity building, and through partnering with institutions across the region and abroad to promote the birth of a new multidisciplinary generation.

143. Table 6.2 summarizes, by country, the most important water-related climate change issues affecting the South Asia region. It also specifies which areas require the most immediate action.
<table>
<thead>
<tr>
<th>Country</th>
<th>Climate change priorities</th>
<th>Scale and magnitude</th>
<th>Priority focus areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Glacier melting in the Himalayas</td>
<td>Regional</td>
<td>Himalayan Hindu Kush</td>
</tr>
<tr>
<td></td>
<td>Lake outburst</td>
<td>Local to national</td>
<td>Hill and mountain areas</td>
</tr>
<tr>
<td></td>
<td>Floods and droughts</td>
<td>National to regional</td>
<td>Helmand and Kabul basins</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Floods</td>
<td>National to regional</td>
<td>Ganges, Brahmaputra, Meghna basins</td>
</tr>
<tr>
<td></td>
<td>Increase in natural disasters (cyclones and sea level surges)</td>
<td>National to regional</td>
<td>Coastal zones</td>
</tr>
<tr>
<td></td>
<td>Salt water intrusion</td>
<td>Local</td>
<td>Coastal zones</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Glacier melting in the Himalayas</td>
<td>Regional</td>
<td>Himalayan Hindu Kush</td>
</tr>
<tr>
<td></td>
<td>Lake outburst</td>
<td>Local to national</td>
<td>Hill and mountain areas</td>
</tr>
<tr>
<td></td>
<td>Floods</td>
<td>National to regional</td>
<td>Ganges tributary basins</td>
</tr>
<tr>
<td></td>
<td>Droughts</td>
<td>Local to national</td>
<td>Throughout</td>
</tr>
<tr>
<td>India</td>
<td>Glacier melting in the Himalayas</td>
<td>Regional</td>
<td>Himalayan Hindu Kush</td>
</tr>
<tr>
<td></td>
<td>Floods</td>
<td>National to regional</td>
<td>Ganges, Brahmaputra, Meghna basins</td>
</tr>
<tr>
<td></td>
<td>Droughts</td>
<td>Local to national</td>
<td>Throughout</td>
</tr>
<tr>
<td></td>
<td>Increase in natural disasters (cyclones)</td>
<td>National to regional</td>
<td>Coastal zones</td>
</tr>
<tr>
<td></td>
<td>Salt water intrusion</td>
<td>Local</td>
<td>Coastal zones</td>
</tr>
<tr>
<td>Maldives</td>
<td>Increase in natural disasters (cyclones and sea level surges)</td>
<td>Local to national</td>
<td>Throughout</td>
</tr>
<tr>
<td>Nepal</td>
<td>Glacier melting in the Himalayas</td>
<td>Regional</td>
<td>Himalayan Hindu Kush</td>
</tr>
<tr>
<td></td>
<td>Lake outburst</td>
<td>Local to national</td>
<td>Hill and mountain areas</td>
</tr>
<tr>
<td></td>
<td>Floods</td>
<td>National to regional</td>
<td>Ganges tributary basins</td>
</tr>
<tr>
<td></td>
<td>Droughts</td>
<td>Local to national</td>
<td>Throughout</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Glacier melting in the Himalayas</td>
<td>Regional</td>
<td>Himalayan Hindu Kush</td>
</tr>
<tr>
<td></td>
<td>Increased water scarcity and droughts</td>
<td>Local to national</td>
<td>Indus basin</td>
</tr>
<tr>
<td></td>
<td>Salt water intrusion</td>
<td>Local</td>
<td>Coastal zones</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Increase in natural disasters (cyclones and sea level surges)</td>
<td>Local to national</td>
<td>Coastal zones</td>
</tr>
</tbody>
</table>
Though the overall impacts of climate change are hard to predict, they are likely to have far-reaching consequences. Water-extreme events, such as floods and droughts, are predicted to impact more people and economies over time in South Asia than in any other region of the world. The effects of these trends will be magnified by population growth and the industrialization of South Asian economies, increasing the need to expedite progress in preparing the region to cope with the impacts of climate change. A fundamental challenge facing the water sector will be how to find a balance between increasing variability of water supply and accelerating demand for water.
Chapter 7. Agriculture and Rural Sector\textsuperscript{49}

145. **Agriculture is critical to South Asia’s development.** Rural areas in the region are home to over 70 percent of its population and agriculture is the region’s principal occupation, employing over 60 percent of the labor force. More than 75 percent of the region’s poor live in rural areas (Figure 7.1) and depend on rainfed agriculture, livestock, and fragile forests for their livelihoods. Agricultural and rural nonfarm growth will be critical to reaching the Millennium Development Goal of halving the number of poor people by 2015. Meeting this challenge calls for growth that stems from agricultural productivity and raises the incomes of small-scale farmers and landless laborers. The Green Revolution of the 1970s and 1980s substantially increased food grain productivity, and improved food security and rural wages. Consequently, those dramatic leaps in agricultural production raised farmer incomes, bringing a significant reduction in rural poverty. In India, for example, the rural poverty rate declined from about 53 percent in 1977/1978 to 26 percent in 1999/2000. The challenge is to replicate and sustain these achievements during the future with a more variable and unpredictable climate.

**Figure 7.1 Breakdown of Poverty (Rural/Urban) by Country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Urban Poor</th>
<th>Rural Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>India 1999/00</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>Nepal 2003/04</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td>Pakistan 2001/02</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td>Sri Lanka 2002</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td>Bhutan 2000</td>
<td>84%</td>
<td>16%</td>
</tr>
</tbody>
</table>

*Source:* World Bank calculations. Data for Afghanistan and Maldives were not available.

146. **The growth of agricultural productivity has slowed down and the sector now languishes behind the other dynamic growth drivers in the region.** Per capita growth in agricultural productivity in South Asia (less than 2 percent) has barely kept pace with population growth; it is also lower than that of East Asia and the Pacific (3.1 percent) and Latin America (2.8 percent). Several problems have emerged that have constrained growth: deteriorating soil fertility and declining quality of inputs such as seeds,

\textsuperscript{49} Authors in alphabetical order: Harshadeep Nagaraja Rao and Winston Yu.
fertilizers, and pesticides; reduced water availability; lack of access to credit; suboptimal farming practices; and lack of investment in new technologies. As a result, there is a large gap between actual yields and technologically feasible yields.

147. While there are many impediments to agricultural growth in South Asia, the one that threatens the economy most is the rapidly deteriorating water situation. Many parts of South Asia face growing water scarcity due to increasing water demands driven by high population growth, urbanization, agricultural needs, and industrial growth. This situation poses a particular threat to agriculture, which uses the large share of the water consumed in South Asia. Recent work in India, for instance, demonstrates that many of the major river basins in the country will face a water deficit in the future by 2050 (Garg and Hassan 2007). This increased pressure on water availability, combined with increasing land and soil degradation, makes rational and efficient utilization of water, and related policy options that promote economic and environmental sustainability of water use, essential to long-term food security in South Asia. The problem is further compounded by the nature of small and marginal landholdings, which are characterized by highly unequal ownership of and access to productive assets such as land and water. Moreover, new challenging demands are being placed on the agricultural sector that add pressure to an already strained sector. These include compliance with sanitary and phytosanitary standards; meeting the growth needs of the biofuels industry; and emerging health epidemics linked to the sector (e.g. avian flu). Addressing these challenges is important to reversing the prolonged slowdown in the agricultural sector, which is in turn essential for inclusive growth.

Climate Variability and Change

148. Climate change poses a particular challenge to the agricultural sector. Of all potential impacts stemming from climate change, those to the agricultural sector stand out as among the most important. Long-term changes in temperatures and precipitation have direct implications on evaporative demands and agricultural yields. It is true that, in some areas, some reduction in yields may be offset by carbon fertilization and increased precipitation (Box 7.1). However, this opportunity is likely to be limited in scope and only applicable to certain species. A large portion of the population in the region is already vulnerable to a range of natural hazards and extreme weather events (e.g. floods, droughts, and cyclones). The changing hydrological characteristics of these extreme events, in relation to the onset, duration, and magnitude of the yearly monsoon season, will affect agricultural production significantly. The combined effects could be devastating for tropical agriculture. In Bangladesh alone, between 1991 and 2000, 93 major natural disasters were recorded, with the agricultural sector suffering the bulk of the losses.50 Finally, sea level rise could have important implications for the availability of land for agriculture. Inundation and changes in the sediment balance and salinity profile of coastal areas could affect large areas of fertile arable land across much of the region.

Box 7.1 Carbon Fertilization Effects

The extent to which increased carbon dioxide levels in the atmosphere may actually improve crop yields (“carbon fertilization”) is a subject of current interest. Much of the debate is focused on the different ways plants fix carbon dioxide. C3 crops, which include rice, wheat, soybeans, fine grains, legumes, and most trees, benefit substantially from increased carbon dioxide levels; C4 crops, which include maize, millet, sorghum, and sugarcane, benefit much less.

Recent research based on experiments using the free air concentration enrichment (FACE) method, which involves pumping carbon dioxide into the open air surrounding crops grown in fields (to simulate more realistic conditions than previous closed-condition studies), suggests that past estimates of the carbon fertilization effect may have been substantially overstated (Long et al. 2005). Elevation of carbon dioxide levels to 550 to 575 parts per million (ppm) resulted in a yield increase of 11 percent for C3 crops and 7 percent for the world’s five major grain crops—maize, rice, sorghum, soybean, and wheat. This was about one-third to one-quarter of the effect modeled in a 2000 assessment for Europe and the United States by Darwin and Kennedy (2000).

149. **Climate change may further stress rural livelihoods, beyond just agriculture.** Climate-induced changes to resource flows (e.g., natural resources, water, biomass) can fundamentally affect the viability of the livelihoods of the rural poor. Resilience is typically low in rural areas as the existing asset base is weak (natural, human, physical, financial, social) and services provided by infrastructure and institutions are often insufficient. Thus, the rural poor are chronically vulnerable to climatic conditions beyond direct agriculture production impacts. This is especially true during natural disasters and in existing climate sensitive areas (e.g., drought-prone and flood affected areas) where the ability to cope to current climate variability is low. The prospect of increasing climate risks underscores the importance of a more integrated and holistic approach to development in the rural areas. For instance, in addition to traditional agriculture activities, including livestock and fisheries, supporting socio-economic activities beyond agriculture are needed to promote livelihood diversification.

**Costs of Climate Change in the Agricultural Sector**

150. **Measuring the precise economic impacts of climate change on agriculture is difficult because of uncertainty.** First, the exact magnitude of impacts is uncertain because the complex bio-physical interactions and feedback processes are poorly understood. Second, any assessment of climate impacts on the agricultural sector must be undertaken against the background of a volatile global food supply and demand system (see Box 7.2 on food price crisis, for example) that is affected by changing socioeconomic conditions, such as population growth, increasing urbanization, changing patterns in consumption and trade, and technology development. These future socioeconomic uncertainties may in fact dominate most impact assessments.
Box 7.2 Food Price Crisis

The surge in global commodity prices of the past few years has presented a tremendous development challenge to South Asian countries. On a net basis South Asia is estimated to have suffered an income loss equivalent to some 9.6 percent of GDP between January 2003 and April 2008. Although much of the income loss resulted from the hike in petroleum prices, the surge in food prices between January 2007 and April 2008, especially of staple food—wheat and rice—has created tremendous adverse social impact in South Asia. All countries have witnessed unprecedented surge in food prices, although India was largely able to limit this increase through a combination of timely interventions. Net food importing countries like Afghanistan, Sri Lanka and Bangladesh have suffered the most from the food price crisis. The adverse effect of the rise in global commodity prices on macroeconomic balances has been substantial. South Asian countries have seen a sharp increase in fiscal deficits and a worsening in the balance of payments. Inflation has been hit badly. For the first time in decades countries have simultaneously experienced double digit inflation rates, exceeding 20 percent in Afghanistan, Pakistan and Sri Lanka. Economic growth is showing signs of slowdown. The emerging global financial crisis is adding fuel to the fire, with further adverse consequences for macroeconomic balances and growth.

Source: Ahmed 2008. Global Food Price Inflation and Implications for South Asia

151. **Several approaches to assessing the impacts of climate change on crops are typical.** Three common methods are: (i) statistical assessments (termed neo-Ricardian models) that examine actual farmers’ responses to climate variation; (ii) agronomic crop models that simulate plant growth and bio-physical changes to the climate; and (iii) hybrid approaches that combine both elements (Cline 2007) (see Box 7.3).
Box 7.3 Approaches to Measuring Climate Impacts on Yields

The Ricardian approach makes use of cross-sectional data to capture the influence of climatic as well as economic and other factors on land values (or farm income). This technique implicitly captures the adaptation measures that farmers will adopt as the climate changes. Moreover, it is assumed that because farmer adaptations will be reflected in land values, the costs and benefits of adaptation are embedded in those values. This approach is used to generate estimates of farm performance across different climate conditions that can be used to infer the consequences of future climate change.

Alternatively, a crop model (or agronomic) approach can be used whereby models are calibrated from controlled field experiments that are designed to simulate climate events and different management regimes. Typically, these models assume that farmers do not respond to predictably changing conditions, nor do they learn from past experiences. As a result, estimates of the costs of adapting to climate change are often larger than those derived from Ricardian approaches. The accompanying figure shows the impacts, by 2030, of climate change on yields of five major crops in the South Asia region, as a percentage change compared to current yields (Lobell et al. 2008). For each crop, the dark vertical line represents the middle value out of one hundred different model projections (range shown in yellow). The number in parentheses is an overall global ranking given to each crop based on its importance to food security, calculated by factoring in the number of malnourished people in the region and the percentage of calories they derive from the crop.

152. There is a strong consensus that climate change will have severe consequences on the agricultural sector and the rural poor in South Asia. Using a range of different approaches, Cline (2007) estimated broad impacts for a number of South Asian countries. The estimates vary substantially, from as little as a 1 percent loss of agricultural revenues in Nepal to a dramatic 49 percent decline in average revenue in India by 2080 (Table 7.1).
Table 7.1 Estimates of Climate Change-related Impacts on Agricultural Production by 2080 for Selected Countries in the South Asia Region

<table>
<thead>
<tr>
<th>Country</th>
<th>Farm area (1,000 ha)</th>
<th>Output per hectare (US$)</th>
<th>Output (mills US$)</th>
<th>% change (Ricardian)</th>
<th>% change (crop models)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>7,827</td>
<td>313</td>
<td>2,448</td>
<td>-9.5</td>
<td>-32.1</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>8,429</td>
<td>1,355</td>
<td>11,421</td>
<td>-14.3</td>
<td>-25.3</td>
</tr>
<tr>
<td>India</td>
<td>170,115</td>
<td>777</td>
<td>132,140</td>
<td>-49.2</td>
<td>-27.0</td>
</tr>
<tr>
<td>Nepal</td>
<td>3,294</td>
<td>728</td>
<td>2,399</td>
<td>-0.9</td>
<td>-25.3</td>
</tr>
<tr>
<td>Pakistan</td>
<td>22,120</td>
<td>856</td>
<td>18,935</td>
<td>-17.9</td>
<td>-36.6</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>1,916</td>
<td>1,808</td>
<td>3,465</td>
<td>-9.5</td>
<td>-25.3</td>
</tr>
</tbody>
</table>

Source: Cline 2007.

Note: Estimates are based on the A2 scenario of the Special Report on Emission Scenarios (SRES) (Nakicenovic and Swart 2000) and a rough average increase in temperature of 3.3°C.

a. Bhutan and Maldives are too small to be resolved with climate data at a 0.5 x 0.5 degree resolution.
b. At 2003 price levels.

153. These estimated changes do not consider crop losses arising from more intense droughts and floods; changes in surface water availability; or threshold effects in the response of crop growth to temperature changes. Nor do they take into account that, for agriculture that is being practiced in low-lying coastal areas (e.g. Bangladesh, and the Mahanadi delta in India) there is also potential for damage arising from sea level rise and increased salt water intrusion in groundwater aquifers.

154. More precise estimates are available for select countries in South Asia and are described in the following subsections.

India

155. Reflecting India’s immense geographic diversity, the projected impacts of climate change on crop yields vary by region. In arid locations where crops already suffer heat stress, a small increase in temperatures could lead to a dramatic decline in yields. The same temperature increase in, say, the cooler Himalayas could generate an increase in yields. Accordingly, agronomic models project a wide range of impacts that vary by location and climate scenario.51 Table 7.2 and Table 7.3 summarize, respectively, the results from studies that have measured the resulting economic losses using the statistical (Ricardian) approach and the agronomic crop model approach(es). The Ricardian models suggest that a temperature increase of 2°C would generate a modest loss of between 3 and 9 percent of current agricultural income (net revenue per hectare).

51 For instance, the yield impacts for rice vary from increases of 22 percent in western India to a reduction of 20 percent in the country’s drier central belt.
However, for a 3°C rise in temperature, the studies predict a wide range of losses from 3 to 26 percent of income. The estimates are broad and approximate averages and need to be treated with caution. In the case of studies that utilize agronomic models, the results also show considerable variation. A general trend that can be ascertained is that increases in temperature greater than 2°C cause higher reductions in yields, which are further exacerbated if rainfall is not increased or is reduced.

Table 7.2 Results of Ricardian Assessments for Selected Crops in India

<table>
<thead>
<tr>
<th>Temperature change</th>
<th>% change (net agricultural revenue per hectare)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2°C</td>
<td>–3 to –6</td>
<td>Sanghi, Mendelsohn, and Dinar 1998</td>
</tr>
<tr>
<td>2°C</td>
<td>–7 to –9</td>
<td>Kumar and Parikh 1998</td>
</tr>
<tr>
<td>2°C</td>
<td>–8</td>
<td>Kumar and Parikh 2001</td>
</tr>
<tr>
<td>3.5°C</td>
<td>–20 to –26</td>
<td>Kumar and Parikh 1998</td>
</tr>
<tr>
<td>3.5°C</td>
<td>–3 to –8</td>
<td>Sanghi, Mendelsohn, and Dinar 1998</td>
</tr>
</tbody>
</table>
Table 7.3 Results of Agronomic Assessments for Crops in India

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield change (%)</th>
<th>Scenario</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lal et al. 1998: northwest India</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>0</td>
<td>+2°C; doubling CO₂</td>
<td>CERES-Rice</td>
</tr>
<tr>
<td></td>
<td>-20</td>
<td>+2°C; doubling CO₂; water shortage</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>0</td>
<td>+3°C; doubling CO₂</td>
<td>CERES-Wheat</td>
</tr>
<tr>
<td><em>Lal et al. 1999: Madhya Pradesh</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>From -4 to 0</td>
<td>+3°C; doubling CO₂; −10% daily rainfall</td>
<td>CROPGR O</td>
</tr>
<tr>
<td><em>Saseendran et al. 2000: Kerala</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>-6</td>
<td>+1.5°C</td>
<td>CERES-Rice</td>
</tr>
<tr>
<td></td>
<td>+12</td>
<td>+1.5°C; +2 mm/day rainfall; 460 ppm CO₂</td>
<td></td>
</tr>
<tr>
<td><em>Aggarwal and Mall 2002: parts of northern, eastern, southern, and western India</em></td>
<td>From +3.5 to +4.3 (2010) From +13.8 to +22.3 (2070)</td>
<td>Optimistic IPCC scenarios: +0.1°C; 416 ppm CO₂; +0.4°C; 755 ppm CO₂. Both at current crop management level</td>
<td>CERES-Rice</td>
</tr>
<tr>
<td>Rice</td>
<td>From +1.3 to +1.9 (2010) From +3.6 to +9 (2070)</td>
<td>Pessimistic IPCC scenarios: +0.3°C; 397 ppm CO₂; +2°C, 605 ppm CO₂. Both at current crop management level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>From +5.1 to +7.4 (2010) From +16.6 to +25.7 (2070)</td>
<td>Optimistic IPCC scenarios</td>
<td>ORYZAI N</td>
</tr>
<tr>
<td></td>
<td>From +2.5 to +4.1 (2010) From +6.1 to +16.8 (2070)</td>
<td>Pessimistic IPCC scenarios</td>
<td></td>
</tr>
<tr>
<td><em>Kalra et al. 2007: DEFRA study</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>From -5 to -8</td>
<td>+1°C; no change in CO₂</td>
<td>CERES-Rice</td>
</tr>
<tr>
<td></td>
<td>From -10 to -16</td>
<td>+2°C; no change in CO₂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>From -21 to -30</td>
<td>+4°C</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>-10 to −30</td>
<td>+1°C to +4°C; 350 ppm CO₂</td>
<td>CERES-Maize</td>
</tr>
<tr>
<td>Jowar</td>
<td>-7</td>
<td>+1°C</td>
<td>CERES-Sorghum</td>
</tr>
<tr>
<td></td>
<td>-12</td>
<td>+2°C</td>
<td></td>
</tr>
<tr>
<td><em>World Bank 2006</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundnut</td>
<td>+2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jowar</td>
<td>+3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>+10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>+3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>0</td>
<td></td>
<td>EPIC</td>
</tr>
<tr>
<td>Groundnut</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jowar</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>+9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a. Margin of error can be as much as 32 percent, depending on the uncertainty in climate change scenario and other factors. Sensitivity analyses were run for increases in temperature, level of nutrients fed to the crops, and variations in CO₂ levels. These showed that, as long as temperature remains unchanged and CO₂ levels increase, yields will increase; however, with temperature increases, this CO₂ effect is nullified for increases in temperature as low as 0.9°C.

b. “Current crop management level” assumes no change in current nutrient application and irrigation.

c. Further increases in temperature resulted always in lower yields irrespective of increases in CO₂. The beneficial effect of additional CO₂ up to 700 ppm was nullified by an increase of only 0.9°C.

**Bangladesh**

156. **Bangladesh is especially vulnerable to climate change and natural disasters.** Cyclones, storm surges, floods, and coastal erosion are frequent occurrences in Bangladesh. It is ranked as one of the most natural disaster-prone countries on the planet, due to the frequency of extreme climate events and its high population density (World Bank 2005). In most years between 20 to 30 percent of the country’s area is affected by floods. The huge sediment loads carried by three Himalayan rivers, coupled with drainage congestion problems, exacerbate the extent of flooding. Climate change is projected to increase the intensity and frequency of natural disasters and to cause changes in agricultural yields, with potentially severe implications for rural poverty. The majority of assessments predict a decline in rice yields. For instance, Karim et al. (1999) anticipate a 17 percent decline in overall rice production, and a decline as high as 60 percent in wheat production, compared to the baseline situation (1994/1995). Wheat and *aus* varieties of rice showed the highest yield impacts. Crop modeling results also suggest that the duration of the growing season could decrease by 2 to 12 days, which may delay the *aman* transplantation (which occurs in December and January). Moisture stress during lean times may also further contribute to a reduction in the yields of *boro* rice (March to May).

157. **Floods (more intense or longer than normal) can also significantly affect agricultural production.** The 1998 flood, for example, caused a 45 percent reduction in agricultural production that year. Moreover, the *aman* production potential of about 2 to 2.3 million hectares could not be realized due to those floods, which lasted 67 days (FAO 1998). As seedlings could not be planted in the flood-affected areas, the resulting estimated shortfall of foodgrain production exceeded 3.5 million metric tons. Higher discharge and low drainage capacity, in combination with increased backwater effects, would increase the frequency of such devastating floods. Calculation of the economic costs of recent extraordinary flood events (1998, 2004) have shown that much of the total economic losses are attributable to the agricultural sector (almost US$700 million in 2004 and affecting almost 5 million families or 42 percent of all farm families) (Karim et al. 1999). Sea level rise would also impact agriculture, but the consequences are poorly understood. Tentative estimates indicate that the loss of foodgrain production due to soil salinity intrusion from sea level rise in the coastal districts could be as much as 40 percent.

**Sri Lanka**

158. **There is much uncertainty about the likely impacts of climate change in Sri Lanka and assessments are sparse.** A recent study by Ajwad et. Al (2004) uses the statistical (Ricardian) approach to estimate the impacts of climate change on the
smallholder agricultural sector in the country. The effect of predicted climate change depends on the scenario used. With mild warming and a large increase in precipitation, net revenue per hectare is projected to increase by 22 percent. On the other hand, with medium warming and only a small increase in precipitation, losses of 23 percent are projected. These impacts are, however, highly location-specific (Figure 7.2). The wet, high-elevation areas are expected to benefit from climate change, while the hot, dry northwestern and southeastern lowlands will be adversely affected. Changes in precipitation are expected to have more impact than temperature changes, especially during key agricultural production months.

Figure 7.2 Distribution of Climate Impacts on Smallholder Agricultural Net Revenues Per Hectare Based on Alternative Climate Scenarios

Adaptation in the Agricultural Sector

159. It is in the context of these potential economic consequences that adaptation measures are needed urgently to reduce the adverse impacts stemming from climate change. Many communities in the South Asia region already face extreme climate variability, both annually (floods and droughts) and in the longer term (El Niño events, long-term shifts in mean climate parameters). Current agricultural systems are often poorly equipped to deal with climate variability. If agricultural communities can be made more resilient to current climate risks, they will be better prepared to face future climate risks.

160. Many different adaptation practices are possible. In some cases, farmers are already adapting by planting resilient crop varieties, changing planting dates, and adapting farming practices to a shorter growing season. In other cases, however, there exist large barriers to adaptation, often related to policy shortcomings and resource constraints. Examples include price controls that promote water-intensive cropping in arid areas; input (e.g. power supply) subsidies that encourage over-abstraction of groundwater; poor irrigation practices; lack of credit or savings; weak extension services; lack of access to improved seeds and inputs; and inadequate agricultural research and technology. Thus, the public sector can facilitate adaptation through improved policy measures such as crop and livestock insurance, social safety nets, research on and dissemination of flood, heat, and drought-resistance crops, including conservation of traditional plant varieties with those characteristics, and in some instances support to new irrigation schemes.

161. Climate change increases the urgency for implementing measures that are needed to ignite agricultural growth in the region and address rural poverty. In this respect, the region’s priorities lie in four core areas:
   
a. Research on and dissemination of climate-resilient agriculture. New climate-resilient agricultural technologies are increasingly complex, knowledge intensive and location specific. They require considerable investment in research and sophisticated systems of extension and dissemination. The Bank and its key partners will play a key role in encouraging research and facilitating the adoption of climate-resilient technologies (e.g. drought-, pest- and saline-resistant crop varieties). Biotechnology will also have an important role to play in developing new, more resilient varieties of crops.

b. Provision of better climate information through improved forecasting and early warning systems. With possible changes in the timing and magnitude of monsoon events, building human and technical capacity and community systems to better prepare for and respond to the wide range of climate risks (e.g. floods, cyclones, droughts) will be critical to sustaining agricultural growth rates in the region and improving rural livelihoods. Although many different information channels exist for farmers, few of them are sufficiently customized that they are able to improve farmers’ productivity and incomes. This will require the strengthening of existing agricultural extension services and other community dissemination means (e.g. information kiosks, community agroclimatic atlases) to provide farmers with improved access to real-time climate information.
Improving information dissemination can also help to remove existing barriers to adaptation.

c. **Improved water resource management** (further details described in chapter 4). Adequate water provision presents the most serious challenge to agriculture. Water is becoming increasingly scarce as rising demand from agriculture and industry encounters the diminishing potential for expansion of water supply. Climate change is projected to increase water scarcity through much of the region. In this context, policies that improve water management and encourage prudent water use will help build more climate-resilient agricultural systems. In addition, irrigation systems in the region are often poorly maintained and rapidly deteriorating, thus accelerating water losses. A priority of the Bank is to improve irrigation systems, create water storage systems, and increase access to water in dryland farming areas and areas vulnerable to recurrent droughts. In flood-prone areas, the priority is to facilitate improvements to drainage systems and flood protection works. Lastly, at the community level, introducing methods to conserve soil and water (e.g. lining canals, dry seeding of rice, furrow irrigation, zero tillage) will help to improve the productivity of increasingly scarce land and water resources.

d. **Improvements in risk management.** Due to the high degree of uncertainty about the future climate, new innovative financial mechanisms are required to protect the agricultural assets upon which so many depend. Strengthening current agricultural and weather insurance mechanisms will be critical. Along similar lines, mapping vulnerable areas and developing and implementing region-specific contingency plans, based on vulnerability and risk assessments, will help to better prepare communities for the challenges that lie ahead. With the advent of extreme climate events, having proper safety nets in place will be important for the protection of those who are most vulnerable.

162. Many of these measures may be effective at reducing climate risks, especially when combined with complementary reforms and better market access for high-value products. Finally, mainstreaming climate change and climate risk issues into the broader economic agenda, rather than taking a narrow agricultural view, will also be critical.

**Adaptation and Mitigation Links**

163. **Agriculture is also a major source of greenhouse gas emissions.** Crops and livestock are large contributors to greenhouse gas emissions, primarily of methane and nitrous oxide. In India, for instance, of a total of 1,469 teragrams (Tg) of CO₂-equivalent greenhouse gases emitted in 2000, almost 13 percent came from livestock-related activities (including both CH₄ and N₂O contributions; these two gases represented 30 percent of total greenhouse gas emissions)⁵² (Table 7.4). CH₄ emissions dominate in

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⁵² In 2000, methane emissions were 18.6 Tg; NO₂ emissions were 0.308 Tg. Amounts are converted into equivalent CO₂ by multiplying by the global warming potentials of 21 and 310, respectively. That is, methane and NO₂ have a greater potential to warm compared to an equivalent mass of CO₂. Other contributors to methane and NO₂ emissions include rice paddy cultivation, municipal solid waste, and biomass burning.
comparison to those of N$_2$O. With almost 300 million cattle and buffalo in the country, livestock contributions to Indian emissions are significant; the negative balance of such emissions is also considerable, due to the generally low productivity and efficiency of livestock farming in the country (and throughout much of the region).

Table 7.4 Contributors to Indian CO$_2$-equivalent Greenhouse Gas Emissions in 2000

<table>
<thead>
<tr>
<th>Source categories</th>
<th>Main emissions</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-based electricity</td>
<td>CO$_2$</td>
<td>29.9</td>
</tr>
<tr>
<td>Steel industry</td>
<td>CO$_2$</td>
<td>8.8</td>
</tr>
<tr>
<td>Cement industry</td>
<td>CO$_2$</td>
<td>5.1</td>
</tr>
<tr>
<td>Livestock related</td>
<td>CH$_4$, N$_2$O</td>
<td>12.6</td>
</tr>
<tr>
<td>Paddy cultivation</td>
<td>CH$_4$</td>
<td>6.6</td>
</tr>
<tr>
<td>Biomass consumption</td>
<td>CH$_4$, N$_2$O</td>
<td>5.2</td>
</tr>
<tr>
<td>Synthetic fertilizer use</td>
<td>N$_2$O</td>
<td>4.1</td>
</tr>
<tr>
<td>Transport sector</td>
<td>CO$_2$</td>
<td>9.5</td>
</tr>
<tr>
<td>Waste disposal</td>
<td>CH$_4$</td>
<td>3.8</td>
</tr>
<tr>
<td>Other sources</td>
<td>CO$_2$, CH$_4$, N$_2$O</td>
<td>14.4</td>
</tr>
</tbody>
</table>

*Source: Garg and Shukla 2002.*

164. Agriculture has much untapped potential to reduce such emissions through changes in land use and agricultural practices, and by reducing deforestation. The most promising area for reduction in methane emissions is in the livestock sector. Improving the diet of livestock can both improve their overall productivity (methane production currently results in a 5 to 15 percent loss of energy) and reduce methane emissions. Swamy and Bhattacharya (2006) find that feed conversion efficiency can be improved through (i) replacement of roughages with concentrates and a change in composition of concentrations; (ii) modification in feeding (e.g. alkali/ammonia treatment of low digestibility straws); and (iii) supplementation with molasses or urea nutrient blocks. If livestock manure is kept under aerobic conditions by turning regularly, methane emissions can also be reduced by as much as 30 to 40 percent.

165. Emissions of carbon dioxide can be further reduced by slowing deforestation; through changes in agricultural land management such as conservation tillage, agroforestry, and rehabilitation of degraded crop and pasture land; utilizing storage and capture technologies for manure; and conversion of emissions into biogas. Opportunities through carbon trading are in principle quite large and offer new possibilities for agriculture to benefit from land uses that sequester carbon.

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53 Based on 1997 census data.
Chapter 8. Natural Disasters\textsuperscript{54}

Toll of Natural Disasters

South Asia is extremely vulnerable to natural disasters, with over 900 events reported since 1970 alone. Between 1990 and 2008, over 750 million people – 50 percent of the population in the region – were affected by a natural disaster, leaving almost 230,000 deaths and about US$45 billion in damages (Table 8.1).

Table 8.1 Reported Natural Disaster Impacts in South Asia (1990–2008)

<table>
<thead>
<tr>
<th>Country</th>
<th>Population ('000)</th>
<th>Deaths ('000)</th>
<th>People affected ('000)</th>
<th>Population affected (%)\textsuperscript{56}</th>
<th>Damage in US$ ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>22,615</td>
<td>6.1</td>
<td>5,410</td>
<td>23.9</td>
<td>69,060</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>143,990</td>
<td>155.3</td>
<td>145,713</td>
<td>101.2</td>
<td>12,984,000</td>
</tr>
<tr>
<td>Bhutan</td>
<td>602</td>
<td>0.2</td>
<td>66</td>
<td>11.0</td>
<td>3,500</td>
</tr>
<tr>
<td>India</td>
<td>1,071,608</td>
<td>53.4</td>
<td>885,244</td>
<td>82.6</td>
<td>25,743,100</td>
</tr>
<tr>
<td>Maldives</td>
<td>279</td>
<td>0.0</td>
<td>2</td>
<td>0.7</td>
<td>500,100</td>
</tr>
<tr>
<td>Nepal</td>
<td>25,278</td>
<td>4.6</td>
<td>2,796</td>
<td>14.1</td>
<td>245,100</td>
</tr>
<tr>
<td>Pakistan</td>
<td>162,662</td>
<td>9.4</td>
<td>27,943</td>
<td>17.2</td>
<td>3,573,054</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>19,258</td>
<td>0.5</td>
<td>6,331</td>
<td>32.9</td>
<td>1,670,070</td>
</tr>
<tr>
<td>Total</td>
<td>1,368,327</td>
<td>229.5</td>
<td>1,073,504</td>
<td>78.5</td>
<td>44,787,984</td>
</tr>
</tbody>
</table>


The toll of natural disasters is high and rising. Since 1970, the number of reported natural disasters in the region has been rising steadily (Figure 8.1). Figure 8.2 shows the principal hazard risks in the region and the distribution of the “hotspots” where they are most likely to be encountered. These hotspots occupy a significant portion of the geographic territory, with several parts being susceptible to more than one type of climate-related hazard. With a coastline of 12,000 kilometers as well as low-lying lands and many islands, the region is highly vulnerable to cyclones, storm surges, and sea level rise. As shown in Figure 8.2, significant portions of Bangladesh, India, Nepal, and Sri Lanka are prone to flooding. In the 1970–2008 period, floods accounted for 50 percent

\textsuperscript{54} Authors in alphabetical order: Siet Meijer, Christophe Pusch, and Ranu Sinha.


\textsuperscript{56} Since this is total number of people affected over 18 years, percentage affected as proportion of average population over this time can be higher than 100 percent since it indicates multiple exposures to disasters.
of the total number of events reported, while droughts accounted for 2 percent (Figure 8.1). Nevertheless, droughts affected more than 50 percent of the total number of affected people. \(^{57}\) Droughts normally occur as a consequence of rainfall deficiency and low air humidity. The arid and semi-arid regions of Afghanistan, India, and Pakistan experience significant drought. Though droughts seldom result in structural damage, they generally extend over a larger geographic area than damages from other natural hazards (American Meteorological Society 2003).

168. Global warming has been correlated with an upward trend in the destructive potential of hurricanes (Emanuel 2005). The eastern coast cyclones originate in the Bay of Bengal, the Andaman Sea, and the South China Sea and move toward the coasts of West Bengal, Orissa, and Andhra Pradesh, eastern and north central parts of Sri Lanka, and the coastal areas of Bangladesh. Recently, observed trends in the intensity of tropical cyclones have raised the probability that the region may face an even stormier future. This prospect might be partially shaped by an increase in sea surface temperature resulting from climate change.

**Figure 8.1 Number of Reported Disasters in South Asia by Disaster Type (1970–2008)**

![Graph showing the number of reported disasters from 1970 to 2008 by disaster type. The x-axis represents years from 1970 to 2008, and the y-axis represents the number of disasters ranging from 0 to 70. There are bars for different disaster types including Wind Storm, Wild Fires, Wave / Surge, Slides, Flood, Extreme Temperature, and Drought.]


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The areas and populations that face the highest risk from natural disasters are located in Bangladesh and Nepal (Table 8.2). However, with 436 events since the 1950s and almost 2 billion people (cumulative) affected during this period, it is India that has suffered the most extensive damage. Population growth and increased infrastructure density in disaster-prone areas only exacerbate this risk.

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58 Map 1 - 4 displays the South Asia region with hazards data that are derived from a global source (Reproduced/modified from Dilley et al. 2005).
59 Ibid.
60 Ibid.
61 Ibid.
Table 8.2 Countries at Relatively High Mortality Risk from Multiple Hazards

<table>
<thead>
<tr>
<th>Global rank</th>
<th>Country</th>
<th>Total area at risk (%)</th>
<th>Population in risk areas (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bangladesh</td>
<td>97.1</td>
<td>97.7</td>
</tr>
<tr>
<td>2</td>
<td>Nepal</td>
<td>80.2</td>
<td>97.4</td>
</tr>
<tr>
<td>31</td>
<td>Bhutan</td>
<td>31.3</td>
<td>60.8</td>
</tr>
<tr>
<td>48</td>
<td>Pakistan</td>
<td>22.8</td>
<td>49.6</td>
</tr>
<tr>
<td>50</td>
<td>Afghanistan</td>
<td>7.2</td>
<td>46.0</td>
</tr>
<tr>
<td>71</td>
<td>India</td>
<td>21.9</td>
<td>27.2</td>
</tr>
</tbody>
</table>

a. Hazards include earthquakes.

170. Figure 8.3 shows the EM-DAT reported costs of damage in South Asia by country and type of disaster in the period 1990–2008. Floods account for the majority of damages (measured by cost), followed by windstorms. Large distributional differences are present within each country. The impact of the 2007 cyclone Sidr on the Bangladesh economy was estimated to be a modest 2.8 percent of gross domestic product (GDP), but at a local scale several districts were much more severely affected. There are also indirect effects of floods, such as the degradation of agricultural lands and the consequent decline in their productivity, long after the floods have receded that add to the toll of natural disasters.

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Figure 8.3 Reported Costs of Damage in South Asia by Country and Disaster Type (1990–2008)


171. With climate change and rising population densities, damage and exposure to natural disasters is set to increase. Since the region shares common geological formations and river basins, natural hazards transcend national boundaries. Heavy rainfall and the high silt load of water bodies cause recurrent floods over large areas, often transboundary in nature. The floods in Bangladesh and India, for example, have their origins in Bhutan and Nepal.

Fiscal Impact of Disasters

172. Relief measures and their financing may not be sustainable in the not-so-distant future. The damages caused by natural disasters are exerting more and more pressure on development opportunities. Public expenditure is placed under stress by the repeated need for relief work in vulnerable areas. In India for instance, the direct losses from natural disasters amount to up to 2 percent of India’s GDP and up to 12 percent of central government revenues (World Bank 2003). Several state governments spend significantly more on relief and damages than on their rural development programs. In the state of Maharashtra, a single drought in 2003 and a flood in 2005 consumed more of the budget (Rs\textsuperscript{63} 175 billion) than the entire planned expenditure (Rs. 152 billion) on irrigation, agriculture, and rural development for the 2002–2007 period (World Bank 2007). Oxfam (2008) estimates that between 2 and 6 percent of South Asia’s GDP is lost to disasters every year.

173. Governments usually respond to natural disasters only in their aftermath. This is largely due to both limited fiscal resources and a lack of economic incentives to

\textsuperscript{63} Indian Rupees.
engage in disaster mitigation strategies. Many countries depend on emergency aid and on easily available reconstruction funds from international development organizations to alleviate the impacts of disasters. This dependence can adversely affect the need for proactive disaster management. Many development programs already experience a reduction in their effectiveness. Though relief programs can be strengthened and will continue to remain a key source of aid to countries suffering from extreme natural disaster events, in the long term there is a clear fiscal and development need to strengthen climate resilience by addressing the root causes of vulnerability (World Bank 2007).

Response to the Natural Hazards Threat: From Relief to Resilience

174. **Economic losses and loss of life from natural disasters can be reduced through a systematic approach to planning and preparation.** Some South Asian countries have recently adopted disaster management plans that focus on prevention and preparedness rather than on relief and response. Several countries have begun to develop national-level disaster management legislation and to institutionalize national disaster management frameworks that engage district- and state-level authorities in action planning to improve resilience to natural disasters (Box 8.1).

175. Recognizing these needs of the region, the World Bank has begun to engage in high-priority risk mitigation activities and to provide support for the mainstreaming of disaster risk practices into the overall development agenda of client governments. Various programs and projects have been developed, such as the establishment of the new Global Facility for Disaster Reduction and Recovery (GFDRR), which provides annual grants of about US$4 million for the countries in the region to mainstream risk mitigation into the development process.

**Box 8.1 India and Bangladesh: National Disaster Management Frameworks**

In India, the National Disaster Management Framework (August 2004) sets out policy parameters and provides guidelines on institutional mechanisms, disaster prevention strategy, early warning systems, disaster mitigation, preparedness and response, and human resource development.

Bangladesh has improved its ability to manage disaster risks, in particular floods and cyclones, after the cyclone of 1991 that claimed nearly 140,000 lives. This has been the result of a gradual shift from a response-based approach to a strategy that incorporates elements of greater emergency preparedness and risk mitigation.

176. **Strategic coordination between the disaster risk management and the climate change agendas is of high importance.** 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. When dealing with climate change risks, it is important to recognize the existing vulnerability to climate variability. Enhancing the ability of local communities to manage current natural hazard risks will help improve their 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.
177. **Maintenance of risk mitigation investments is critical for many protective infrastructures but is often overlooked.** It has become increasingly apparent that expensive disaster prevention infrastructure often fails due to lack of maintenance. Reasons for this include a shortage of human resources available for maintenance tasks, inadequate levels of training in maintenance management, and a lack of beneficiary ownership and accountability.

178. The high concentration of risk also suggests that mechanisms are needed to either finance or transfer the financial risks of catastrophic events. How to fund the necessary response is always a key question for disaster-affected countries. There is a clear need in most cases for immediate funds that might be covered by contingency funding. The World Bank has already supported such initiatives in Colombia, Mexico, and Turkey, and similar mechanisms may be applicable to the countries of South Asia.

179. **Key elements of the framework** proposed to deal with these issues include:

   a. Disaster funding approaches that encourage *ex ante* mitigation efforts (i.e., risk management) as well as reinforcing *ex post* response capacity (i.e., coping mechanisms).

   b. Three basic and interlinked building blocks:

      • A formal institutional structure (disaster management agency) to guide, support, and fund mitigation efforts and response capacity enhancement, particularly with respect to critical infrastructure and the poor.

      • A national capacity to offer catastrophe insurance to better-off households and small business owners. Where insurance markets are undeveloped, this may take the form of a separately managed catastrophe pool, possibly backed by international capital (e.g. reinsurance and catastrophe bonds).

      • A “visibility filter” whereby decision makers can be shown to be responding to all affected households after a catastrophe. This will often take the form of a low-interest loan facility for reconstruction costs, including the cost of any post-disaster mitigation requirements, and modest relief grants.

   c. Techniques to identify gaps between *ex post* resource availability and post-disaster financing needs (particularly for those countries and states with concentrated and vulnerable exposures). Modern technology can enable these to be identified and appropriate ex ante funding strategies developed.

   d. *Ex ante* funding mechanisms will need to be designed explicitly to support the three building blocks listed above. World Bank contingent credit and reinsurance funding instruments have already taken on this role in a number of countries subject to earthquake risk.

**Role of the World Bank**

180. The **World Bank is strongly promoting a proactive and strategic approach to natural disaster risk management in the South Asia region** by supporting the
establishment of effective disaster risk management systems. The Bank’s proposed disaster risk management framework is based on five basic pillars:

a. **Risk identification and assessment.** What is the country’s hazard exposure? What are the economic and social losses? What is the probability of loss exceedance? Where is the risk concentrated?

b. **Risk mitigation.** What structural and nonstructural measures are suitable and affordable to mitigate physical damage? What are the priorities for intervention, considering risk to lives, livelihoods, and the need for emergency facilities? How best can these measures be financed and sustained?

c. **Emergency preparedness.** Is the country sufficiently prepared to respond to emergency situations, organizationally and technically? Does the existing coordination and response mechanism function under stress? How efficiently are public, nongovernmental, bilateral, and international aid institutions integrated in the emergency response system?

d. **Catastrophe risk financing or transfer.** What is the country’s financial capacity to absorb catastrophic events? Is there a funding gap? What are the most suitable financial instruments with which to address the funding gap?

e. **Institutional capacity building.** What is the country’s capacity to manage risk at different levels of government? Is an institutional framework and coordination mechanism in place that allows strategic planning and decision making at the central, regional, and local levels? Are technical, social, and economic considerations integrated adequately in the investment decision process?

181. South Asian countries have achieved impressive rates of economic growth since the 1990s. However, the region is highly vulnerable to natural disasters. The increasing frequency and intensity of these natural events pose a significant threat to development and may challenge the prospects for achieving the Millennium Development Goals. The increase in surface sea temperature due to climate change is likely to intensify tropical cyclones and hurricanes. It is imperative that the region improves disaster preparedness in order to save lives, but also that it promotes adaptation to climate change risks. Both disaster risk reduction and climate change adaptation have to be integrated into national planning strategies.
Chapter 9. The Health Sector

182. Climate change will affect the basic determinants of health: clean air and water, disease vectors, and the availability of food. Many major diseases are highly climate sensitive. A warmer and more variable climate threatens to increase air pollutants, which in turn is expected to lead to an increase in respiratory and airborne diseases. As hazards from extreme events such as floods and cyclones become more frequent and devastating, transmission of diseases through unclean water and contaminated food is also likely to proliferate. Climate change threatens to slow the considerable progress that has been made in combating climate-sensitive diseases.

183. In South Asia many of the leading causes of mortality, such as diarrheal diseases and respiratory infections, reflect the poverty that remains endemic to much of the region. For example, in areas with inadequate sanitation, diarrheal disease outbreaks are likely during times of flooding. With increased rainfall during the monsoon season, these outbreaks will become more frequent. In urban areas, an increase in air pollutants associated with rising ozone levels will exacerbate chronic illnesses such as cardiovascular disease and asthma. Climate change will affect both communicable and chronic causes of illness. The more prosperous parts of the region are undergoing an epidemiologic transition, with the health burden shifting away from communicable diseases toward higher incidence of chronic diseases.

184. The relationship between climate change and human illness is complex and difficult to assess. Accordingly, this chapter provides a broad qualitative overview of its likely impacts. The risks to health stemming from climate change will occur through three channels: (i) the impacts that are directly related to weather or climate; (ii) the impacts that result from environmental changes that occur due to climate change; and (iii) the impacts that result from consequences of climate-induced economic dislocation, environmental decline, and conflict (WHO 2005). Each of these is explored in the South Asian context in greater detail.

Impacts Directly Related to Weather or Climate

185. Human health impacts directly related to weather or climate include changes in the frequency and intensity of temperature extremes and severe weather events. In South Asia, this includes heatwaves, flooding, and increased intensity of tropical cyclones and storm surges.

Heatwaves

186. As summer temperatures rise, heatwaves are projected to become more common and of longer duration. This is likely to cause an increase in heatstroke and in the incidence of cardiovascular, cerebrovascular, and respiratory diseases (Hales, Edwards, and Kovats 2003). In South Asia, heatwaves are associated with high mortality rates in rural areas and, also, among the poor and outdoor laborers (Chaudhury, Gore, and

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64 Authors in alphabetical order: Michael Engelgau, George Luber, Bryan Moy, Melissa Poulsen,
Ray 2000). A large number of heatwave-related deaths have been reported, mainly among vulnerable populations: the poor, the elderly, and laborers such as rickshaw pullers and agricultural workers (Lal 2003). A heatwave that took place in Andhra Pradesh, India, in 2003, with temperatures rising to over 48°C, caused more than 3,000 deaths (Government of Andhra Pradesh 2004).

187. **Rising temperatures are also expected to exacerbate the existing urban heat island effect, thus increasing the vulnerability of some urban environments to heat-related mortality.** The air temperature in cities can be up to 12°C warmer than that in surrounding suburban and rural areas due to absorption of heat by dark-paved surfaces and buildings; lack of vegetation and trees; heat emitted from buildings, vehicles, and air conditioners; and reduced airflow around buildings (CEIDH 2001). With five of the world’s megacities and many other urban areas situated in South Asia, rising city temperatures have the potential to impact the health of city dwellers and, particularly, of those residing in slums, who usually lack access to air conditioning and other adaptive strategies.

**Flooding**

188. **Greater intensity of rainfall events in South Asia is projected to increase the frequency of floods** (Cruz et al. 2007). These trends are already being seen. In 2007, floods resulting from monsoon rains killed over 2,000 people and displaced more than 20 million people in Bangladesh, India, and Nepal. In the Himalayas, the frequency of glacier lake outburst floods rose during the second half of the 20th century65 (WHO 2005).

189. **Flooding has been associated with direct and induced health risks.** Direct risks include death due to drowning and trauma from being hit by objects moving rapidly in the flood stream (Ahern et al. 2005). Often the greatest harm stems from induced impacts. Flooding creates an environment conducive to the transmission of disease. If floodwaters become contaminated with human or animal waste, the rate of fecal-oral disease transmission may increase, allowing diarrheal disease and other bacterial and viral illnesses to flourish. Fecal-oral transmission of diseases is of particular concern in regions where access to clean water and sanitation is limited. Increases in diarrheal disease, cholera, dysentery, and typhoid are of specific concern (Morgan et al. 2005). For example, flooding in West Bengal caused an outbreak of cholera-induced diarrhea that resulted in 276 deaths (Sur et al. 2000). Numerous studies have correlated previous floods in Bangladesh and India with outbreaks of diarrhea and respiratory infections (Siddique et al. 1991; Kunii et al. 2002; Biswas, Pal, and Mukhopadhyay 1999; Mondal, Biswas, and Manna 2001). Flooding can also contribute to increased vector- and rodent-borne diseases. Stagnant water provides breeding grounds for mosquitoes, potentially aiding the spread of malaria (Ahern et al. 2005). Other studies have correlated flooding in Bangladesh and India with outbreaks of rotavirus infections (Fun et al. 1991) and leptospirosis (Leptospirosis, India, 2000; Sehgal, Sugunan, and Vijayachari 2002; Karande et al. 2003; Karande et al. 2002).

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Tropical Cyclones and Storm Surges

190. South Asia is particularly vulnerable to cyclones, which often have devastating health consequences. Of all deaths resulting from the world’s 35 most deadly cyclones (from the years 1584 to 1991), India and Bangladesh accounted for 76 percent (Ali 1999). Two of the world’s three deadliest cyclones occurred in Bangladesh, causing 300,000 deaths in the 1970 cyclone and 138,000 deaths in the 1991 cyclone (Keim 2006). Rising sea-surface temperatures are expected to increase tropical cyclone intensity and the height of storm surges in the region (Ali 1999) (Box 9.1). Although the frequency of cyclones originating in the Bay of Bengal and the Arabian Sea has decreased, their intensity has increased since 1970, causing significant damage (Ali 1999; Lal 2001; Lal 2003) (see also Chapter 6).

Box 9.1 Storm Surges
Storm surges are bodies of water that are pushed toward the shore by swirling winds around a storm. The surges combine with normal tides to create the storm tide, which can increase the mean water level to heights that can impact roads, homes, and other critical infrastructure. Additional wind-driven waves can amplify the storm tide and cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides. Because much of the Southern Asian coastal zone lies less than three meters above mean sea level, the danger presented by storm tides is tremendous.


191. The main health risks associated with these phenomena are drowning and the spread of diseases. The majority of deaths occur at the impact phase of the cyclone due to drowning (Keim 2006). Chronic diseases are known to be exacerbated after cyclones, as cyclone-affected populations undergo intense physical and mental stress and have limited coping abilities (Hess, Malllafy, and Parkinson 2008). Unfortunately, disruptions in critical health services are highly likely following a cyclone (Keim 2006), leaving those suffering from chronic illness without care for indefinite periods of time. As in the case of flooding, other public health effects of cyclones include disease and illness associated with the loss of clean water, hygiene, and sanitation, particularly in densely populated shelters; increased pest- and vector-borne diseases; toxic exposures; and loss of shelter and population displacement that increase vulnerability to disease (Keim 2006).

Impacts Resulting from Climate-Induced Environmental Changes

192. Other human health impacts will stem from changes in the environment due to altered climatic conditions. In South Asia, environmental changes are likely to decrease agricultural productivity and alter ecosystems in ways that will lead to a reduction in the food supply and an increase in vulnerability to outbreaks of infectious diseases, both water and vector borne. The prevalence of diseases associated with air pollutants and aeroallergens is also predicted to increase with changes in the hydrologic cycle and increases in ambient temperature.
193. **The burden of climate-related disease is greatest for the poorest populations.** For example, per capita mortality rates from vector-borne diseases are 300 times higher in developing nations than in developed countries. This is due, in part, to the fact that vector-borne diseases are more common in warmer regions, but it also reflects poverty-related vulnerability. Individuals without adequate food, shelter, or health services are obviously more vulnerable to climate-related health risks.

**Water-Borne Diseases**

194. **Water-borne diseases, including cholera and diarrheal diseases such as giardiasis, salmonellosis, and cryptosporidiosis, could become more frequent in South Asia as an effect of a warmer climate** (Hales, Edwards, and Kovats 2003). Diarrheal disease is already a major cause of morbidity and mortality in South Asia particularly among children. It is estimated that one-quarter of childhood deaths are due to diarrhea (Zaidi, Awasthi, and de Silva 2004). Diarrheal diseases are largely attributable to drinking of unsafe water and lack of basic sanitation (Ezzati et al. 2004), and reductions in the availability of freshwater are therefore likely to increase the incidence of such diseases. Water shortages are already being seen in the region due to rapid urbanization and industrialization, population growth, and inefficient water use (Cruz et al. 2007). The shortage of freshwater will be aggravated by climate change. As previously discussed, flooding is also associated with increased incidence of diarrheal disease, particularly in regions where access to clean water and sanitation is limited: as floodwaters become contaminated with feces, fecal-oral disease transmission routes increase the incidence of diarrheal disease.

195. **Evidence is emerging to show that cholera outbreaks could increase in some areas.** Phytoplankton blooms, which are supported by warmer sea-surface temperatures, provide an excellent habitat for the survival and spread of infectious bacterial diseases such as cholera (Pascual, Bouma, and Dobson 2002). Evidence also shows that El Niño plays an important role in the interannual variability of endemic cholera (Pascual, Bouma, and Dobson 2002), and annual weather patterns also influence these patterns (Box 9.2). In Bangladesh there are two peaks of cholera cases, one in the spring, and a larger peak following the monsoon season. The onset of these epidemics is correlated with dry weather and warm water temperatures (Lipp, Huq, and Colwell 2002).
Box 9.2 Cholera and El Niño

A study by Rodo et al. (2002) determined a relationship between stronger El Niño events and cholera prevalence in Bangladesh over a 70-year period. The study used statistical methods to verify periods of historical cholera data dating back to 1893, enabling examination of the effect of nonstationary interannual variability possibly associated with climate change.

Since the 1980s there has been a marked intensification of the El Niño southern oscillation (ENSO), beyond that expected from the known shift in the Pacific basin temperature regime that began in the mid-1970s. The authors found the association of cholera incidence with ENSO in the earlier part of the study period (1893–1940) to be weak, while later in the period (1980–2001) a strong correlation emerged between intensified ENSO events and the incidence of cholera.


Vector-Borne Diseases

Several tropical vector-borne diseases are highly sensitive to climate change. Not only does temperature and precipitation influence pathogen development within vectors, but vectors themselves are also subject to climactic variability. Given the complexity of the interactions, the relationship between climate change and human illness caused by vector-borne pathogens is difficult to assess. However, studies suggest that climatic variability and extreme weather events, projected to occur in South Asia, may increase the occurrence of outbreaks and the spread of vector-borne diseases in some areas. Climate changes that induce changes in human behavior can also alter the patterns of vector-borne diseases; for example, changes in population density, water storage, irrigation practices, land use, construction techniques, and the use of air conditioning can all vary the way in which vectors and humans interact (Gage et al. 2008). Box 9.3 uses the example of migratory birds to illustrate the complex relationships that can exist between climate change, species population dynamics, and disease vectors.

Box 9.3 Climate Change, Migratory Birds, and Infectious Diseases

Several species of wild birds can act as biological or mechanical carriers of human pathogens and vectors of infectious agents. Many of these birds are migratory species that seasonally fly long distances through different continents. Climate change has been implicated in changes in the migratory patterns, reproductive penology, abundance, and population dynamics of several bird species, and a northward expansion of their geographic range in Europe. Two possible consequences of these changes for the dispersion of pathogens and their vectors are:

- Shifts in the geographic distribution of the vectors and pathogens due to altered distributions or changed migratory patterns of bird populations.
- Changes in the life cycles of bird-associated pathogens due to mistiming between bird breeding and the breeding of vectors, such as mosquitoes.

*Source:* Confalonieri et al. 2007.

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66 For example, arthropod vectors are exothermic; thus, fluctuating temperatures impact their development and reproduction. The distribution and abundance of zoonotic hosts to pathogens is also affected by climate.
197. **The threat from malaria is likely to be the greatest concern.** Malaria is already one of the most important vector-borne diseases in Bangladesh, India, and Sri Lanka. Changes in temperature and precipitation patterns have the potential to expand the geographic range of malaria into temperate and arid parts of South Asia (Hales, Edwards, and Kovats 2003). For example, in India the malaria distribution is expected to expand to higher latitudes and altitudes. Again, the relationship between climate and disease distribution is complex: in some areas increasing temperatures may restrict malaria transmission, but the extent is not known (Gage et al. 2008).

198. **Other diseases of concern are mosquito-borne dengue and chikungunya fever; parasitic diseases such as leishmaniasis, lymphatic filariasis, and onchocerciasis; and tick-borne diseases.** These have the potential to shift geographic ranges and the timing of peak abundance. Human plague, a vector-borne disease carried by fleas, has had devastating effects in South Asia historically, but it may also be heavily influenced by climatic factors. Rainfall and temperature are likely to influence the frequency of plague in the future by affecting the spread of rodents, which carry fleas. Murine typhus – an arthropod-borne infectious disease caused by *Rickettsia typhi* bacteria – is also transmitted by fleas; its survival and development is also heavily influenced by temperature and humidity (Gage et al. 2008).

**Diseases Associated with Air Pollutants and Aeroallergens**

199. **Air quality is significantly affected by weather conditions, including amounts of ground-level ozone, fine particulate matter, smoke, and aeroallergens.** In urban areas, warmer temperatures may result in the production of more ground-level ozone through conversion of carbon dioxide emissions. Ozone is known to have negative respiratory effects, particularly affecting individuals with asthma. Being home to five of the world’s megacities, South Asia will continue to be affected considerably by urban air pollution. Rising carbon dioxide levels and warmer temperatures have the potential to increase the amount of aeroallergens, such as pollen or spores, in the air. These airborne substances are characterized by their ability to cause an allergic response in humans (Githeko and Woodward 2003), which can in turn lead to an increase in the incidence of respiratory allergies.

**Impacts Resulting from the Consequences of Climate-Induced Economic Dislocation**

200. **As climate change alters the environment, a growing concern will be the health consequences of social and economic dislocation.** Specifically, the greatest health impacts associated with environmental decline in South Asia will be population dislocation and displacement.

201. **Population displacement is certain to occur, thus creating “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. Since many
cities are situated along the coasts, the coastal impacts of climate change could result in mass displacement of enormous urban populations.

202. **People displaced internally or across borders are vulnerable to disease** (St. Louis, Campbell-Lendrum, and Hess 2008). Displaced populations often end up living in refugee camps or urban slums; these are environments in which health suffers dramatically, as they are characterized by close quarters, poor sanitation, and insufficient food supply or livelihood opportunities. Mental health impacts of extreme climate events and disasters present another public health challenge. The most common consequences of severe weather events, such as floods and cyclones, include anxiety, depression, and post-traumatic stress disorder (Ahern et al. 2005; Keim 2006). Although the mental health impacts of disasters are not well studied, an assessment in Bangladesh did show increased behavioral problems among children following flooding (Durkin et al. 1993). These behavioral health effects may be the least apparent, but they are among the most long-term and debilitating public health impacts of natural disasters (Ursano, Fullerton, and Mcaugahey 1994; WHO 1992).

**Health Sector Strategies to Address Climate Change**

*Strategy Priorities*

203. **Because climate change is global in its impact, regional collaboration is necessary.** In an economically integrated world, infectious diseases can spread rapidly, far beyond their origins. The last decade saw the reemergence and regional spread of many climate-sensitive diseases such as cholera, Rift Valley fever in Africa and dengue in South Asia and Latin America. These outbreaks can cause major economic loss. Consequently, surveillance systems capable of detecting and tracking disease activity in a timely fashion, as well as able to dispense quick disease control responses, will be essential. This will need to go beyond infectious diseases to include monitoring of acute population migration, nutrition, mental health, air quality, and stress-related chronic disease. These surveillance and disease control systems need agility and flexibility to respond quickly to the health effects of heatwaves, flooding, and severe storms. They also need to be sensitive enough that they can detect changes in nutritional status linked to agricultural output declines and population migration.

204. **Strategies to minimize the health-related burden of climate change in South Asia need to focus on improving responses to ongoing issues that, in the future, will occur with greater frequency, intensity, and geographic range.** New and unique issues will likely be less apparent. A major component of a country’s climate change strategy will be the prioritization of actions (see following section). The urgency of the problem, the country’s current public health capacity, technology, and other limiting circumstances will all need consideration. Notwithstanding some successes, most of the countries in the region are now struggling with developing quality surveillance systems and provision of health services. Many issues, including higher-level ones such as migration, have challenged or slowed the development of the health sector. Thus, prioritizing climate change activities will need to consider this context as well as ongoing developments in other nonhealth sectors. Increases in the incidence of infectious diseases require health surveillance, preventive measures, and treatment efforts that are effective
and have the capacity to deal with increased workloads expected in the health and related sectors.

205. **Due to differences in vulnerabilities to climate change health effects, country-specific strategies will be essential.** However, all strategies will need to include health and environmental surveillance, building new systems or enhancing systems that are currently in place. It will be necessary to assess these needs and retool public and curative health-care services so they provide effective responses.

**Role of World Bank**

206. The proposed role of the Bank in assisting the countries in the region to tackle the health impacts of climate change and variability will be guided by the following priorities:

- It will play a convening role to highlight the health dimension of the climate change issue in the region.
- It will facilitate regional- and country-level efforts aimed at developing strategies and policy dialogues.
- It will provide technical assistance and knowledge products to improve health policy development.

207. Table 9.1 presents an action matrix for health sector response to climate change in South Asia, demonstrating the role of the World Bank in underpinning related activities at national and regional levels.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Purpose</th>
<th>Bank Role</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of the health implications of climate change</td>
<td>To improve policy and decision makers’ understanding of the implications of climate change and the need for strategic planning</td>
<td>Analytic and advisory assistance for impact assessments and review of the evidence base</td>
<td>Some common themes will emerge across the region and specific priority issues will emerge for each country</td>
</tr>
<tr>
<td>Disease surveillance</td>
<td>To improve government’s ability to detect and monitor injuries, environmental exposures, infectious diseases, and chronic diseases that are sensitive to climate change</td>
<td>Technical assistance, lending and financing</td>
<td>Country-specific priority issues need to be addressed first. Countries are already struggling with developing adequate disease surveillance systems outside climate change issues</td>
</tr>
<tr>
<td>Response capacity</td>
<td>To improve the population-base public health awareness, interventions, and health system capacity for climate change-sensitive issues and diseases</td>
<td>Technical assistance, lending and financing</td>
<td>Country-specific priority issues need to be addressed first. Countries are already struggling with developing adequate public health messages and health services delivery</td>
</tr>
<tr>
<td>Current and future impact of climate change</td>
<td>To assess current health burden due to climate change and to project it into the future, such that it will inform policy directions</td>
<td>Technical assistance and AAA</td>
<td>This should be related to increasing awareness. However, the focus is more on information to drive prioritization and policy decisions</td>
</tr>
<tr>
<td>Country and regional strategy</td>
<td>To develop a plan with short-, medium-, and long-term country strategies and to integrate with regional strategies</td>
<td>Technical assistance, convening role, facilitating national and regional policy dialogues</td>
<td>It will be critical to integrate regional issues across countries and create synergy where common issues exist</td>
</tr>
</tbody>
</table>
Chapter 10. The Social Dimensions of Climate Change

The Human Face of Climate Change

208. **Climate change is the defining human development challenge of our time.** Climate change threatens to stall poverty reduction and the hard-earned progress made in achieving the Millennium Development Goals (MDGs) (Box 10.1). In South Asia, the early signs of dangerous climate change are already threatening the lives, livelihoods, health and well-being of millions, especially the poor and vulnerable who lack the financial, technical, human and institutional resources to adapt. Future changes in precipitation, incidence of extreme events, sea level and glacial cover are expected to affect food security, nutrition, access to water, sanitation, shelter, health, labor productivity, productive sectors and household incomes. These changes may exacerbate the already low levels of human development in the region (Table 10.1).

Table 10.1 Human Development and Vulnerability in South Asian Countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>2201</td>
<td>36</td>
<td>139</td>
</tr>
<tr>
<td>Bhutan</td>
<td>--</td>
<td>--</td>
<td>134</td>
</tr>
<tr>
<td>India</td>
<td>2417</td>
<td>34.7</td>
<td>127</td>
</tr>
<tr>
<td>Nepal</td>
<td>2264</td>
<td>37.7</td>
<td>136</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2462</td>
<td>13.4</td>
<td>135</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>2411</td>
<td>6.6</td>
<td>93</td>
</tr>
</tbody>
</table>


209. **Climate change affects everyone, but it does not affect everyone equally.** Vulnerability is dictated by both individual and social factors. The livelihood context, location, level of income, education, asset holdings, gender, age, social class and ethnicity all combine to determine vulnerability and coping abilities. Different social groups will be able to adapt and respond differently to climate change depending on the scope and strength of their formal and informal coping mechanisms, and the level of societal influence. Within social groups too, some may be more vulnerable than others depending on their economic status, level of education, and physical location.

210. **Those most heavily dependent on natural resources and exposed to multiple risks of climate change are the most vulnerable – the rural and urban poor, the women, children, and indigenous peoples** – and as a result, they will suffer disproportionately from the expected adverse impacts of climate change. Poor women are vulnerable because of socially constructed gender roles and behaviors, while the rural poor and indigenous people with their greater dependence on climate sensitive sectors

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67 Authors in alphabetical order: Nilufar Ahmed, Hari B. Dalal and Samantha L. Forusz.
and lower asset holdings are more exposed to climate shocks and also have limited coping capacity. Urban slum dwellers, with poor amenities and access to basic sanitation are the first to suffer from damages to assets, spread of disease and loss of lives as the incidence of flooding, extreme events become more prevalent in the future.

**Box 10.1 Potential Impacts of Climate Change on MDGs**

<table>
<thead>
<tr>
<th>Millennium Development Goal</th>
<th>Examples of link with climate change</th>
</tr>
</thead>
</table>
| Eradicate extreme poverty and hunger (Goal 1) | - Climate change is projected to reduce poor people’s livelihood assets such as health, access to water, homes, and infrastructure  
- Climate change is expected to alter the path and rate of economic growth due to changes in natural systems and resources, infrastructure, and labor productivity. A reduction in economic growth directly impacts poverty through reduced income opportunities  
- Climate change is projected to alter regional food security. In Africa, in particular, food security is expected to worsen |
| Health-related goals:  
  - Combat major diseases  
  - Reduce infant mortality  
  - Improve maternal health (Goals 4, 5 and 6) | - Direct effects of climate change include increases in heat-related mortality and illness associated with heat waves (which may be balanced by less winter cold-related deaths in some regions)  
- Climate change may increase the prevalence of some vectorborne diseases (for example, malaria and dengue fever), and vulnerability to water-, food-, or person-to-person borne diseases such as cholera and dysentery  
- Children and pregnant women are particularly susceptible to vector- and water-borne diseases. Anemia – resulting from malaria – is responsible for a quarter of maternal mortality  
- Climate change will likely result in declining quantity and quality of drinking water, which is a prerequisite for good health, and it may also exacerbate malnutrition – an important cause of ill health among children – by reducing natural resource productivity and threatening food security, particularly in Sub-Saharan Africa |
| Achieve universal primary education (Goal 2) | - Links to climate change are less direct, but loss of livelihoods assets (social, natural, physical, human and financial capital) may reduce opportunities for full-time education in numerous ways. Natural disasters and drought reduce children’s available time (which may be diverted to household tasks), while displacement and migration can reduce access to education opportunities |
| Promote gender equality and empower women (Goal 3) | - Climate change is expected to exacerbate current gender inequalities. Depletion of natural resources and decreasing agricultural productivity may place additional burdens on women’s health and reduce time available to participate in decision-making processes and income-generating activities  
- Climate-related disasters have been found to impact more severely on female-headed households, particularly where they have fewer assets to start with |
Ensure environmental sustainability (Goal 7)

- Climate change will alter the quality and productivity of natural resources and ecosystems, some of which may be irreversibly damaged, and these changes may also decrease biological diversity and compound existing environmental degradation.

Global partnerships

- Global climate change is a global issue and response requires global cooperation, especially to help developing countries to adapt to the adverse impacts of climate change.

**Vulnerable Groups to Climate Change**

211. The impacts of climate change will not be gender-neutral. Climate change affects women and men differently because of unequal power relations and differential access to resources and economic opportunities. Through much of South Asia women’s labor force participation rate is among the lowest in the world and varies between 7 to 40 percent. Wage disparities are also striking. On average, women earn 30–50 percent less than men. Though primary enrolment has achieved, gender parity dropout rates for girls across the region are higher than those for boys; and literacy rates of women are lower than men. Low levels of education, poor health, and limited access to resources and employment not only depress women's quality of life, but also limit productivity and hinder and growth. The so-called “benign neglect” of girls has led to large gender based health disparities. Female child mortality rates are typically higher across all of South Asia (see Table 10.2). This is a consequence of nutritional deficiencies, lack of preventive care (specifically immunization), and delays in seeking medical intervention (Fikre and Pasha 2004). Contrary to global norms, in some states in India and Pakistan, there are less women than men. Climate induced shortages would likely accentuate these prevailing inequalities, suggesting an urgent need to address the underlying socio-economic drivers of gender disparities.

<table>
<thead>
<tr>
<th>Country</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>71</td>
<td>73</td>
</tr>
<tr>
<td>Bhutan</td>
<td>93</td>
<td>92</td>
</tr>
<tr>
<td>India</td>
<td>87</td>
<td>95</td>
</tr>
<tr>
<td>Maldives</td>
<td>38</td>
<td>43</td>
</tr>
<tr>
<td>Nepal</td>
<td>81</td>
<td>87</td>
</tr>
<tr>
<td>Pakistan</td>
<td>105</td>
<td>115</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>20</td>
<td>16</td>
</tr>
</tbody>
</table>

**Table 10.2 Probability of Dying Under Age 5 (per 1000)**


68 Girls are married off at a young age and about 50 percent have their first child by age 20. In many parts of the region – notably India and Bangladesh – dowry puts pressure on families of girls to marry them early, leading to preference for sons. In some countries, deaths of women associated with childbirth are among the highest in the world. Contrary to demographic norms, more girls than boys die at a young age in some countries. Legal and judicial systems, as well as law enforcement mechanisms, have failed to address the high incidence of violence against women in both private and public domains.
212. **Climate change would place additional burdens on women by altering roles and tasks they perform.** Low-caste, tribal, and poor rural women that depend on the natural environment for water, fuel, fodder, and food are the ones that would be most affected by climate induced changes. As crop yields decline and natural resources become scarce, women’s workloads increase, jeopardizing their chances to work outside the home or attend school. In times of drought, they will also have to spend more time performing another typical female responsibility – carrying, purifying and supplying the family’s water.

213. **Rural women are also disproportionately affected by natural disasters.** In natural disasters female mortality vastly outnumbers that of males. Women accounted for 90 percent of the 140,000 people killed in the 1991 cyclone in Bangladesh. Likewise in the Asian tsunami of 2004 more women than men perished across India and Bangladesh (Kumar 2002, Aguilar 2004). Social exclusion is gendered in ways that make women more vulnerable to natural disasters. Cultural and behavioral norms often restrict women’s mobility, while economic inequality such as the lack of assets, shelter and resources make them more susceptible to disaster related physical impacts. Effective adaptation strategies would need to address these fundamental gender disparities.

214. **The rural poor whose livelihoods are based on agriculture are another group that will be directly impacted by climate change.** Crop simulation models suggest that by the middle of the 21st century, the output of major crops in central and south Asia could fall by as much as 20-30 percent in some scenarios. The yields of key cash crops such as tea, rubber, and coconut would also be adversely affected, though the magnitude is unknown (MENR 2000). The consequences would be particularly severe for women and children. Through much of South Asia custom dictates that male members of the household are favored in the distribution of food, suggesting the possibility of increased nutritional deficiencies amongst women and children. This cultural phenomenon is responsible for chronic nutritional deficiencies among women. For example, in Bangladesh, the nutritional intake of women is 88 percent that of men. In Nepal, approximately, 28.7 percent of rural women have a body mass index below the cut-off point and 60 percent of women in the region suffer from anemia (IFAD 2000). The prevalence of anemia in women aged 13-39 years is the highest in South Asia (see table 10.3). Climate change could exacerbate the profound intra-household inequalities in food consumption.

**Table 10.3 Prevalence of Anemia in Women Aged 13-49 Years, 1992**

<table>
<thead>
<tr>
<th>Region</th>
<th>Non-pregnant (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Saharan Africa</td>
<td>40</td>
</tr>
<tr>
<td>Near-East and North Africa</td>
<td>31</td>
</tr>
<tr>
<td><strong>South Asia</strong></td>
<td><strong>64</strong></td>
</tr>
<tr>
<td>South-East Asia</td>
<td>47</td>
</tr>
<tr>
<td>Middle America and Caribbean</td>
<td>27</td>
</tr>
<tr>
<td>South America</td>
<td>21</td>
</tr>
</tbody>
</table>

215. **In semi-arid areas of South Asia, households dependent upon pastoral lands for livelihoods face the threat of food and water insecurity and malnutrition.** Loss of soil moisture due to temperature increases and inadequate precipitation will reduce water supplies and intensify foraging and grazing activities which degrade soil quality and land productivity. The drylands of Pakistan, India and Afghanistan are most susceptible to the risks of more intense drought and desertification. Even moderate growth in population will increase the competition for scarcer water and pasture resources. In other areas, new disease burdens will be brought by higher temperatures and more erratic rainfall pattern. The incidence of climate sensitive diseases such as malaria is already high and could emerge as leading cause of child mortality in the future.

216. **Indigenous people, with their dependence on forests and natural resources are especially sensitive to climate variations.** Nearly half the indigenous peoples in the world live in South Asia (around 100 million). They are also among the poorest in the world. Indigenous livelihoods and cultures are closely intertwined with ecosystems upon which they depend. They are therefore especially vulnerable to climate induced fluctuations in ecosystem productivity. In addition, many of the proposed mitigation measures, such as the replacement of forests with plantations and biofuel crops, have the potential to undermine the customary rights to lands and natural resources of indigenous peoples.

217. Recognition of indigenous peoples’ customary rights and their inclusion as key partners and decision makers in the design and implementation of mitigation and adaptation interventions is necessary to enhance coping capacities. They should be recognized as repositories of traditional ecological knowledge and customary institutions passed down over many generations which has potential to complement and enrich existing scientific knowledge of climate change and coping mechanisms. Interventions also need to recognize that indigenous people, with their limited human capital, may have limited capacity to adapt to changes in livelihood opportunities and economic circumstances.

218. **In the coastal areas communities will have to confront storms of greater magnitude and frequency, sea water level and ocean acidity.** Most vulnerable are those with poor climate-resistant dwellings and a high dependence upon fishing livelihood and eco-tourism. As an example the communities of the Sundarban, among the poorest of the poor in the region could be trapped to a systemic cycle of poverty as seasonal flooding and natural disasters erode their coping capacities, damage their settlements and undermine livelihoods.

219. **Climate change may also induce forced migration from rural areas.** Distress migration patterns are typically shaped by assets, community social capital, networks and support from local institutions. The immediate impacts of climate stressors such as sea level rise, increased flooding and prolonged droughts would be on local communities and ecosystems. Ripple effects could be felt beyond the borders of these countries if there is large scale displacement of populations. Migration could increase tension and competition for resources in urban areas, with competition for limited space in already crowded cities. Poor households are usually forced into urban slums that are vulnerable to climate risks and where there is limited access to safe water and sanitation and high rates of child mortality. The gender dimension of migration is also significant. Male members
of households are typically more mobile and leave vulnerable areas in search of employment opportunities, resulting in social disruption. In some areas the status of women is defined in relationship to their male partners. The absence of male members of the family may add to already existing barrier to access public services and health care facilities, often located at a distance from local villages.

Social Development Adaptation Strategies

220. **Strengthening Local Governments and Communities.** In order to increase their preparedness to adapt and mitigate the impacts of climate change, local governments and communities will need to build their capacity to raise awareness, engage stakeholders, undertake adaptation and resilience building programs, as well as deliver critical services in post-disaster settings. Robust governance mechanisms will help ensure the effective delivery of adaptive responses, strengthen a community’s capacity to cope, and mitigate the impacts of a climate related shock. Cohesive communities are better equipped to respond to external shocks, including the growing risks associated with climate change. Human society has an inherent quality to work collectively and respond to any urgent problem or crises. As most rural societies in South Asia are community-based social capital and social networks can play a role in building climate resilience. Not only are communities with strong social capital more climate resilient, but they can also play a role in promoting local government accountability. Finding ways to strengthen communitarian responses to climate crises would provide an effective way of building climate resilience. Already existing approaches that promote decentralized, participatory decision-making and accountability, can be utilized for climate change related initiatives to strengthen social capital, improve livelihood options, and increase food security. Local institutions and other first responders will need to deliver or facilitate short-term relief and safety net measures. Close institutional coordination and partnerships are needed among public and civil society institutions. As part of the process, poor and vulnerable groups will need to strengthen their voice and effectively use their political capital to demand access to services and support.

221. **Promoting Consultation and Participation.** In crisis situations, communication systems play a critical role. The poor and vulnerable people are often the last ones to understand what is happening and may be excluded for reasons of caste, ethnicity, gender, and education, from public dialogue. As over reliance on one-way communication can result in the exclusion of vulnerable groups from critical information. Work on the promotion of participation among communities and Civil Society Organization, can become a useful tool in diversifying the available avenues of communication.

222. **Managing Resettlement and Rehabilitation.** In South Asia, estimates show that with just a 1 to 2 degree increase, in a country like Bangladesh, more than 35 million people may need to be physically relocated. The same is also true for countries with expanded valleys or plains like India, and to some extent Pakistan, particularly in its central province (Karachi Bay). There are a number of likely climate change scenarios that could result in the need for mass involuntary resettlement and economic rehabilitation. Multisectoral experience in helping governments and other agencies design and implement context specific resettlement and rehabilitation plans (under
Operational Policy 4.12), across the region, can be effectively applied to the resettlement and rehabilitation needs associated with climate change.

223. **Enhancing resilience of Indigenous Peoples in culturally appropriate ways.** Through a process of Free Informed Prior Consultation, Social Development has been directly involved in ensuring that Indigenous Peoples (under Operational Policy 4.10) participate in and benefit from Bank-funded operations in a culturally appropriate way, and in addition, that any adverse impacts are avoided, or where not feasible, minimized or mitigated. Experience in safeguarding the assets and indigenous knowledge of these communities, as well as knowledge of how these communities have adapted to changes in their external environment over time, would be a valuable resource in designing adaptation plans or interventions that will involve indigenous and traditional communities as key partners.

<table>
<thead>
<tr>
<th>Box 10.2 Good Practice Example: Community-Level Involvement in Jharkhand, India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kanke, a small village in Ranchi District in Jharkand, India serves as an example of how social capital aids in climate change adaptation. In the 1970s, state government initiated a small irrigation project, which after three years of implementation, became non-functional. Non-participation of community in the planning and implementation stage of the project was cited as the main reason behind the project failure. In 2001, senior citizens from Kanke approached the state government officials and expressed a need of an irrigation project. They proposed their own plan and mechanism of water distribution. Except for the cost of a water lifting device and conduit pipes they did not seek any other external assistance. With their own local knowledge, villagers implemented the project themselves by forming a ‘village development committee’. Impact study of this project shows that crop production increased and almost stabilized.</td>
</tr>
<tr>
<td>Source: Prasad et al. 2007.</td>
</tr>
</tbody>
</table>

224. **Filling knowledge gaps.** In addition to operational support, there is a need to undertake research and analytical work to better assess the socioeconomic implications of climate change. Further work is needed to improve our understanding of Social Risk Management, Migration, Social Capital, Conflict Management, etc. – areas where local and country knowledge could be effectively applied – and their impact on helping the poorest and the most vulnerable adapt to and mitigate the effects of climate change.
Table 10.4 Climate Change Risks and World Bank’s Potential Role

<table>
<thead>
<tr>
<th>Risks</th>
<th>Priority Response</th>
<th>World Bank’s Potential Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased poverty, vulnerability and nutrition insecurity</td>
<td>Awareness raising, social mobilization and capacity building</td>
<td>Financial and technical support for:</td>
</tr>
<tr>
<td>Social conflict</td>
<td>Education and skill training for women, IPs and other vulnerable groups for reducing agricultural dependence.</td>
<td>Promoting equity, inclusion, rights and livelihoods through targeting vulnerable groups and enhancing voice, decision making and capacity of the vulnerable to adapt.</td>
</tr>
<tr>
<td>Aggravation of social exclusion and inequity</td>
<td>Promotion of SHGs; and enhancing access to microfinance and banking services</td>
<td>Partnership with CBO, CSO, NGOs and private sector for capacity-building.</td>
</tr>
<tr>
<td>Indebtedness in climate vulnerable areas</td>
<td>Strengthening public-private partnerships and social capital of vulnerable groups, their access and decision making</td>
<td>Governance, strengthening institutions and social capital by initiating parallel capacity building and social accountability initiatives.</td>
</tr>
<tr>
<td>Migration</td>
<td>Promotion of community based asset building and sharing of natural resources</td>
<td>Research in areas of climate induced migration and conflict</td>
</tr>
<tr>
<td>Increased urban slum population</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 11. Ecosystems and Biodiversity

South Asia’s Rich Biodiversity Under Stress

225. **South Asia is endowed with an exceptional array of biodiversity.** The region’s biodiversity is reflected in varied biomes and the wide range of habitats within its ecosystems. Its geographical expanse include several diverse ecosystems, such as the mountains of the Himalayan Hindu Kush, the rangelands of Bhutan, the Thar Desert, the high-altitude freshwater lakes of Nepal, the Deosai plains in Kashmir, the extended contiguous mangrove swamps of India and Bangladesh, and the coral reefs and atolls of Maldives. Forests range from tropical, subtropical, and coastal to temperate; and the deserts from hot to cold. Bengal tigers, snow leopards, sloth bears, rhinos, elephants, red panda, wild boar, hoofed animals, birds, and reptiles dwell in these forests, savannas, and deserts. The unique topography and climate has shaped the remarkable variation within the forests, rangelands, deserts, wetlands, freshwater areas and coasts of South Asia. These ecosystems occupy about 3.6 percent of the world’s area but contain 16 percent of floral and 12 percent of faunal species found in the world (UNEP 2001).

226. **This rich ecological landscape has been integral to the lives, well-being, and livelihoods of millions of people.** The ecosystems and their diversity have sustained the supply of food, water, fodder, fuelwood, clothing, shelter, medicine, and energy. Biodiversity is the foundation of agriculture and rural livelihoods. The region’s livelihoods are derived in large part from forestry, fishery, and tourism, and the services performed by its ecosystems support life (through soil formation, nutrient cycling, primary production, oxygen production, and habitats) and regulate processes crucial to well-being (air quality, climate, water flow, soil retention, water purification, and biological and disease control). Biodiversity has thus been crucial to ensuring food security, income, nutrition, access to improved water, good health, safety, and the environmental sustainability of the region. The ability to adapt to changes in the environment is also determined in great part by the variation and resilience of species and ecosystems. In addition ecosystems play a crucial role in absorbing greenhouse gas emissions. Appropriate management of natural systems can therefore play a critical role in contributing to cost effective adaptation as well as reducing greenhouse gas emissions.

227. **South Asia’s natural resources face tremendous pressure from rapid population growth.** Economic expansion and a burgeoning population have led to unsustainable extraction of natural resources and accelerating levels of air and water pollution. Poverty, high resource dependence, and policy failures have lowered resource productivity with negative implications for development. About 10–30 percent of the region’s faunal species are currently under threat of extinction. Of concern is the unsustainable resource extraction and pollution in previously remote areas with relatively large numbers of endemic species. Three global biodiversity hotspots have

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69 Authors in alphabetical order: Rahimaisa Abdula and Anupam Joshi.

70 About 3 gigatons of CO₂ are absorbed by terrestrial ecosystems, which is about half the amount released by fossil fuel combustion.
been identified in the region: the Western Ghats of India and Sri Lanka and the Eastern Himalayas. Table 11.1 gives a profile of the rich biodiversity of SAR countries.

Table 11.1 Biodiversity Profile of SAR Countries

<table>
<thead>
<tr>
<th></th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Maldives</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Area (% of land area)</td>
<td>1.3</td>
<td>6.7</td>
<td>68</td>
<td>22.8</td>
<td>3.3</td>
<td>25.4</td>
<td>2.5</td>
<td>29.9</td>
</tr>
<tr>
<td>Deforestation (average annual %; 1990-2005)</td>
<td>2.7</td>
<td>0.1</td>
<td>-0.3</td>
<td>-0.4</td>
<td>0</td>
<td>1.9</td>
<td>1.9</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Conservation Status**

<table>
<thead>
<tr>
<th>% Threatened Animal Species</th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Maldives</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically Endangered (all species)</td>
<td>3</td>
<td>10</td>
<td>3</td>
<td>72</td>
<td>1</td>
<td>4</td>
<td>8</td>
<td>129</td>
</tr>
<tr>
<td>Endangered (all species)</td>
<td>5</td>
<td>28</td>
<td>12</td>
<td>161</td>
<td>3</td>
<td>18</td>
<td>16</td>
<td>127</td>
</tr>
<tr>
<td>Vulnerable (all species)</td>
<td>22</td>
<td>51</td>
<td>32</td>
<td>240</td>
<td>7</td>
<td>52</td>
<td>50</td>
<td>159</td>
</tr>
<tr>
<td>Endemic (all species)</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>276</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>361</td>
</tr>
</tbody>
</table>

**Globally Threatened Species Present in the Country**

<table>
<thead>
<tr>
<th></th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Maldives</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammals</td>
<td>14</td>
<td>23</td>
<td>22</td>
<td>86</td>
<td>0</td>
<td>31</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Birds</td>
<td>12</td>
<td>23</td>
<td>16</td>
<td>73</td>
<td>0</td>
<td>27</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Reptiles</td>
<td>1</td>
<td>21</td>
<td>0</td>
<td>25</td>
<td>2</td>
<td>6</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Amphibians</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>66</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>Fish</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>35</td>
<td>9</td>
<td>0</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>Plants</td>
<td>1</td>
<td>10</td>
<td>7</td>
<td>166</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>238</td>
</tr>
</tbody>
</table>

**Protected Areas**

<table>
<thead>
<tr>
<th></th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>India</th>
<th>Maldives</th>
<th>Nepal</th>
<th>Pakistan</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nationally Protected Area (% of land area)</td>
<td>0.3</td>
<td>0.5</td>
<td>25.6</td>
<td>5.3</td>
<td>0</td>
<td>18.6</td>
<td>9.5</td>
<td>27.3</td>
</tr>
<tr>
<td>Total Protected Areas (number)</td>
<td>9</td>
<td>26</td>
<td>9</td>
<td>718</td>
<td>25</td>
<td>30</td>
<td>234</td>
<td>278</td>
</tr>
</tbody>
</table>

* Includes all IUCN category reserves (IA, IB, II, III, IV, V and VI), Ramsar Wetlands, UNESCO-MAB Reserves, World Heritage Sites and sites that are protected but do not fall in any IUCN categories.

**Sources:** The World Bank’s The Little Green Data Book 2008; 2008 International Union for Conservation of Nature (IUCN) Red List of Threatened Species (www.iucnredlist.org), accessed on January 27, 2009; World Biodiversity Database (WBDB) 2008, joint project of BirdLife International and Conservation International; and World Database on Protected Areas (WDPA) 2007, joint project of UNEP and IUCN 2007, managed by UNEP World Conservation Monitoring Centre (UNEP-WCMC) and IUCN World Commission on Protected Areas (WCPA).
Threats of Climate Change upon Ecosystems and Biodiversity in South Asia

228. Climate change will increase the damage from current risks and present new challenges to the sustainability of ecosystems and their services. The increased precipitation (predicted for many areas) and incidence of extreme events under future climate change will magnify existing vulnerabilities. Increased incidence of rapid onset disasters will threaten vulnerable species, while slow onset ones will prolong existing stress. Sea level rise will induce greater flooding and exacerbate the damage to coastal ecosystems. The extent of damage from sea level rise will span the coastal wetlands, aquifers, freshwater systems, forests, and low-lying plains, while the costs of reduced glacial cover include biodiversity loss in the mountain and low-lying ecosystems of the Hindu Kush Himalayan range. New issues will also arise from expected changes in seawater chemistry; for example, the increased acidity levels in the oceans due to warmer sea temperature will slow down coral reef formation, disturb the marine food chain, and adversely affect fisheries.

229. Climate change will affect all ecosystems and intensify many existing stresses caused by unsustainable resource use. The changes in precipitation, sea level, seawater chemistry, incidence of extreme events, and rate of de-glaciation will modify the conditions that shape ecosystems and biodiversity. These climatic changes can disrupt ecosystem functions and distort the growth, size, composition and roles of species (IPCC 2002). The most vulnerable ecosystems are the mountain biota, rangelands, and coastal and marine ecosystems. Endemic mountain species, biota restricted to islands or coastal areas, and species with small populations, limited climatic ranges, and restricted habitat requirements are most in danger of extinction. There are more subtle impacts too such as the reduced capacity of ecosystems to perform sequestration that could aggravate the impacts of climate change (IPCC 2007c). There are significant knowledge gaps and a limited understanding of the impacts. Accordingly the following sections provide an overview based largely on global assessments.

Risks to Terrestrial Ecosystems

230. The biodiverse forests, rangelands, and deserts of South Asia support basic human needs and livelihoods. Forest accounts for about 20–30 percent of the total land area of India, Nepal, and Sri Lanka and about 68 percent in Bhutan (Table 11.1). These are important to energy, housing, and the livelihoods of many people in rural South Asia. Savannas and dry forests are grazing areas for the region’s large population of livestock, which is essential to food security and agricultural draught.

231. Climate change will affect the vegetation, productivity, and biodiversity of these ecosystems. Forests and rangelands that receive increased precipitation relative to evapo-transpiration will experience primary productivity gains. But in the long run as critical thresholds are reached, productivity losses could ensue. Biodiversity loss occurs during the transition over the medium term and during the long run collapse of forest types. The critical impacts on South Asia’s terrestrial ecosystems include transformations in the areas supporting large habitats, such as the savanna of India, the highly endemic areas of the Hindu Kush, and the drylands at threat of desertification.
Vegetation Shifts and Loss of Biodiversity in Mountain and Forest Ecosystems

232. While climate change could improve forest productivity in the short to medium term, the resulting transformation of vegetation systems is likely to result in a loss of biodiversity and productivity as critical thresholds are reached. The IPCC projects that carbon fertilization will lead to net primary productivity gains in the medium term (IPCC 2007c), with the gains experienced in some forest types outweighing the losses in others. \(^7\) Vegetation types will shift to higher elevations as a result of global warming, and some vegetation types may disappear in the process, together with dependent species and ecosystems with strict climate niches (CBD 2003; IPCC 2007c).

233. In India, climate change is projected to lead to loss of savanna cover. Vegetation is expected to shift towards wetter types in the northeast and to drier types in the northwest of India by 2085. This will transform the currently dominant land cover into tropical dry forest. Wildlife adapted only to the savanna landscape could be threatened by loss of habitat. Net primary productivity gains are expected for many vegetation types, but reduction in population in several species, and extinction of some species, will inevitably occur. The highly endemic areas of the Western Ghats and central Himalayas are projected to experience forest dieback and loss of biodiversity in the long run (Ravindranath et al. 2006).

234. In the high altitude Himalayan Hindu Kush, climate change will transform vegetation and reduce biodiversity of the mountain ranges. Climate change is expected to lead to a northward shift of vegetation and to the reduction and loss of alpine tundra cover in the dry temperate and temperate mountains of the region. The changes in precipitation in the dry temperate mountains of Pakistan are expected to expand conifer coverage at the expense of alpine vegetation even before the mid-century (Ministry of Environment 2003). The upward migration of plants in the Himalayas could lead to similar reduction in alpine meadows, thus impacting the habitats of several high altitude mammals including wild sheep, goat, antelope and cattle (Garg 2005).

235. Changes in forest composition and density will inevitably alter the carbon budget with uncertain feedback effects on the regional climate. Shifts in and losses of vegetation cover can distort the carbon uptake of terrestrial ecosystems (IPCC 2007c). The growth in tropical forest predicted in some areas in India is expected to increase carbon sequestration in the medium run (White et al. 1999). In areas where forests shift to drier types, such as in Sri Lanka, carbon uptake could decline. The modification in carbon budget in turn transforms the feedbacks to regional and global climate (CBD 2003). Increased temperature will also raise the risks from fire outbreaks that could destroy many forest species and alter the carbon budget (IPCC 2007c). Forest fire is one of the biggest threats to the forests of Bhutan. There are on average 50 forest fires reported every year in the country. About 40 percent of its forest area is identified to be susceptible to frequent fire. Forest fires also degrade the soil, release stored carbon and emit other greenhouse gases (IPCC 1998).

\(^7\) IPCC (2007c) predicts some reversal of forest productivity in the later part of the century.
Threat of Desertification in Rangelands and Semi-deserts

236. Climate change poses a threat of desertification in drylands expected to undergo increased aridity. South Asia’s arid and semi-arid rangelands provide livelihood for millions of herders and pastoralists in Afghanistan, India, and Pakistan (Ministry of Environment 2003). The deserts of the Indus valley and Thar support population densities of about 150 per square kilometer – almost five times the global average for desert areas. Though projections of the impacts of climate change on the arid areas are uncertain, there is growing consensus that El Niño southern oscillation events in the Pacific basin are likely to increase the incidence and duration of droughts in drylands and deserts. In most deserts and rangelands, the combined effects of higher evapotranspiration, lower precipitation, and more intense and protracted droughts will reduce soil moisture and promote desertification. Fewer flood events with greater intensity will also induce aridity as less moisture is infiltrated into soils (UNEP 2006).

237. Future changes will likely be most severe in desert margins and desert montane areas where the principal arid rangelands are located (UNEP 2006). The rangelands and semi-deserts of Afghanistan, India, and Pakistan are vulnerable due to the projected increase in the intensity and frequency of drought in the future. Projections suggest that the Thar Desert will expand over the coming century due to local shortfall in precipitation and increased aridity in its northeast and eastern neighboring areas (Goswamy and Ramesh 2007). Desertification has also been identified as a major threat to Pakistan’s biodiversity (IUCN 2002). Deserts and rangelands fed by melting snow or ice, such as those in India and Pakistan, will be susceptible to future desiccation of rivers. As the volume of snowpack diminishes, rivers will shift from glacial fed to pluvial.

The changes in desert, rangelands, and savanna cover brought about by climate change will feed back to regional and global climate. On balance, savannas and grasslands are likely to show reduced carbon sequestration capacity given the greater loss in soil respiration induced by warming, fire regime changes, and rainfall variability. Shifts of rangelands to deserts could release stored carbon, but will have uncertain effects upon regional and global climate (MEA 2005). There are however potential gains that may arise from enhanced woody coverage resulting from carbon fertilization. Desert albedo in areas projected to undergo greater aridity and loss of vegetation will also enhance global cooling effect (UNEP 2006). However, there are uncertainties in the feedback of desert dusts upon global climate.

Challenges Facing Freshwater and Marine Ecosystems

238. Freshwater and marine ecosystems are crucial to the well-being and survival of the region’s population and are under threat from multiple stressors due to climate change. The water resources of South Asia are the most important economic asset threatened by climate change. They supply water to millions of people and remain an important input to economic survival and prosperity. The wetlands of South Asia provide food, livestock grazing, fodder, fuelwood, timber, medicine, transport, energy, and outdoor recreation. Coral reefs on the other hand match tropical rainforests in biodiversity and are important sources of revenue from tourism. Coral reefs and mangroves also protect hinterlands against coastal erosion, sedimentation, floods, and
storm surges. Climate change will alter these ecosystems through changes in hydrology, sea level, sea temperature, and water chemistry.

**Multiple Stresses Threatening Freshwater, Wetlands, and Coastal Resources**

239. **Freshwater and inland wetlands will be affected by the likely impacts of sea level rise, glacial melt, and extreme weather events.** Of all ecosystems, freshwater aquatic resources appear to have the highest proportion of species threatened with extinction by climate change (MEA 2005). Freshwater resources and species in low-lying plains can be affected by sea level rise through salt water intrusion and by flood through inundation. In semi-arid areas, lower seasonal stream flow and drying up of lakes can have profound effects upon biodiversity and ecosystem services (IPCC 2007c). The drying of stream beds and lakes for extended periods could reduce ecosystem productivity due to the impacts of lower oxygen levels on aquatic habitats and water quality. The endorheic lakes in arid and semi-arid areas, such as those in the deserts of Afghanistan, could disappear as a result of climate change (IPCC 2008).

240. **Among the multiple stresses, drought presents the major challenge to the sustainability of freshwater and inland wetlands services** (CBD 2003). Most delta regions in India and Pakistan where shortfall in precipitation and drought have already led to parchedness and degradation of wetlands, are projected to face further evapotranspiration. Climate change could erode their ability to regulate water quality and quantity (Ramsar Convention and UNFCCC 1999). The magnitude and possible timing of these impacts is unknown and suggests the need for greater research into the likely consequences of climate change on wetlands.

241. **Coastal ecosystems are vulnerable to the myriad impacts of sea level rise.** The effects of expanding sea levels are multiple and include inundation of wetlands and lowlands; erosion of shorelines; coastal flooding; increased salinity of estuaries and aquifers; changes in tidal ranges in rivers and bays; and increase in the heights of waves. High levels of global warming are expected to lead to an average sea level rise of up to 88 centimeters over the next century. This would contaminate surface and groundwater resources (Ramsar and UNFCC 1999; IPCC 2007c) and could exacerbate the damage caused by tsunamis, storms, and flooding. The low-elevation small island state of Maldives, the mangroves of the Sundarbans, and the coastal ecosystems of Sri Lanka are particularly vulnerable to these impacts (Box 11.1). Sea level rise could also displace low-lying floodplain and swamps, submerge intertidal areas such as mudflats and eliminate the wetland plants and animals sensitive to salinity (CBD 2003).

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72 Refer to Chapter 6 on climate change and the water sector.
Box 11.1 Sea Level Rise and the Biodiversity of the Bangladesh Coastal Area

Bangladesh is particularly at risk from sea level rise, given that its coastal zone, comprising intertidal mudflats, mangroves, and tidal creeks, covers about 30 percent of its area. These coastal ecosystems are habitat for many species, sources of livelihood for many communities, and a natural defense against storms and floods. The coastline mangroves of the Sundarbans will be threatened by the increase in inundated areas and salinity of water.

The Sundarbans supports a diversity of wildlife: Bengal tigers, Indian otters, spotted deer, wild boars, some of the largest estuarine reptiles, and endangered turtles. Moderate increases in sea level could disturb its exotic wildlife and spur conflict between human and animal. A 1-meter rise in sea level, which is likely to occur by the end of the century, will lead to the disappearance of the Sundarbans and its biodiversity (IPCC 2001).

Coral Bleaching, Ocean Acidification and the Impacts on Marine Ecosystems

242. **Coral reefs are exceptionally rich in marine biodiversity and play a crucial role in sustaining fisheries and low-lying coastal areas.** Coral reefs, like rainforests, support complex habitat niches that host a wide diversity of species. Corals are formed through the action of living organisms, called polyps, which secrete an external limestone skeleton that constitutes the reef framework. These coral reef builders serve as the sturdy base that dissipate tidal and storm wave velocity and provide natural protection to low lying areas. Indeed the existence of the Maldivian islands is largely dependent on the integrity of the ring of corals that protect them from erosion and inundation.

243. **Climate change will increase the incidence of coral bleaching.** Tropical corals survive within a narrow range of water temperatures and nutrient loads (UNEP 2008). Even an ocean warming of 1°C to 2°C can cause bleaching of coral reefs,\(^73\) weakening the health and services of corals and dependent species and distorting the dynamics within the ecosystem (UNEP 2008). Sustained ocean warming of 3°C to 4°C would cause large scale coral mortality. The reestablishment of coral reefs takes centuries, and the consequences for coral reefs of climate change may be irreversible. According to the IPCC (2007d), the projected temperature rise will exceed current tolerance levels of corals in major coral biomes in the coming 20 to 50 years.

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\(^{73}\) Coral bleaching occurs when the symbiotic algae in coral tissues separate from their hosts due to sustained stress. Coral can survive this condition for a short period and even restore its symbiotic algae, but prolonged stress can cause its mortality.
The irreversible losses to biodiversity, and the impact upon food security and livelihood, would adversely impact economic opportunities in coastal communities. Coral coverage in the Indian Ocean islands, and South Asia combined has declined from more than 40 percent in 1997 to slightly above 20 percent in 2002. In areas where coral reefs have functional linkages with other ecosystems, including deep sea fisheries, mangroves and seafloor grasses, the impact of coral bleaching will be wide ranging. The loss of biodiversity from coral bleaching and ocean acidification could translate to losses in revenue from fisheries, mangrove ecosystem productivity, and tourism.

**Glacial Melt and the Biodiversity of the Himalayas**

The rapid retreat of glaciers in the Himalayas will significantly impact its freshwater resources and the vast ecosystems fed by them. At the other end of the altitudinal spectrum climate change is affecting the Himalayan ecosystem. Glacial melt will have a wide range of impacts on river systems and the biodiversity they host (WHO 2006). The effects of the drying of rivers will extend to terrestrial systems, from mountain forest ecosystem, rangelands and low-lying wetland and other ecosystems. Glaciers supplying the river Indus and its tributaries are predicted to be particularly susceptible to climatic warming, with a rise in temperature of 3°C reducing river flow by 40 percent and seriously affecting the riverine forests, wetlands, lakes, and mangrove forests and dependent species in Pakistan. In the short run, earlier thaw in the mountains feeding the system will reduce freshwater runoff in the summer months, placing forests and other vegetation at risk from drought. The magnitude and duration of these impacts is however largely unknown.

**Recommended Next Steps**

The impact of climate change upon ecosystems and biodiversity is a key development concern that needs to be integrated in development programs and responses to climate change. Many facets of the impacts of climate change upon biodiversity and species are still unknown, and implementation of informed programs of action requires a considerable investment in knowledge building. The existing engagement on natural resource management and biodiversity conservation must be scaled up or reconfigured to

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74 Refer to Chapter 6.
take account of the many risks from climate change. Further action must revolve around the following areas:

a. **Knowledge building.** Generation of knowledge must be directed towards reducing the information gaps and uncertainties regarding the effects of climate change upon ecosystems and biodiversity and identifying national priorities for conservation. Reducing the uncertainties requires an assessment of the status and vulnerabilities of species and biodiversity to socioeconomic drivers and climate change, and the possible impediments to their adaptive migration. Knowledge management should also take stock of local knowledge of ecosystems and best practices in management. Increased scientific knowledge is also needed to better understand the ecological responses to climate change (time lag, nonlinearity in reaction, natural adaptation mechanisms, and threshold limits). Valuation of the environmental damages of climate change must be incorporated in the assessment of the cost of climate change and benefits of adaptation strategies. Efforts should also be directed towards model development and coupling to better predict the impacts of climate change upon biodiversity and its feedbacks.

b. **Management of ecosystems and biodiversity.** New approaches to the management of ecosystems and biodiversity are required to respond to the emerging threats of climate change. Ecosystem and biodiversity considerations must be integrated into climate mitigation, adaptation, and risk management approaches. Shift from a piecemeal to an ecosystem-based approach to management and conservation of biodiversity must be considered, particularly for interdependent and complex ecosystems such as coastal ecosystems (including coral seascapes) and the Himalayan Hindu Kush, and the conservation of endangered species. Protected area networks would need to be expanded to prevent further habitat fragmentation that could hinder adaptive migration of species. Table 11.3 presents a detailed approach to protecting, upgrading, restoring, sustaining, and expanding ecosystems to develop a climate-resilient economy based on sustainable use of the natural resource capital.

c. **Integration in national and sectoral development.** Ecosystem and biodiversity concerns must also be reflected in national and sectoral development. Environmentally sensitive development and poverty reduction should integrate ecosystem and biodiversity consideration in development strategies in a wide range of sectors, including agricultural and rural development, forestry, fisheries, tourism, energy, and infrastructural development. Spatial planning and coastal and upland development, in particular, must carry safeguards to maintain ecosystem connectivity and enhance climate resilience of rural communities.

d. **Financing of biodiversity conservation.** Financing is a key challenge to biodiversity conservation. Achieving sustainable finance for biodiversity conservation will involve the creation of appropriate conditions through the removal of perverse subsidies, building capacity to design and manage biodiversity-based revenue-generating activities, and expanding the funding base through a wide range of instruments, including grants from donors, debt relief, and equity and market-based instruments.
### Table 11.2 Climate Change Impacts and Vulnerability Index

<table>
<thead>
<tr>
<th>Ecosystems</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal (mangroves, mudflats, estuaries)</td>
<td>Inundation, salination, storms, species loss</td>
</tr>
<tr>
<td>Coral reefs</td>
<td>Bleaching, acidification, loss of ecological and protective services, reduction in species diversity</td>
</tr>
<tr>
<td>Inland wetlands</td>
<td>Desiccation, drainage and diversion, degradation and service loss</td>
</tr>
<tr>
<td>Forests</td>
<td>Loss of forest cover and species, altered composition and structure, enhanced evapo-transpiration</td>
</tr>
<tr>
<td>Mountain (temperate, subtemperate, temperate)</td>
<td>Altitudinal shifts in vegetation disrupting species types</td>
</tr>
<tr>
<td>Mountain (subalpine, alpine)</td>
<td>Loss of vegetation cover</td>
</tr>
<tr>
<td>Glaciers</td>
<td>Loss of coverage</td>
</tr>
<tr>
<td>Desert</td>
<td>Expansion</td>
</tr>
<tr>
<td>Rangelands &amp; grasslands</td>
<td>Regime shift, degradation due to overgrazing and increased incidence of fire</td>
</tr>
<tr>
<td>Freshwater (rivers, lakes)</td>
<td>Desiccation, increased salinity at coast, degradation due to increased demand</td>
</tr>
<tr>
<td>Species diversity (floral &amp; faunal)</td>
<td>Loss of diversity and habitat, changes in species composition and food web</td>
</tr>
</tbody>
</table>

**Key:** Locations particularly vulnerable to impacts of climate change.
<table>
<thead>
<tr>
<th>Approach</th>
<th>Investments required in:</th>
<th>Gaps</th>
<th>Investment support for:</th>
<th>Bank’s strategic engagement in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protect</td>
<td>Existing public awareness network</td>
<td>Lack of training on participatory resource management approaches</td>
<td>Improved public awareness and management skills</td>
<td>Capacity building</td>
</tr>
<tr>
<td></td>
<td>Community reserves</td>
<td>Inadequate use of conservation planning tools, e.g. GIS</td>
<td>Rural livelihoods support</td>
<td>Training</td>
</tr>
<tr>
<td></td>
<td>Remaining wilderness and catchment areas</td>
<td>Limited livelihoods opportunities</td>
<td>Landscape-based conservation approach</td>
<td>Project planning and design</td>
</tr>
<tr>
<td></td>
<td>Unpolluted water bodies</td>
<td>No long-term engagement – only project-based approaches</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Old staff, poor work conditions, no incentives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrade</td>
<td>Existing reserves and protected forests</td>
<td>Old efforts lying in neglect – dilapidated reserves and protected forests</td>
<td>Awareness generation at state level</td>
<td>Global Environment Facility Small Grants Programme</td>
</tr>
<tr>
<td></td>
<td>Community reserves</td>
<td>No coordinated effort to deal with exotics and biological invasions</td>
<td>Supporting local-level civil society and NGOs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fodder banks</td>
<td>Nontransparent resource-sharing mechanisms</td>
<td>Generating scientific knowledge and research</td>
<td></td>
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<tr>
<td></td>
<td>Social forestry plots</td>
<td></td>
<td>Develop robust monitoring and evaluation framework</td>
<td></td>
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<tr>
<td></td>
<td>Canal-side plantations</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Restore</td>
<td>Mined-out areas</td>
<td>No regional or sector focus on restoration, poor investment support</td>
<td>New national-level project on restoration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Degraded ecosystems (forests, wetlands, rivers, grasslands etc.)</td>
<td>Limited knowledge base and availability of technologies</td>
<td>Help create database and GIS maps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overgrazed pastures</td>
<td>International technologies not tried under regional conditions</td>
<td>Help develop biotechnologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wastelands</td>
<td>Limited or no phytoremediation</td>
<td>Partner with local research institutes</td>
<td></td>
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<tr>
<td></td>
<td>Alkaline and saline soils</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sustain</td>
<td>Existing watersheds</td>
<td>Poor PRI capacities in resource sharing</td>
<td>Building community ownership</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remaining natural habitats (mangroves, corals, homesteads, private forests etc.)</td>
<td>Inadequate conflict resolution system and rights settlement incomplete</td>
<td>Livelihood support in ecosystem fringe areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Undisturbed ecosystems</td>
<td>Encroachment on natural ecosystems not addressed politically</td>
<td>Settlements of rights</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alternate livelihoods, technological options not fully introduced</td>
<td>Designing pilots</td>
<td></td>
</tr>
<tr>
<td>Expand</td>
<td>Forest ecosystems</td>
<td>No innovative thinking for expanding ecological resource base</td>
<td>Planning Commission (India) target of 5 percent increase in forest cover (XI Plan)</td>
<td>Start dialogue with potential states and Planning Commission</td>
</tr>
<tr>
<td></td>
<td>Wetlands (create new)</td>
<td>(create forest ecosystems instead of plantations)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Watersheds, catchments</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Other natural resource base</td>
<td>Wetlands considered as wastelands</td>
<td>New approaches for habitat creation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor budgetary support and investments for developing ecosystem resilience</td>
<td>Mapping and database</td>
<td>Knowledge services</td>
</tr>
<tr>
<td>Short-term</td>
<td>Medium-term</td>
<td>Long-term</td>
<td></td>
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</tbody>
</table>
Chapter 12. The Energy Sector

247. Buoyant economic growth in the past decade has fuelled an insatiable thirst for energy in South Asia. Rising energy demand is driven by urbanization, industrialization, and prosperity, all of which are parts of a broader process of development that is lifting millions out of poverty. However, increased energy consumption has been accompanied by rising greenhouse gas emissions. On average, emissions have risen by about 3.3 percent annually in the South Asia region since 1990, more rapidly than in any other region except the Middle East and North Africa. Total emissions exceed 2.5 billion tons of carbon dioxide equivalents and the region has emerged as one of the major contributors to global greenhouse gas emissions. As the region strives to meet its development goals, the potential for further growth in emissions is enormous. Over 400 million people in the region have no access to electricity, more than in all of Sub-Saharan Africa. How the region meets these demands will have far-reaching consequences on global greenhouse gas emissions.

248. Reflecting the size of its economy, population, and territory, India remains the largest contributor to greenhouse gases in the region, accounting for about 75 percent of emissions. Consequently, greater attention is focused on India in this chapter. Though globally India is the seventh largest emitter of greenhouse gases, it has low per capita emissions and low-carbon intensity. In terms of emissions per unit of gross domestic product (GDP), India remains an exceptionally low-intensity producer of CO₂ emissions. Per capita emissions in India, and the region as a whole, are low by international standards. In India, per capita energy consumption is less than one-tenth of the average of the OECD and about one-half the average for developing countries. Of the remaining seven South Asian countries, the following discussion mostly concerns Bangladesh, Pakistan, and Sri Lanka, where incremental emissions could be globally significant, but where future emission paths can potentially be influenced. The energy outlook and energy options available to these countries are discussed in detail in the following section.

South Asia Region: Energy Outlook and Options in Selected Countries

India

249. Coal is the backbone of the Indian energy sector. India has about 38 billion tons of oil equivalent of proven coal reserves, the third largest in the world after the United States and China. Though coal is abundant, it is of low calorie and high ash content and, therefore, highly polluting. Currently, about 70–80 percent of the country’s electricity is produced from coal. Poor-quality coal, aged legal framework, low levels of plant efficiency, and an ageing capital stock combine to make the power sector highly carbon intensive. Average emissions in Indian power plants are significantly higher than

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75 Authors in alphabetical order: Jeremy Levin and Alan F. Townsend
76 See Figure 2.5.
77 When GDP is measured either by purchasing power parity (PPP) or nominal exchange rates.
the global average\textsuperscript{78}. Transmission and distribution losses are a further drain on system efficiency and may exceed 20 percent in some states, well above global best practice (Government of India, Press Information Bureau 2001). Consequently, energy efficiency opportunities exist to reduce the carbon intensity of power production while simultaneously increasing electricity supply.

250. **Strategies to lower emissions by diversifying into cleaner sources of power are constrained by the country’s energy resources and import possibilities.** India is not well endowed with reserves of cleaner fuels such as oil, gas, and uranium.\textsuperscript{79} Hydropower potential is significant and large in absolute terms (150,000 megawatts), but small compared to the country’s vast energy needs. In addition, there are possibilities for importing about 50,000 megawatts of hydropower from Bhutan and Nepal, and perhaps as much as 20,000 megawatts of wind power from Sri Lanka. However, even when exploitation of hydropower is technically feasible, there are social and environmental concerns to take into consideration, and there remain difficulties in establishing transboundary energy trade agreements. Hydropower development is also made more complex by glacial melting, which increases the medium- and long-term hydrological risk associated with such investments.

251. **Under most plausible scenarios, coal is expected to remain the dominant fuel used for power generation.** Detailed assessments by India’s Planning Commission suggest that, even under the most optimistic scenarios, renewable energy sources (including wind, solar, and hydro power) and nuclear power would play a minor role in the country’s energy mix (Box 12.1). For India, transformational climate change interventions would therefore need to increase the efficiency of coal use through migration to more efficient technologies; and, in parallel, other futuristic technology options such as mass solar power should be pursued, as has been suggested in the India National Action Plan on Climate Change (Government of India, Prime Minister’s Council on Climate Change 2008). To be truly transformational, such supply side interventions would need to be complemented by energy efficiency initiatives, so that growth in overall energy demand is better managed. Box 12.2 illustrates the energy mix under alternative scenarios and reinforces the likely importance of coal in the energy mix.

\textsuperscript{78} With emissions from the power sector of roughly 750 grams of CO\textsubscript{2} per kilowatt, India’s power sector is, for instance, 50 percent more CO\textsubscript{2} intensive than the United Kingdom’s. (Government of India, Ministry of Power, Central Electricity Authority; H.M. Government, Department of Trade and Industry 2007).

\textsuperscript{79}In 2005-6 oil reserves were estimated at 786 metric tons and gas reserves are 1,101 billion cubic meters (Government of India, Planning Commission 2006).
Box 12.1 India Supply Options for Lowering Emissions: Planning Commission Estimates

The Planning Commission has explored possibilities for energy diversification to meet the demands of a rapidly growing economy. The figure below presents estimates for three scenarios in 2031. The economy is assumed to grow at 8 percent on average, which in turn implies more than a tripling of energy needs. In the business as usual scenario over 60 percent of generation is coal based. In this case, by 2030, India’s emissions approach those of the United States today (approximately 6,000 million tons). The forced nuclear, hydro, and natural gas scenario and the high-efficiency coal, power, and transport plus renewables scenario are the most optimistic conceivable cases and are useful in illustrating limits and possibilities. These assume that all available hydropower potential (150,000 megawatts) is exploited, nuclear capacity increases at an optimistic pace, demand-side management (DSM) reduces demand by 15 percent, and at least 11 percent of generation is from gas, irrespective of price differentials. Even in the most optimistic scenario coal remains a dominant fuel, accounting for over 40 percent of the mix, though emissions decline somewhat to about 4,000 million tons. The implication is clear: under any plausible setup, coal is likely to dominate and other fuels will play a lesser role, even under extreme assumptions that are very favorable to the growth of those alternatives. Consequently, a clean energy strategy must aim to lower emissions from coal.

India’s CO₂ Projections in the Integrated Energy Policy Report

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Coal scenario (million tons oil equivalent/%)</th>
<th>Forced scenario (million tons oil equivalent/%)</th>
<th>High efficiency coal and transport plus renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>467 (28%)</td>
<td>467 (34%)</td>
<td>406 (29%)</td>
</tr>
<tr>
<td>Gas</td>
<td>114 (7%)</td>
<td>164 (11%)</td>
<td>168 (12%)</td>
</tr>
<tr>
<td>Coal</td>
<td>1,082 (65%)</td>
<td>658 (45%)</td>
<td>573 (42%)</td>
</tr>
<tr>
<td>Hydro</td>
<td>0</td>
<td>50 (3%)</td>
<td>50 (4%)</td>
</tr>
<tr>
<td>Nuclear</td>
<td>0</td>
<td>89 (6%)</td>
<td>89 (6%)</td>
</tr>
<tr>
<td>Other</td>
<td>&lt; 1</td>
<td>0</td>
<td>89 (6%)</td>
</tr>
</tbody>
</table>

Box 12.2 Emissions from Coal and Natural Gas

Addressing coal’s market share is one way to lower the emission footprint of the energy sector. The table below summarizes conventional emission standards. The carbon advantage of natural gas is plainly evident, with combined-cycle plants having just more than one-third of the carbon emissions of a conventional coal-fired plant (assuming the conventional coal-fired plant is efficient). The advantage of supercritical and ultra-supercritical technology vs. conventional coal is also evident; given India’s dependence on coal, yet its increasing need to import coal supplies to meet growing demand, it is easy to see why India is so keen on increasing efficiency of coal use in the power sector.\(^8^0\)

<table>
<thead>
<tr>
<th>Technology and fuel combinations</th>
<th>Kilograms of CO(_2) emissions per megawatt-hour</th>
<th>Annual tons of CO(_2) per 1,000 megawatts at 70% load factor(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural gas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple cycle</td>
<td>600</td>
<td>3,679,200</td>
</tr>
<tr>
<td>Combined cycle</td>
<td>360</td>
<td>2,207,520</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>1,000</td>
<td>6,132,000</td>
</tr>
<tr>
<td>Supercritical</td>
<td>900</td>
<td>5,518,800</td>
</tr>
<tr>
<td>Ultra-supercritical</td>
<td>800</td>
<td>4,905,600</td>
</tr>
</tbody>
</table>

\(^a\) Load factor: A measure of the output of a power plant compared to the maximum output it could produce.

The table suggests that low-emission “near-zero” technologies will also be very attractive and will have significant carbon advantages, even compared to efficient natural gas. These technologies or approaches include nuclear and hydro power, non-hydro renewables, reduction of loss during transmission and distribution, and increased energy efficiency. In all of these cases, a kilowatt-hour that is not generated from conventional coal (for the major South Asian markets, the default technology at this time) has a carbon benefit equal to 1 ton of CO\(_2\) per megawatt-hour of generation. It should also be stressed that most of India’s installed, operating coal-fired capacity is less efficient that the conventional coal baseline shown in the table. The 1,000 kilogram per megawatt-hour standard used in the table represents an efficiency of roughly 35 percent; however, in the state electricity board, there are plants operating at efficiencies of only two-thirds of that.


**Bangladesh, Nepal, and Pakistan**

252. Because of the cost advantage of coal and the relative security of the fuel supply streams, Bangladesh, Pakistan, and Sri Lanka will increasingly see coal emerge as the front-running fuel for incremental generation of power. Bangladesh and Pakistan have substantial, unexploited coal reserves (albeit of dubious quality and difficult to extract); and Sri Lanka has unfettered access to global coal markets. The risks

\(^8^0\) Supercritical and ultra-supercritical technologies operate at higher temperatures and pressures than conventional coal-fired technologies, increasing efficiency.
around investment in coal-fired capacity are perceived as being lower than those of alternative power sources, and the overall cost of the delivered power is competitive versus other options, based on prevailing market prices for coal and competing fuels. This suggests that there is a need for more active and extensive interventions to tilt the balance in favor of cleaner technologies. To the extent that these countries can delay the next generation of coal-fired plants under consideration, the carbon savings would be substantial, perhaps as much as 3 million tons per year per 1,000 megawatts of capacity, if it is assumed that the alternative to coal is natural gas.

253. For Pakistan, the alternative to coal is likely to be 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 its health and environmental implications.

254. On the other hand, Bangladesh has significant reserves of natural gas, but exploration drilling has not kept pace with demand for gas. Policy constraints, especially those related to pricing, are the key impediment to revitalizing exploration and production, enhancing production and reservoir management from existing fields, and reducing losses (mostly due to theft, but also to substantial amounts of leakage) from the existing gas supply network. Thus, the situation in Bangladesh is significantly different from that in Pakistan and Sri Lanka, as Bangladesh will not need large incentives from a global carbon market to inform investment decisions that choose between coal and natural gas. What it will need is simply more domestic gas development, and these remain firmly in the range of the possible, provided that its financial policy improves. Otherwise, the country will be forced to analyze the tradeoffs between coal and imported gas, much as Pakistan and Sri Lanka must do.

**Approaches for Reducing Emission Intensity**

**Options for Cleaner Coal**

255. In the immediate future, there are three main options for lowering the emission intensity of coal that are appropriate to the Indian setting: (i) rehabilitation of old plants; (ii) replacement of inefficient plants; and (iii) adoption of cleaner-generation technologies that are economically justifiable. Each of these is considered in turn:

- **Rehabilitation.** India’s state electricity boards and their successor entities own and operate plants that represent more than 50,000 megawatts of generation capacity. Some of these are old, inefficient, and highly polluting. Rehabilitation of these with energy efficiency as a priority can generate substantial emission reductions. For example, plant efficiency can increase to 35 percent from 30 percent or below, and, as a result, the annual CO₂ emission reduction would be over 1 million tons for every 1,000 megawatts power plant that was so renovated. The World Bank already has an engagement to carry out a large-scale pilot to rehabilitate nearly 1,000
megawatts of such capacity, with energy efficiency, life extension, and reliability as high priorities.

- **Replacement.** Ageing coal-fired power plants with no further rehabilitation potential would be replaced by new, more efficient plants, ideally using supercritical technology, where technically and economically feasible. The successor of the Kyoto Protocol after 2012 could play a role in influencing technology choices.

- **Cleaner generation.** A favored option in India is supercritical technology, based on its track record internationally, availability in India, and suitability with coal streams (domestic and imported). It is likely that many such investments will be led by private sector entities or state organizations with substantial access to market financing, such as the National Thermal Power Corporation. There is scope to expand the use of supercritical technologies to other countries in the region.

**Loss Reduction, Energy Efficiency, and Pricing**

For South Asia in general, and India in particular, there are large gains to be had from addressing loss reduction or efficiency gains. The energy that does not have to be generated due to loss reduction or efficiency gains is attractive from both the cost and the climate change standpoints. There are large opportunities for efficiency gains and loss reduction in South Asia (Table 12.1). Much of the industrial output in the region is from small- and medium-scale enterprises that utilize outdated and inefficient technologies and processes. Cost-effective energy efficiency opportunities exist across the entire chain of modern energy production, distribution, and consumption in all South Asian countries. However, success in capturing these benefits has been elusive; many energy efficiency projects with positive economic returns remain unimplemented.

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81 Given the rapid development in the sector and other factors, selecting clean coal technology options appropriate to developing countries is difficult. Two recent papers (Tavoulareas 2007; Chikkatur and Sagar 2007) have identified supercritical and ultra-supercritical technologies as appropriate choices for immediate investment focus in India, based on commercial availability, suitability for Indian and imported coal, and demonstrated track records. India is pursuing this technology actively, with licensing arrangements in place and plants (such as that at Mundra, Gujarat) under development. Other technologies, such as integrated gasification with carbon capture, offer potential to take into consideration by the World Bank. Care should be taken, however, to ensure that such technologies have been fully tested and are suitable country specific conditions.
Table 12.1 Energy Efficiency Opportunities and Measures in Key Consuming Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy efficiency improvement opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings</td>
<td>Integrated building design and measures such as better insulation, advanced windows, energy-efficient lighting, space conditioning, water heating, and refrigeration technologies plus energy efficient brick manufacturing and wall paneling.</td>
</tr>
<tr>
<td>Industry</td>
<td>Industrial processes, cogeneration, waste heat recovery, preheating, efficient drives (motor, pump, compressors)</td>
</tr>
<tr>
<td>Cities and municipalities</td>
<td>District heating systems, combined heat and power, efficient street lighting, efficient water supply, pumping, and sewage removal systems, solid waste management (methane capture to generate electricity)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Efficient irrigation pumping and efficient water use, such as drip irrigation</td>
</tr>
<tr>
<td>Power supply</td>
<td>New thermal power plants: Combined cycle, supercritical boilers, integrated gasification combined cycle (IGCC), etc. Existing generation facilities: Refurbishment and repowering (including hydro), improved operation and maintenance practices, and better resource utilization (higher plant load factors and availability) Reduced transmission and distribution losses: High-voltage lines, better insulated conductors, capacitors, efficient and low-loss transformers, and improved metering systems and instrumentation</td>
</tr>
<tr>
<td>Transport</td>
<td>Efficient gasoline/diesel engines, urban mass transport systems, modal shifts to inter- and intra-city rail and water transport, improved fleet usage, compressed natural gas (CNG) vehicles</td>
</tr>
<tr>
<td>Households</td>
<td>Efficient lighting, appliance efficiency, improved cook stoves, solar panels for heating and cooking.</td>
</tr>
</tbody>
</table>

257. The classical barriers to increased energy efficiency include noneconomic pricing of energy (encouraging overconsumption), imperfect information, and institutional barriers. Additionally, weight is often given to reducing up-front costs instead of considering the lower recurring life cycle costs typically available from installation of more cost-efficient equipment and adoption of more efficient processes. Energy efficiency projects can also face higher transaction costs due to their small average size. Finally, capital constraints at small and medium enterprises often leads to allocation of capital towards new production capacities rather than towards investments that will reduce operating costs through energy efficiency, especially if energy costs are a small component of total production costs.

258. The International Energy Agency has noted that over 60 percent of greenhouse gas reductions could come from adoption of energy-efficient policies and measures. Though contested, this conclusion highlights the importance that energy efficiency can
play in reducing demand and dependence on fossil fuel use, reducing levels of power shortages by capacity-constrained electric utility companies, and improving economic competitiveness, while capturing the environmental benefits to be derived from the numerous government-led initiatives currently under way. In India, the Planning Commission estimates that improving energy efficiency in industry will have the greatest impact in reducing India’s CO₂ emissions. The Government of India has demonstrated its commitment to and support for improving efficiency with the passage of the Energy Conservation Act (2001) and the formation and operation of the Bureau of Energy Efficiency. Recognizing the importance of lowering demand through energy conservation and improved efficiency, the 11th Five Year Plan seeks to improve Indian efficiency by 20 percent by 2016/7, and the recently released Climate Change Action Plan of the Government of India includes a specific mission to increase efficiency through deployment of several innovative market mechanisms. Government-supported programs for efficiency have also been launched in Afghanistan, Nepal, Pakistan, and Sri Lanka.

259. The World Bank Group has provided support for numerous initiatives and has a number of additional activities under preparation to maintain its commitment to addressing this important area. This support includes International Finance Corporation (IFC) equity investments; direct lending and other activities to increase local access to finance for energy-efficient investments by the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA); Global Environment Facility grant support to overcome market barriers; analytic and advisory activities to assist policy makers in decision making and to build capacity in implementing institutions; and mobilization of carbon finance and other climate investment funds to provide an additional financial incentive for adoption of efficient equipment. The World Bank Group will continue to support these and other market-based mechanisms aiming to encourage scale-up and accelerated adoption of efficient technologies to further develop the most important option for reducing carbon intensity in the South Asian region.

Hydroelectricity and Regional Trade

260. Though India’s hydropower potential is limited relative to its needs, the hydropower sector can contribute to the reduction in emissions. The Bank already has a significant presence in the Indian hydro sector, with one project under implementation (Rampur) and two more under preparation (Vishnugad Pipalkoti and Luhri). This engagement is set to grow rapidly in the future. There are also good prospects for an increased Bank involvement in financing of hydro capacity in Nepal and Pakistan.

261. There are significant opportunities in energy trade between the countries with a surplus of clean renewable sources of energy – hydropower in Bhutan and Nepal, and wind energy in Sri Lanka – and the energy-deficit countries – India, Pakistan, and Bangladesh. Trading this clean energy would allow climate change mitigation benefits to arise from reduced operation of thermal (particularly coal-fired) power plants. The improved interconnectedness and efficiency associated with this regional trade would also yield improvements in operational performance. However, given the inadequacy of existing interconnections for trading large quantities of clean energy and current
shortages of power, at the present time imported power would serve mainly to reduce load shedding, and substantial benefits would only materialize over the long term.

**Other Renewables**

262. The contribution of non hydro-renewables in the overall mix in South Asia is likely to be small. Even if such alternatives experience vigorous growth their contribution to mitigation of overall carbon emissions will be limited, though individual projects will be able to attract potentially significant volumes of carbon finance. Renewable energy development will remain a focus of the Bank as well as other multilateral agencies, given its significant relevance beyond the climate change mitigation aspects, including in projects related to rural development, rural access, and reduction of indoor air pollution. However, more work and research will be needed to deploy viable technologies and support emerging technologies. Recognizing this need, the government of India has recently unveiled an ambitious strategy in its National Action Plan on Climate Change to raise solar power production capacity and invest heavily in research and development in this field.

**Leveraging Climate Change-Related Funds**

263. Without adequate and additional funding it is unlikely that the South Asia region can achieve the transformation needed to create low-carbon economies. Ultimately, good projects will be the key, but the long delays in obtaining carbon finance (including through clean development mechanisms) are often a hurdle. The magnitude of available funds is also inadequate for the scale of the challenges in the energy sector.

**Private Sector Players**

264. The private sector will be playing a key role across the board in investing in new, clean coal plants, gas-fired plants, and renewable energy. The Clean Development Mechanism already provides, to some extent, a signal towards future prices of carbon; however, there will still be significant risks attached to private investment in clean energy technology that is not least cost, or whose potential remains unproven. While much of the private sector focus falls in the ambit of the IFC, the Bank Group as a whole is actively involved in assessing existing instruments and developing new instruments that could accelerate private investment in cleaner power plants (as well as in other areas such as energy efficiency and loss reduction). It remains to be seen whether new instruments can be developed and mainstreamed that would accelerate low-carbon growth opportunities. South Asia’s strategy in this area should be driven by analytic work under way within the Bank Group at this time.
**Box 12.2 Priorities for the Energy Sector**

- Scale-up T&D loss reduction investments in India, Pakistan and Bangladesh, including selected Indian state-level T&D companies
- Expand renewable energy support through leveraging climate investment funds and advancing investments in hydropower (India, Nepal, Pakistan), coal (India), gas-fired (Bangladesh)
- Operationalize energy efficiency possibilities in India, Pakistan and Bangladesh
- Advance energy pricing reform dialogue
- Groundwork and dialog for investments in regional energy trade infrastructure
- Low-carbon growth studies for Pakistan, Bangladesh, and Sri Lanka
Chapter 13. The Transport Sector

Overview of Greenhouse Gas Emissions from the Transport Sector

The transport sector is an important source of greenhouse gas emissions worldwide; however, in South Asia, its contribution to CO₂, the main GHG, has been low relative to other regions of the world. During the period of 2000-2004, the transport sector only accounted for 10 percent of the region’s total CO₂ emissions while in the rest of the world it contributed to about 20 percent of total CO₂ emissions. Given the region’s significant population and economic size, this share implies carbon emitted from transport use per person and per unit of economic output is particularly low (Table 13.1). Between 1990 and 2005, the rate of growth of transport CO₂ emissions was the second lowest in the developing world (2.1 percent), after the former Soviet Union. While many of the developing regions have experienced an increase in transport CO₂ emissions in recent years, South Asia has managed to become even less transport-CO₂ intensive (Table 13.2).

Table 13.1 Per Capita and Per Unit of GDP Transport CO₂ Emissions by Region and by South Asian Country, 2005

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Per capita CO₂ emissions (kilograms of CO₂)</th>
<th>CO₂ emissions per US$ of GDP a (grams of CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>985</td>
<td>116</td>
</tr>
<tr>
<td>OECD North America</td>
<td>4,846</td>
<td>162</td>
</tr>
<tr>
<td>OECD Pacific</td>
<td>2,142</td>
<td>84</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>1,839</td>
<td>81</td>
</tr>
<tr>
<td>Africa</td>
<td>203</td>
<td>88</td>
</tr>
<tr>
<td>Latin America</td>
<td>723</td>
<td>102</td>
</tr>
<tr>
<td>Middle East</td>
<td>1,502</td>
<td>207</td>
</tr>
<tr>
<td>Non-OECD Europe</td>
<td>834</td>
<td>106</td>
</tr>
<tr>
<td>Former USSR</td>
<td>980</td>
<td>133</td>
</tr>
<tr>
<td>Asia (excluding China)</td>
<td>196</td>
<td>57</td>
</tr>
<tr>
<td>China (including Hong Kong)</td>
<td>257</td>
<td>42</td>
</tr>
<tr>
<td>South Asia</td>
<td>94</td>
<td>33</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>India</td>
<td>89</td>
<td>29</td>
</tr>
<tr>
<td>Nepal</td>
<td>31</td>
<td>22</td>
</tr>
<tr>
<td>Pakistan</td>
<td>170</td>
<td>81</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>279</td>
<td>68</td>
</tr>
</tbody>
</table>


Authors in alphabetical order: Rahima Abdula, Ke Fang, Roger Gorham and Carla Vale.

World Resources Institute Climate Analysis Indicators Tool (CAIT) (http://www.wri.org/project/cait).
266. There is some variation in the level of emissions among South Asian countries, with Pakistan and Sri Lanka being the most transport CO₂-intensive. The average Sri Lankan emits nearly 300 percent more CO₂ from transport than an average person living elsewhere in the region. In Pakistan, producing a given amount of economic output requires more than twice the amount of CO₂ emissions from transport than the region’s average. On the other hand, at 6.9 percent, Bangladesh experienced the largest rate of growth in transport CO₂ emissions between 2000 and 2005 (Table 13.2).

267. When examined in the context of the high levels of economic growth the region has been experiencing, the low intensification rate of transport CO₂ emissions in South Asia as a whole is remarkable. The economy of the region grew at an impressive 5.3 percent per year between 2000 and 2005, a rate of growth that is second only to that of China (7.5 percent per year). However, while China’s rate of CO₂ emissions from transport kept pace with economic growth (growing by 7.3 percent per year), that of South Asia grew at a paltry annual rate of 1.3 percent. This difference may reflect, to some degree, the nature of the respective economic engines fueling the growth in South Asia, and in India in particular, which represents nearly 83 percent of the region’s economy. India’s economic growth is powered by non-transport-intensive sectors, particularly information technology, biotechnology, and research and development, while China’s is driven largely by manufacturing and production of goods for export.

Table 13.2 Growth Rate of Transport CO₂ Emissions by Region and by South Asian Country (1990–2005); (2000–2005)

<table>
<thead>
<tr>
<th>Region/country</th>
<th>Annual growth rate of transport CO₂ emissions (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>2.22</td>
</tr>
<tr>
<td>OECD North America</td>
<td>1.58</td>
</tr>
<tr>
<td>OECD Pacific</td>
<td>2.39</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>1.58</td>
</tr>
<tr>
<td>Africa</td>
<td>3.59</td>
</tr>
<tr>
<td>Latin America</td>
<td>3.11</td>
</tr>
<tr>
<td>Middle East</td>
<td>4.45</td>
</tr>
<tr>
<td>Non-OECD Europe</td>
<td>1.97</td>
</tr>
<tr>
<td>Former USSR</td>
<td>–0.67</td>
</tr>
<tr>
<td>Asia (excluding China)</td>
<td>4.38</td>
</tr>
<tr>
<td>China (including Hong Kong)</td>
<td>6.46</td>
</tr>
<tr>
<td>South Asia</td>
<td>2.12</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>6.86</td>
</tr>
<tr>
<td>India</td>
<td>1.43</td>
</tr>
<tr>
<td>Nepal</td>
<td>8.20</td>
</tr>
<tr>
<td>Pakistan</td>
<td>4.52</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>5.85</td>
</tr>
</tbody>
</table>

Factors Underlying South Asia’s Transport Carbon Emissions

268. The relatively low-carbon intensity of the transport sector reflects unique features of South Asia’s urbanization and economy, including its low urbanization rates, low urban and rural mobility rates, and the labor-intensive nature of economic production. Only about 28 percent of the population resides in the cities of South Asia; of this, 35 percent live in cities with populations less than 100,000 (Toutain and Gopiprasad 2006). Per capita trip rates, even in urban areas, are low. Labor rather than capital and energy remain the dominant input in production. Additionally, high fuel prices in the region may be having a price effect in restraining the transport-related greenhouse gas emissions from the region, but this effect is likely to be small. Rather, it is more likely that wage rates function as the primary constraint in South Asia. For example, the ratio of fuel price to per capita income in India is among the highest in the world – it is six times as high as in China, and over 55 times as high as the OECD average (Muralikrishna 2007).84

269. More specifically, the total amount of CO₂ produced by the transport sector generally depends upon three main factors: (i) the amount and nature of the demand for vehicular travel; (ii) the energy intensity of the vehicles used to meet that demand; and (iii) the life-cycle carbon content (LCC) of the system used to generate and deliver that energy.85 Public policy, intentional or otherwise, can influence many of these factors in significant ways. This section briefly examines these factors in the South Asian context.

Demand for Vehicular Travel

270. Vehicular travel demand is best understood by subsector: urban passenger travel, interurban passenger travel, and freight transport. In urban areas, the magnitude and nature of demand for vehicular travel is influenced by the size of the urban population, mobility rates, amount of time people are willing to spend traveling, prevailing speeds on existing transport networks, proportion of desired trips that are walkable, the costs of vehicle movement and storage, and the viability of public transport or non-motorized modes of transport.

271. In South Asia, the mobility rates, travel speeds, and motorization are low. According to RITES (1998), there are about 0.51 motorized trips per person in India. Prevailing travel speeds are low, as is the tolerance for long travel times. Gakenheimer and Zegras (2003) report typical speeds for urban buses of 6 to 10 kilometers per hour in many large cities. In city centers, average speeds during peak hours reach 5 to 15 kilometers per hour. The vast availability of the public transport system and low real wages also undermined the practicality of private motorized use. The high level of crowding in urban centers leads as well to a significant number of trips without the use of motorized vehicles. In general, the more centralized the population, the more feasible are walking trips.

84 India’s and Pakistan’s gasoline prices in 2007 (US$1.01 per liter) were about 15 percent higher than the world average (US$0.88 per liter).
85 This decomposition is a minor modification of the one proposed by Schipper and Marie-Lilieu 1999 as the “ASIF identity”.
272. The motorization rate, while currently low, is expected to rise dramatically in the future. India’s rate of car ownership in 2000 was just 10 vehicles per 1,000 persons, compared to a worldwide average of about 113 vehicles per 1000 persons (WBCSD 2003). Even including two-wheelers, vehicle ownership, although higher than the rates for either Africa or China, is still substantially lower than the worldwide average (WBCSD 2003). Forecasts however suggest a meteoric rise in vehicle ownership. Ownership of light-duty vehicles (cars and light trucks) is predicted to increase by 5.7 to 10 percent (WBCSD 2003; WEO 2007), resulting in car ownership of between 56 million and 115 million in 2030. Including two-wheelers, total vehicle stock under the WEO projection in 2030 at 295 million will overtake that of the United States. These figures predate the announcement of Tata Motors of the distribution of an affordable mini car model known as the “Nano”. This likely increase in vehicle penetration, even above those predicted in these early studies, will raise the trajectory of future CO2 emissions.

273. Interurban travel tends to be a relatively important source of overall travel demand. Thus, it is an important submarket for consideration in any strategy aimed at heading off a growth in greenhouse gas emissions from the transport sector as a whole. Intercity passenger transport occurs mostly via bus and rail (99 percent in 2006), and it constitutes a relatively important source of overall travel demand. Based on reported figures from Indian Railways and the domestic airline industry, there were 6.8 billion intercity passenger trips in India in 2006/2007.

274. Even though air travel mode shares are quite low, the potential growth of this market is of particular concern for CO2 emissions over the long run. An analysis of Indian Railways’ fuel consumption shows a CO2 emissions factor of about 9.6 grams of CO2 per passenger-kilometer in 2006, or about 1 kilogram of CO2 per passenger trip. By contrast, CO2 emissions per passenger-kilometer from air transport in the United States in 2006 were 136 grams. (India-specific aviation emissions factors were not available for the present report). Assuming these emissions factors are reasonably applicable in India, each air trip that could occur by rail instead of by air would reduce CO2 emissions by a factor of 14.

275. While the drivers of freight transport demand may indicate the success of other desirable economic or social development policies (such as improved rural accessibility), effective policies to mitigate CO2 emissions can focus on improving modal competitiveness. For example, in India, the government is investing in two dedicated, high-speed freight rail corridors to improve rail freight competitiveness, reduce costs, and increase reliability.

Energy Intensity of Vehicles

276. Energy intensity of the vehicle fleet is largely determined by four factors, each of which can be influenced by public policy. These factors are: (i) the energy efficiency of newly acquired vehicles entering the fleet; (ii) the maintenance practices employed to minimize energy intensity of vehicles over their lifetimes; (iii) the profile of

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86 Key author’s calculations from data provided on Indian Railways website (http://www.indianrailways.gov.in/depts/stat-eco/Stat_index-06_07.htm).
87 Key author’s calculations from National Transportation Statistics (Bureau of Transportation Statistics).
vehicle utilization – which vehicles tend to be used for which purposes, how intensively, and for how long; and (iv) the nature of traffic conditions on the roadways where vehicles are most predominantly used. Regrettably there are too few data on any of these factors in the region to attempt drawing definite conclusions.

277. Based on available comparable data on energy intensity, the extensive use of two-wheeler vehicles seems to produce the effect that energy consumption per vehicle-kilometer driven in South Asia is the lowest in the world. Fuel economy results from in-use fleet sampling showed that the vehicles in Pune, India, are less energy intensive compared to those in Mexico City, Shanghai, and Los Angeles (Table 13.3). This apparent efficiency does not reflect a fundamental technological difference among the regions; rather, it is reflective of the type of vehicle used for travel. About 66 percent of vehicle-kilometers traveled in Pune occurred on two-wheelers, while only 20 percent and 2 percent occurred on two-wheelers in Shanghai and Mexico City, respectively. Passenger cars accounted for 71 percent and 95 percent of vehicle-kilometers traveled in Shanghai and Mexico City, respectively, compared with only 14 percent in Pune.

Table 13.3 CO₂ Emissions Intensity (Grams per Vehicle-Kilometer) in Four Cities

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>Pune</th>
<th>Los Angeles</th>
<th>Mexico</th>
<th>Shanghai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-wheeler</td>
<td>44</td>
<td>—</td>
<td>67</td>
<td>71</td>
</tr>
<tr>
<td>Three-wheeler</td>
<td>71</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bus</td>
<td>1,288</td>
<td>—</td>
<td>800</td>
<td>1,013</td>
</tr>
<tr>
<td>Passenger car</td>
<td>353</td>
<td>—</td>
<td>377</td>
<td>413</td>
</tr>
<tr>
<td>Delivery truck</td>
<td>876</td>
<td>—</td>
<td>—</td>
<td>803</td>
</tr>
<tr>
<td>All vehicles</td>
<td>125</td>
<td>249</td>
<td>387</td>
<td>400</td>
</tr>
</tbody>
</table>

*Source:* Key author’s calculations from output of International Vehicle Emissions Model (University of California at Riverside College of Engineering Center for Environmental Research and Technology, based on databases compiled by University of California Riverside research team in 2004).

— Not available.

278. The data available on fuel efficiency for new vehicles does not lend itself to international comparisons because of methodological differences. It is known, however, that fuel economy standards (or CO₂ emissions standards) for new vehicles have not yet been adopted by any country in South Asia. They are however under active consideration in India.²⁹

279. While vehicle maintenance is a critical factor in the fuel efficiency of the in-use fleet, the extent to which such maintenance practices are carried out in South

²⁸ These data may not be a representative sample for the region, but are probably the best evidence available regarding fleet energy intensity.

²⁹ The effort is being led by the Petroleum Conservation Research Association (PCRA), but the time frame for development of such standards is unclear.

³⁰ A recent study carried out by the Automobile Research Association of India in the Indian vehicle fleet revealed that maintenance seems to improve fuel economy between 2 and 19 percent, depending on the type and model year of the vehicle (Marathe and Chaudhari 2007).
Asia is unknown, and more research is needed. The factors that affect fuel economy that are most often cited include keeping tires adequately inflated and aligned, checking and replacing air filters regularly, changing oil and oil filters regularly, keeping the engine lubed, and avoiding aggressive driving practices, particularly heavy accelerations and breaking. Given the high ratio of fuel prices to per capita income cited earlier, however, it would be expected that such practices are widespread. There are also few data available regarding the profile of vehicle use in South Asia. Specifically, the usage patterns of older vehicles relative to newer vehicles as the vehicle fleet is expanded, and the amount of annual kilometrage older vehicles perform relative to newer vehicles, are of interest.

280. Finally, the behavior of traffic streams in which vehicles operate also determines the overall fuel intensity of the vehicle fleet. As is well known, South Asian cities are characterized by high traffic congestion and lower-than-average road conditions, both of which negatively affect fuel intensity. In rural areas, paved roads are more the exception than the rule. Fuel economy is linked both to average speeds and to the relative proportion of acceleration to steady-state driving over a given distance. The more variable the travel speed, the higher the fuel consumption, all else equal. While fuel intensity and CO₂ emissions are lower at higher speeds, simply adopting a policy of facilitating higher-speed travel would induce mode switching and potentially additional trip making as well, thus rendering walking and cycling dangerous; this induced travel could substantially offset any fuel intensity improvements from improved traffic conditions.

**Fuel Carbon Content**

281. In the near term, utilization of bio-fuels, particularly ethanol and biodiesel, holds the most promise for affecting life-cycle carbon content of fuels used in the sector. One set of estimates of emissions factors for Indian production techniques is shown in Table 11.4. The emission factors suggest that a 5 percent ethanol blend into gasoline would reduce CO₂ emissions by about 3 percent, and a 20 percent biodiesel blend would reduce CO₂ emissions by about 11 percent. Current levels of ethanol production in India would be sufficient to cover the needs in the domestic market to achieve the 5 percent ethanol blend proposition (the need has been estimated at only 700 million liters while average output per year is 1.9 billion liters).⁹¹

282. Whereas India has become one of the world’s largest ethanol producers, its production capacity for biodiesel is yet to be developed. Acknowledging this need, the government of India has pursued an ambitious National Biodiesel Mission since 2003. The objective of this mission is to supply 20 percent of national diesel demand with domestically produced biodiesel, primarily from *Jatropha*. As a desert-blooming plant, *Jatropha* is particularly attractive in that it does not compete with food products, and it can be cultivated on heretofore marginal land. Based on a demonstration phase begun in 2003, it was estimated that production costs of *Jatropha*-based biodiesel would be about US$0.47 per liter (Gonsalves 2006), though this may have been based on optimistic

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⁹¹ This output is almost entirely produced from molasses, a by-product of sugar production; if crop sugar itself were used directly in ethanol production, annual output is estimated to be about 2.3 billion liters (Gonsalves 2006).
assumptions about production costs of *Jatropha* seed oil (Mohan and Kumar 2005). Under a policy established in 2007, state-owned distribution firms are required to purchase biodiesel at a fixed price of about US$0.68 per liter, but even that seems to be below current production viability (Kukrika 2008).

**Table 13.4 Estimates of Life-Cycle Carbon Emissions from Select Conventional Fuels and Biofuels**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Life-cycle carbon emissions factor (grams/kilometer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional gasoline</td>
<td>230</td>
</tr>
<tr>
<td>Conventional diesel</td>
<td>145</td>
</tr>
<tr>
<td>Ethanol (molasses derivative)</td>
<td>75</td>
</tr>
<tr>
<td>Biodiesel (<em>Jatropha</em> derivative)</td>
<td>65</td>
</tr>
</tbody>
</table>


**Future Challenges**

283. While the transport sector has been a relatively small contributor to South Asia’s CO₂ emissions compared to other regions, the rapid pace of urbanization and likely acceleration of motorization trends present a threat to mitigation efforts in the future. Urbanization, while low compared to other regions, is proceeding at a fast pace, and the mobility demanded by new urban populations serving the new information economy in rapidly transforming cities such as Bangalore, Hyderabad, and Mumbai is indicative of the looming challenge to future mitigation. India has already undertaken substantial steps to respond to the transport demands of urbanization through technological transformation of vehicle fleets in many of its cities, adoption of the National Urban Transport Strategy, propagation of a funding mechanism through the Jawaharlal Nehru National Urban Renewal Mission, 92 preparation of a nationwide demonstration Sustainable Urban Transport Program, and development of ambitious biofuel goals. The motorization in the region has long been predicted and is well documented.

284. Current policy measures and initiatives, while well-commended, may not be sufficient to address the impending increase in transport carbon emissions. Whether the various initiatives and measures being put in place by national and local governments will be sufficient to keep transport CO₂ emissions restrained in the future is an open question. The demand for vehicular travel was forecast to be high even before the announcement of plans to build and market small, low-cost cars in India. Even more

92 Under this program, the national government provides 35 percent of infrastructure investment funds to cities over 4 million people; 50 percent of such funds to cities over 1 million people; and 80 percent of such funds to certain enumerated cities under 1 million people. In all cases, the cities must undertake certain reforms, develop a city development plan if it does not already have one, and finance the remainder of the investment with a combination of state, city, or outside resources (such as development finance).
aggressive measures than those already under way may not be effective in maintaining low transport emissions if motorization rates accelerate precipitously as a result. The focus would need to be on the energy efficiency of the fleet and integrated planning measures.

285. **Integrated urban transport planning will be key to achieving sizable mitigation in the transport sector.** According to a study carried out by the World Resources Institute’s Embarq Center in cooperation with the World Bank during 2007, a policy scenario that emphasized both developing integrated public transport systems – including bus rapid transit and harmonizing transport and land use development – and engaging in rather aggressive transport demand management strategies was found to lead to the lowest level of CO₂ emissions growth through 2030, compared with market-based energy efficiency initiatives and a standards-driven clean two- and three-wheeler scenario. In the integrated urban transport scenario, total transport-related CO₂ emissions were still projected to increase by a factor of nearly 5 (i.e., 39 percent less than the business-as-usual scenario), and per capita transport-related CO₂ emissions by a factor of 3.4, but these increases were the lowest of the scenarios (Box 13.1). The implication is clear. For the short term policies that target fuel efficiency are vital. For the long term integrated transport systems that include bus rapid transport, land-use policies and aggressive demand side management will be needed to curb the growth of transport related emissions. Ultimately new technology will be required to render clean energy transport carriers more economic.

**Box 13.1 Scenario Assessment of Future Growth for the Transport Sector in India and the Impact of Nano Distribution on GHG Emissions**

The study, carried out by Embarq and the World Bank in 2007, defined four scenarios for potential development and growth of the transport sector. They were the following:

i. **A baseline scenario** (“business-as-usual” or BAU), whereby projections of GDP are used to forecast projections of vehicle ownership; vehicle ownership rates at different levels of GDP are assumed to be the same as those observed in the Republic of Korea over the past two decades; two-wheelers ownership rates continue at the same trajectory; and infrastructure (or lack thereof) is not considered a constraint on this level of ownership.

ii. **An energy efficiency scenario** (EF), whereby “higher fuel prices and taxes drive consumers to both smaller and more efficient cars”. Those taxes are assumed to be the rates that presently characterize Japanese policy. These prices drive not only choice of cars but also the extent to which they are driven.

iii. **A clean two- and three-wheeler scenario** (“two-wheeler world” or TWW), in which Indian policy focuses on developing very clean two-wheelers in recognition of the enormous difficulties in transforming its infrastructure to one that accommodates the large growth in passenger cars assumed under the baseline scenario. Under this scenario, use of public transport grows marginally faster than in the base case, and growth in car ownership grows slower than in the base case.

iv. **An integrated urban transport planning approach**, in which cities focus on developing integrated public transport systems, including bus rapid transit, coordination with land use development, and engagement in rather aggressive transport demand management strategies.
In response to the announcement of the production of the Nano by Tata Motors, and a competitor by the Renault-Nissan-Bajaj consortium, an additional scenario, “Nano world”, was added to the repertoire.

Tata Motors announced in February of 2008 that it would begin producing and selling a mini-car branded as the “Nano” for the South Asian market. This car would sell for Rs. 100,000—about US $2,500—per vehicle, making it the least expensive car on the market. Its price point would make it about half as expensive as its nearest competitor, Suzuki’s Maruti 800, currently the top selling car in the Indian market. It has already set the stage for a price war and marketing war in the Indian car market. Renault-Nissan recently announced a partnership with Bajaj to produce a competitor to the Nano—the “ULC”.

The halving of the cost of owning a car will have huge implications on India’s, South Asia’s—and, indeed, the world’s—climate change footprint in the coming years. In fact, the penetration of the Nano into the South Asian vehicle market could swamp the combined effects of any of the measures discussed in this chapter, notwithstanding the relative high fuel economy of the Nano. Indeed, that fuel economy, anticipated to be 22 kilometers per liter (city) and 26 (highway), would presumably be set somewhat by additional driving that would not have occurred were people driving lower fuel-economy cars.

**Forecast of Modal CO₂ Emissions for Adjusted WRI’s Embarq-World Bank India Scenarios**

![Forecast of Modal CO₂ Emissions for Adjusted WRI’s Embarq-World Bank India Scenarios](image)

*Source: Schipper et al. 2007.

* “Other” refers to small, low-cost car use in the Nano world scenario, and bus rapid transport use in the integrated urban planning scenario.

**Opportunities for World Bank Engagement**

286. **The World Bank should advocate a multipronged approach**, as summarized in Table 13.5, but its comparative advantage probably lies in providing substantive support for the kinds of policies envisioned in the integrated urban transport planning scenario described earlier. Specifically, its comparative advantage, through technical and financial support, probably fits most squarely with the following types of measures:

- **Support for public transport enhancement and integration**. Public transport must be seen as a viable alternative for different segments of the population,
particularly those who might otherwise use cars or two-wheelers. To engage in such support, the overall emphasis should be on network connectivity and integration; the types of measures that are specifically needed will depend on local circumstances. The World Bank’s resources should be used to provide unbiased advice regarding the best way to enhance public transport as a network – as opposed to the development of individual services – for a given amount of resources. The Sustainable Urban Transport Project in India, supported by the Global Environment Facility, is an early example of this type of support.  

- **Support for more aggressive transport demand management.** While often politically unpopular, aggressive transport demand management will increasingly be a necessity to grapple with the kinds of challenges South Asian cities will face over the next several decades. Transport demand management measures include strategic use of parking charges and parking management rules to discourage use of private vehicles for commuting to work or school; control of traffic flow in such a way as to prioritize high-occupancy vehicles, particularly public transport; employing congestion charges for particular facilities or in dense traffic zones to keep traffic flowing without inducing additional travel; and vehicle pricing regimes that are oriented toward use rather than fixed periods of ownership, such as pay-as-you-drive vehicle insurance, or annual registration fees linked to recorded kilometrage of vehicles. Because these kinds of measures affect public allocation of road space, they create “winners and losers”, but the latter tend to be more vocal and strident in expressing their opinions to policy makers. The Bank might be able to take better advantage of opportunities for one-time compensation through the use of DPLs and other instruments. Voluntary policies that target fuel efficiency could provide the first stepping stone to pave the way for more robust measures.

- **Improved support and priority placed on long-range urban planning,** particularly integration of land use planning, facility siting, and transport network developments. The Bank would emphasize that the trajectories of vehicle usage patterns, and resulting CO₂ emissions, are set at the time of urbanization, and that subsequent opportunities to reduce CO₂ emissions resulting from such patterns are limited. Engaging such an agenda would mean closer cooperation between the transport and urban sectors than has been World Bank practice in the past, as well as incorporating new areas of focus for each.  

- **Improved due diligence in ensuring that climate change impact assessment be integrated across a range of projects in which the World Bank and its client**

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93 The total GEF grant proposed for the project is US$25 million, which will be complemented with a grant of US$150 million from the government of India, state governments, and implementing agencies, along with a US$200 million investment loan from the World Bank, implemented over a four-year period, starting from 2009. The project’s objectives are (i) to strengthen capacity of the national government, as well as participating states and cities, in planning, financing, operating, and managing sustainable urban transport systems; and (ii) to assist states and cities in preparing and implementing demonstration “green transport” or “GEF-supportable transport” projects (GT projects).

94 As was expressed recently in a Brown Bag roundtable on this subject, this emphasis probably means that staff of both the urban and transport sectors will need to leave their “comfort zones”.

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countries are involved, not simply those that target climate change. Such an emphasis has implications for both Bank work and the way it interacts with clients, as follows:

- Upstream strategic evaluation to be given greater priority than downstream, project-by-project evaluations (e.g. alternatives analysis more important than feasibility studies, strategic environmental assessment more important than environmental impact studies, etc.)
- Greater attention to be paid to secondary and cumulative impacts in both environmental and economic analyses of a range of projects, including health, education, urban, social development, and transport projects.

287. The World Bank should also strengthen its institutional position in the region, beyond the role of simply financing and providing technical assistance to particular projects. First, it will need to develop the dexterity to not only engage countries on issues related to the demand for vehicular travel, the energy intensity of vehicle fleets, and the fuels available for use in the transport sector, as outlined in this report, but also to understand the best way to engage with governments and other institutions on each of these issues. The Bank should also be prepared to provide expertise and policy clarity to countries throughout the region, not only India. This would involve identifying the resources to allow more concerted engagement in ongoing processes, such as the Clean Air Initiative for Asian Cities, or for organizing events to help disseminate best practice. It will need to engage counterparts at national and sub-national levels, particularly in cities, given that motorization and policies will have their loci primarily at the city level. Again, the GEF Sustainable Urban Transport Project could provide a model for the type of engagement necessary.
<table>
<thead>
<tr>
<th></th>
<th>Reduce the demand for vehicular travel</th>
<th>Reduce the energy intensity of the vehicles used</th>
<th>Reduce the life-cycle carbon intensity of the energy sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport sector as a whole</td>
<td>• Shift the lifetime costs of vehicle ownership from time- to use-basis as much as possible</td>
<td>• Fuel economy or CO₂ emissions standards for vehicles entering fleet beginning with voluntary standards</td>
<td>• More extensive production and use of biofuels (e.g. <em>Jatropha</em>-based biodiesel, sugar, or woody-biomass-based ethanol)</td>
</tr>
<tr>
<td></td>
<td>• Invest in viable public transport networks, and ensure that they are competitive with private vehicles in terms of frequencies, travel time, and cost (e.g. bus rapid transit, metro, rail, where appropriate)</td>
<td>• Develop scrappage programs to target older and inefficient vehicles, and tie these programs into labor market development programs whereby former owners have alternatives to simply buying another vehicle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• &quot;Feebates&quot; and other incentive mechanisms to encourage purchase of fuel-efficient cars (such as hybrids) without further incentivizing motorization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban passenger transport</td>
<td>• Coordinate land use with public transport networks by focusing development on corridors and at nodes, and mixing primary land uses where possible, coordinate and think more strategically about facility siting and land use change relative to transport networks; use value capture of the one to help finance the other</td>
<td>• Develop production and distribution capability for low-sulfur diesel, so that diesel with advanced exhaust aftertreatment is a viable alternative to compressed natural gas (CNG)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Encourage cycling and walking by creating favorable conditions for both. This means focusing on facilities, motorist behavior, and public attitudes</td>
<td>• Accelerate transition from 2-stroke to 4-stroke vehicles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use network, parking, and vehicle pricing to incentivize travel in vehicles with higher occupancy (i.e. transport demand management)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Where and when appropriate, limit access to key activity centers of city by private vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-urban passenger transport</td>
<td>Reduce the demand for vehicular travel</td>
<td>Reduce the energy intensity of the vehicles used</td>
<td>Reduce the life-cycle carbon intensity of the energy sources</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------</td>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Limit growth of short- and medium-distance air travel by identifying key intercity corridors and developing strategies to strengthen ground transport connections</td>
<td>• Develop and implement fleet maintenance programs</td>
<td>• Rail electrification where appropriate</td>
</tr>
<tr>
<td></td>
<td>• Consider pricing noncommercial facility use in such a manner as to discourage noncommercial intercity vehicle-kilometers of travel (VKT) growth</td>
<td>• Disseminate best practices on aerodynamic loading and vehicle operations, and incentivize their adoption (e.g. USEPA SmartWay)</td>
<td></td>
</tr>
<tr>
<td>Freight transport</td>
<td>• Multimodal integration</td>
<td>• Expand rail services through strategic, commodity-targeting-led investments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Create logistics management incentives to reduce truck vehicle-kilometers traveled</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source:* Based on Darido 2008.
Chapter 14. The Urban Sector

Cities have a twofold relationship with climate change. On the one hand, they are the magnets of consumption and production and their footprint accounts for the bulk of greenhouse gas emissions. On the other hand, with their high concentrations of economic activity and population, cities are also vulnerable to the impacts of climate change. Urbanization is increasing: cities around the world are projected to be home to 60 percent of the world’s population by 2030, compared to 50 percent today (UNFPA 2007). This process of urbanization will inevitably be accompanied by higher incomes, innovation, and specialization and greater use of energy-intensive goods, such as cars and household appliances. The growing impact of cities will require particular consideration when planning measures to mitigate and adapt to the effects of climate change.

Greenhouse gas emissions in cities are generated primarily through transportation, energy use, and public services. Buildings use energy for lighting, heating, and cooling. Air conditioning in households is a major cause of emissions as rising temperatures result in increased energy use. This is exacerbated in cities, where temperatures are already higher than in the surrounding rural areas due to the urban heat island effect. Public services, such as power supply, wastewater disposal, sanitation, drainage and land fills, are also major contributors to greenhouse gas emissions.

The concentration of people and assets in cities increases their vulnerability to climate change. Cities are vulnerable to a range of climate-related impacts, such as flooding, storm surges, landslides, drought, salt water intrusion, and cyclones, and also to earthquakes and other hazards, the effects of which are exacerbated by poor-quality and ill-maintained infrastructure, low-quality building stock, and the low resilience of much of the population. Coastal cities are especially endangered by rising sea levels and more intense weather phenomena, including storm surges. Other impacts include decreased water availability and adverse impact on human health due to the incidence of vector- and water-borne diseases. The poor, with their limited access to safe areas and scant livelihood opportunities, are especially vulnerable and bear the greatest burden of such impacts.

The cities are where a significant part of the battle against climate change will be won or lost. Cities can adopt various widely adopted mitigation strategies, such as improving energy efficiency, building codes, public transport, and capturing greenhouse gases from wastewater treatment and solid waste disposal facilities. Furthermore, adaptation measures need to be more localized and geared to particular circumstances.

Urban Sector in South Asia

Vulnerability to Climate Change

Cities in South Asia are particularly vulnerable to climate change impacts. This is due to a combination of nonclimatic and climatic risks. Factors such as high levels of poverty, underperformance in service delivery, infrastructure gaps, and lack of...
capacity increase the vulnerability of South Asian cities. Climatic risks include sea level rise and changes in precipitation and temperature, which will affect water supply and energy availability and use, and increases in extreme events such as cyclones, floods, and droughts, impact of wind (dust, suspended particles), etc.

293. **The threats are likely to grow as cities expand in a largely unplanned manner.** Historically, the South Asia region has been the least urbanized region in the world (Figure 14.1). However, this trend is set to change. The annual urban growth rate is 2.53 percent, faster than that of Asia as whole (2.4 percent) and of the world (1.98 percent) (United Nations Population Division 2007). Close to 400 million people live in South Asian cities, more than the total populations of the Latin America and the Caribbean and Africa regions. The region has three of the 10 most populous countries in the world – Bangladesh, India, and Pakistan – and five of the world’s megacities: Karachi, Mumbai, Delhi, Dhaka, and Kolkata (Figure 14.2). It has more than 60 urban agglomerations having populations over 500,000. Among South Asian countries, Pakistan has the highest urbanization rate in the region, followed by India, Bangladesh, Sri Lanka, Nepal, and Bhutan. Table 14.1 shows changes in the percentage of the total population living in urban areas in South Asian countries between 1990 and 2006.

**Figure 14.1 Urbanization and Economic Development: South Asian Countries in World Context**
294. Much of this growth is fueled by rural–urban migration, and climatic stresses could induce sudden spikes in migration. Economic growth has resulted in a decrease in the proportion of households in the farm sector relative to the nonfarm sector, representing a shift in population and economic activity from rural areas to urbanized areas. For example, between 1984 and 1996, the percentage of households in the farm sector in Bangladesh decreased from 73 to 66 percent, while in the nonfarm sector it increased from 27 to 34 percent. Over this period, the proportion of nonfarm households grew at a rate of about 4 percent per annum, almost triple the rate for farm households (Deshingkar and Farrington 2006). The United Nations Population Division projects that world population will grow by almost 500 million at an annual urban growth rate of 2.6 percent for the next 20 years (2007). Climatic changes in South Asia are likely to result in
sudden spikes of rural–urban migration and may even cause urban unrest (Cruz et al. 2007).

295. **Local governments in South Asia are struggling to cope with the rising demands and problems associated with urbanization and rapid economic growth.** The region’s cities lack adequate infrastructure to meet the demands of the current population and the growing influx of migrants from rural areas. The burgeoning population rapidly outpaces the provision of basic municipal services such as water, sanitation, electricity and solid waste management. Improving living standards lead to higher demand for cars, bigger apartments, and more energy-intensive electrical goods such as televisions, refrigerators, and air conditioners. Environmental quality is rapidly deteriorating in the cities with air pollution, poor solid waste management, and polluted water resources. Some of these problems, for example air pollution and improper management of landfills, directly contribute to climate change. Other problems, such as pollution of water resources, could be minimized by adopting various climate change adaptation strategies. Co-benefits of this nature should be further explored and adopted in combating urban-related climate change issues.

296. **Climate change will exacerbate the problems arising from urban poverty.** Particular attention needs to be paid to climate change impacts on the urban poor. It is well recognized that climate change will affect the poorest populations, who are usually located in high-risk urban environments and are least able to cope with changes in climate. Urban poverty in South Asian cities is significant, with most megacities harboring more than 50 percent of poor residents. This high level of urban poverty is a major issue that needs to be addressed in urban-related climate change agendas.

### Risks Associated with Climate Change

297. **South Asian cities will face a number of risks emanating from climate change.** Three principal sources of risk – sea level rise, changes in precipitation and temperature, and extreme events – are explored further in the ensuing paragraphs.

298. **Sea level rise.** Rising sea levels are predicted to negatively affect coastal infrastructure and coastal cities such as Mumbai, Kolkata, Karachi, and Chittagong. Table 14.2 shows the total urban population in South Asia and the urban population residing in the low-elevation coastal zone, less than 10 meters above sea level, in 2000. Among the South Asian countries, Bangladesh and Maldives would be the most impacted by sea level rise in terms of percentage of land area affected by any projection of sea level rise. More than 80 percent of the landmass of Maldives will be inundated by a one meter sea level rise, while about a million people will be directly affected in Bangladesh by 2050. In addition, coastal areas are susceptible to increasing salinity of ground and surface water due to sea level rise.
Table 14.2 Total Urban Population and Urban Population in the Low Elevation Coastal Zone in 2000

<table>
<thead>
<tr>
<th></th>
<th>Total urban population (in ‘000)</th>
<th>Urban population in low-elevation coastal zone (in ‘000)</th>
<th>Urban Population in low elevation coastal zone (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>4,320</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>30,692</td>
<td>15,429</td>
<td>50</td>
</tr>
<tr>
<td>Bhutan</td>
<td>148</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>India</td>
<td>301,206</td>
<td>31,515</td>
<td>10</td>
</tr>
<tr>
<td>Maldives</td>
<td>6</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>Nepal</td>
<td>2,719</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pakistan</td>
<td>48,111</td>
<td>2,227</td>
<td>5</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>4,223</td>
<td>962</td>
<td>23</td>
</tr>
</tbody>
</table>


299. Changes in precipitation and temperature. Climate change is predicted to increase the variability of precipitation and raise temperatures across South Asia. This will have a range of outcomes with potential negative impacts on urban areas, including heatwaves and the accompanying threat to water supplies; flooding, compounded by inadequate wastewater treatment systems and stormwater drainage facilities; and health-related issues, such as outbreaks of cholera and contamination of drinking water. Climate change will also likely bring higher frequency and intensity storms and cyclones. Particularly vulnerable are the urban poor who live in temporary shelters in typically vulnerable locations.

Climate Change and the City Governance Challenge

Facing the Institutional Challenge

300. Current urban management responses will be insufficient to address climate change threats. Despite recent improvements in urban physical infrastructure, there remains a huge gap in attaining a full coverage of services. Investments have focused more on building infrastructure than on service provision. Ineffective planning has resulted in inadequate, and in some cases a total lack of, provision of services, including wastewater treatment, stormwater drainage, and collection and disposal of solid waste. Pervasive weak city and utility finances hamper further development and limit the ability of cities to solve their own problems. Investment therefore becomes heavily dependent on programs sponsored by higher levels of government.
301. **The institutional dimension is critical when dealing with the climate change agenda.** Local governments are often unable to work with poor communities – those most at risk. Moreover, most South Asian cities are characterized by inefficient urban planning, which has led to discriminatory land use regulations and a limited supply of land for commercial, industrial, and residential development. Land in these cities tends to have a high price relative to household and business incomes as demand exceeds the finite supply. Many urban governments have weak capacity and are strongly influenced by central and state or provincial governments. Lack of fiscal decentralization limits the financial autonomy of cities and their utilities are often operated by inefficient state companies, without adequate performance incentives or clear delegation of responsibilities at the city level.

302. **There is a large overlap between the climate needs and the development needs of cities.** In many cases, adaptation to climate change involves improvements in basic infrastructure, with positive outcomes for inhabitants who live in poor-quality housing and lack access to water, sanitation, and drainage facilities, and who are most likely to be affected by flooding, drought, sea level rise, and other predicted consequences of climate change. The adaptation actions that are needed will vary by threat and location. Box 14.1 summarizes the more common elements of these.

### Box 14.1 Potential Strategies for Adaptation to Climate Change

Strategies to improve adaptation of cities to climate change include:

- **Drainage system.** Flooding can be mitigated by installing stormwater systems, providing proper drainage from household water, rain and waste disposal sites, and improvement of solid waste and water supply would also contribute to the mitigation of potential floodings.

- **Disaster risk management.** Contingency plans should be prepared to deal with natural disasters such as flooding. The building of larger water reservoirs and other facilities for sufficient storage of water in the case of drought is needed, in addition to dikes against surges of flooding and seawater.

- **Strengthening the knowledge base.** Increased knowledge of the consequences of climate change and the development of related adaptation responses in South Asian countries will render governments better able to cope with and respond to climate risks.

- **Improving energy efficiency of buildings and construction.** This measure will help reduce the heating and cooling demands of offices, dwellings, and other buildings.

303. **There is also a considerable overlap between adaptation and mitigation measures in the urban context.** For example, improving the energy efficiency of buildings through improved insulation, reflective glass, and efficient air conditioning will mitigate climate change by reducing greenhouse gas emissions while also rendering the urban infrastructure more adaptable to warmer climatic conditions. Mitigation and adaptation potential in solid waste management can also be explored to avert further increase in emissions and the spread of water-borne diseases related to climate change. Likewise, improving efficiency in water supply and sanitation facilities would help to both curb greenhouse gas emissions and preserve water availability and quality.
304. **Urban water supply and sanitation services, already inadequate relative to urban demand, are likely to be further jeopardized by climate change.** In the region, a relatively low 84 percent of the population has access to water supply. Reduction of water wastage and leakages in urban water infrastructure, and demand management will be some of the key strategies required to address potential threat to urban water services. In the region, approximately 35 percent of the population has access to sanitation. Wastewater treatment is generally absent, with most treatment plants not functioning. Overall, despite significant recent investments in water supply and sanitation in South Asian countries, particularly India, it is expected that the region will not attain Millennium Development Goals on these basic services. The effects of climate change will only render that shortfall more likely.

305. **Urban infrastructure and maintenance is poor throughout the region and is essential to addressing climate threats.** Inefficient water supply systems (physical losses of more than 50 percent of the water produced are common) exacerbate the water availability risk posed by increased droughts, and aged and inefficient pumping systems increase the demand for electricity. Flooding and the lack of wastewater treatment systems, coupled with inadequate stormwater drainage facilities, may in emergency situations result in major public health threats such as outbreaks of cholera and contamination of drinking water. Improved operational planning and maintenance of basic infrastructure are needed to ensure that services function when required.

**Elements of an Urban Climate Change Strategy for South Asia**

306. **An urban climate change strategy needs to be fully linked with and integrated into a larger development framework for cities and made fully coherent with the disaster management program, with which it shares many overlapping elements.** The Bank will need to be selective in its efforts to build climate resilience in South Asian cities. The size of the Bank financed urban portfolio is generally very small compared to overall investments in urban and water in the region. This is particularly true in India, where the World Bank portfolio represents less than 3 percent of investments. Furthermore, these infrastructure projects are concentrated in a few cities and locations. The Bank is better positioned to contribute in aspects such as policy dialogue, knowledge sharing, and capacity building. It can also contribute by initiating demonstration climate-resilient projects that can be replicated more widely.

307. **Concentrate on the Bank’s comparative advantage.** The Bank’s current portfolio and near-future pipeline represent a small percentage of investment in urban infrastructure. The Bank is better positioned to contribute in aspects such as policy dialogue, knowledge sharing, and capacity building. In particular the Bank can assist cities in developing their own climate change agendas. Also, as noted in a World Bank study on climate change mitigation in cities (World Bank 2008), there are a number of opportunities to make ongoing and future urban projects make significant contributions to the mitigation and adaptation agendas (Box 14.2).
Synergies between urban and climate change strategies. A number of climate change adaptation strategies are synonymous with sound urban management. The agendas for urban climate change and city management largely coincide with and reinforce each other. For example, reducing leakage in water supply pipes reduces wastage, which is an adaptation strategy, but also increases revenue, which is an effective city policy. In many cases, climate change does not create new infrastructure and service delivery challenges, but exacerbates current ones. Both agendas serve to reduce vulnerability by designing and building resilience to climate-related scenarios. Similarly, city development and climate change mitigation agendas have many points in common, such as lowering pollution, increasing the efficiency of buildings, and building energy-efficient infrastructure. Given that climate change mitigation and adaptation may not be top priorities for South Asian cities, as these cities face other pressing and more immediate challenges, the synergies between the two agendas should be highlighted.

Synergies between urban strategies and disaster risk management and reduction. Local climate change impacts will progressively be felt through an increase in severity and frequency of disasters, such as cyclones, storms, and floods, as well as by changes in mean conditions that could alter the vulnerability of populations to hazards. Disaster risk management encompasses actions taken to reduce impacts of disasters before, during, and after they occur. Hence, one of the main entry points for engaging cities on climate change is through disaster risk management, specifically through policies and incentives that are in the pecuniary interest of cities. For example, with better land zoning and building codes as means of reducing climate change and disaster-related risks, city officials can increase value capture through increased property taxes. India is one of the few countries that has a central and various state agencies to address disaster risk management (Revi 2007). The Bank should assist these agencies in integrating climate change adaptation within their agendas.

Maximizing mitigation potential. Services such as solid waste disposal and wastewater treatment are large generators of greenhouse gas emissions, particularly in cities with inefficient management and improper techniques. Where possible, South Asian cities should be encouraged to adopt mitigation strategies, be aware of technology options, and be able to access the carbon finance market. The World Bank can play a key role in knowledge and capacity building in this respect.
311. **Institutional development.** Institutional development would include assisting cities to prepare for climate change. A model is needed that would facilitate the integration of climate change risks into major infrastructure investments. Infrastructure projects, particularly in energy, transport, and telecommunications, generally have long life spans, and it is easier to plan them in such a way as to minimize damage and destruction from extreme events as adaptation at a later time can be difficult.

312. **Capacity building.** The capacity of South Asian cities to put in place and implement programs related to climate change is low. While a thorough capacity assessment has not been conducted, low capacity is evident, as cities are still struggling with weak finances, low level of public services, and inefficient transportation systems. Lack of effective decentralization makes management of climate change a particularly large challenge. Going forward, it is important to keep in mind the following:

- States in India and provinces in Pakistan are crucial interlocutors in any climate change effort, even in large cities.
- Larger efforts would be needed to empower cities to be able to better face the challenges of climate change mitigation and adaptation.
- The response to climate change represents an opportunity for cities in South Asia to hasten the pace of the decentralization agenda, thereby reaping a number of co-benefits.

313. **Continue to promote decentralization.** While most urban programs in South Asia will be funded by state or provincial and central governments, such programs should be designed in a way that places the recipient cities in the driver’s seat, taking key decisions during the planning and implementation phase. Higher levels of government should have a supportive role.

314. **The current and proposed urban portfolio in South Asia contributes directly and indirectly to the climate change agenda, both on mitigation and adaptation.** However, there is potential to increase the impact on climate change through Bank operations that remain untapped. Future Bank urban operations in South Asia, should be designed to place more emphasis on climate change. Some examples include:

- Ensure that infrastructure is conceived and designed taking into account predicted impacts on hydrology.
- Pay special attention to implications for the poor, particularly in slums.
- Include capacity building and training within institutional strengthening and governance components.
- Look for opportunities to include climate change-related analytical and advisory activities.
- Share knowledge of policies and practices that have worked in the past in similar situations and across countries, and become a repository of knowledge.
- Participate in carbon finance, cap-and-trade mechanisms, and global reporting initiatives.
Appendix. Country Profiles
Afghanistan

Afghanistan is a mountainous and very arid country in South Asia that has grappled with a long history of violent conflict and drought. Agriculture is the primary source of productivity and livelihood in the country, accounting for 48 percent of GDP and 85 percent of total employment. Prolonged drought and violent conflict have limited its development and has caused extensive degradation to its natural and physical capital, limiting its future growth opportunities and capacity to adapt to climate shocks. The rapid loss of forest and plant cover over the last 25 years has accelerated soil erosion and land degradation in the country, making it susceptible to landslides, flash floods and extreme flooding events. Human development in the country has been among the lowest in the world. Water shortages, desertification and future environmental degradation, which are impending threats of climate change, and continued conflict are expected to mire the country to deeper poverty and protracted underdevelopment.

Observed Climate Trends

Afghanistan has experienced an increase in temperature and frequency of hot days and nights since 1960. Average temperature has been recorded to increase by 0.6°C and there were 25 more hot days and nights observed than usual. The shortfall in precipitation of 2% per decade led to the prolonged drought condition in the country. Rainfall has become scarcer particularly during the months of March to May, declining by 6.6% per decade since 1960. Afghanistan is also at risk from drought, cyclone and flood.

Projected Future Climate Trends

The country is predicted to experience a warming of 1.4° to 4°C by 2060s and 2.0° to 6.2°C by 2090s. Days considered ‘hot’ by current climate standards will increase by 14–25 percent by 2060s and by 16–32 percent by 2090s. The duration of heat wave will rise by 26 days. Cold days and nights, on the other hand, will become exceedingly rare, occurring on 0–6 percent of days by 2090s. The increase in temperature will be accompanied by a reduction in annual rainfall, particularly in the wettest season. Mean annual precipitation will decline by 10 percent in 2030–2049 from their 1980–1999 level. By 2090s, projections will vary between -31 percent and +28 percent with median values of -5 to -8 percent. These changes in temperature and rainfall will reduce annual runoff. By mid-century, annual runoff decreases by 24 percent. Despite overall decreasing trends in total rainfall, precipitation during heavy events will tend to increase.
## Current GHG Contribution

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG Emissions</td>
<td>8.8 MtCO₂ eq</td>
</tr>
<tr>
<td>Emissions per capita</td>
<td>0.9 tCO₂ eq</td>
</tr>
<tr>
<td>Emission intensity</td>
<td>1185 tCO₂ eq/US$</td>
</tr>
</tbody>
</table>

Main Sources of GHG Emissions:
- Land-Use Change and Forestry (100%)

![Graph: Afghanistan, 1990-2004](image)

Note: GDP in current PPP

## Key Climate Change Risks

### Main Vulnerabilities

- **Water Resources**
  - Water scarcity due to reduced precipitation, increased evapotranspiration and long run depletion of water supplies of glacier fed rivers
- **Public Health**
  - Increasing risk from malaria
- **Natural Disasters**
  - Flooding from glacial melt, drought and desertification
- **Social Development**
  - Food insecurity, malnutrition and possible migration and conflict
- **Agriculture and Ecosystems**
  - Exposure of agriculture (pasture), wetlands and other ecosystems to drought and desertification

### Mitigation Issues:

- Continued reliance upon fuelwood for primary energy supply (85–97 percent)
- Growth of emissions from land-use changes and deforestation due to population growth and conflict

**Sources:** World Bank Climate Change Portal; World Resources Institute Country Profiles (http://www.earthtrends.wri.org/); UNDP Climate Change Country Profiles (http://country-profiles.geog.ox.ac.uk/).
Bangladesh

Bangladesh is one of the most populous countries in South Asia and has one of the highest proportions of the poor in the world. The country is comprised of low-lying lands, which are about less than 1 to 6 meter above sea level. About 80 percent of its land are floodplains and are thus prone to flooding. It is also frequently visited by extreme climatic events, which have become normal to the country, causing damage to life, property and economy. The country’s geographic location, low elevation, high population density and poverty incidence and dependence upon natural resources and services render the country particularly vulnerable to future climate change. The increased precipitation, rapid glacial retreat in the Himalayas and rise in sea level will increase the likelihood of flooding in the future. The increased incidence and severity of extreme events under climate change will also bring greater damages to the country.

**Observed Climate Trends**

Average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during 1985–1998. Rainfall exhibited increasing trend and irregularity. Serious and recurring floods have taken place and the frequency of monsoon depression and cyclones formation in Bay of Bengal has increased. Between 1991 and 2000, 93 major disasters were recorded in the country. Some areas of the country are also at high risk from drought.

The increase in sea level in coastal Bangladesh in recent decades has already led to coastal inundation, erosion, saline intrusion, loss of biodiversity and agriculture and migration. Salt water intrusion from the Bay of Bengal affects about 100 kilometers or more of its inland in dry season.

**Projected Future Climate Trends**

Temperature and rainfall projections for Bangladesh over the next decades show significant increase over both monsoon and winter. Temperature is expected to increase by 1°C in 2030 and up to 2.7°C by 2100, while precipitation by 3.8 percent in 2030 and 9.7 percent in 2100. A significant increase in runoff is estimated, leading to more flooding.

**Areas Vulnerable to Flooding**

Bangladesh will likely to continue to be vulnerable to more intense storm surges. Currently, storm surge range from 1.5 to 9 meters. Future rise in sea level will further exacerbate its damages.
Current GHG Contribution

Emissions: 112.8 MtCO₂ eq
Emissions per capita: 0.9 tCO₂ eq
Emission intensity: 574.6 tCO₂ eq

Sources of Emissions:
Agriculture (47%), energy (21%), waste (10%)

Key Climate Change Issues

Main Vulnerabilities

○ *Agriculture*
  Lower agricultural output and incomes, and food insecurity through diminished yields and loss of land

○ *Ecosystems*
  Loss of biodiversity particularly in coastal ecosystems – Sunderbans at high risk, increased sea temperatures of 2°C above long term average and reduced fishery production.

○ *Water Resources*
  Freshwater stress, groundwater depletion and reduced fish aquaculture production

○ *Disasters and Other Hazards*
  Exposure to more intense cyclones and drought in some areas, combined impacts of sea level rise and glacial melt lead to increased incidence of flooding and land loss.

○ *Public Health*
  Increased incidence of heat-related illnesses, water-borne diseases, poverty, child and infant mortality; lower access to safe water and sanitation, loss of settlements and damages to infrastructure, possible migration

Mitigation Issues:

○ Increased coal dependence (risks of early transition to coal)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Certainty</th>
<th>Timing</th>
<th>Severity</th>
<th>Importance of Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Resources</td>
<td>M-H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Coastal resources</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Human health</td>
<td>L-M</td>
<td>M</td>
<td>M-H</td>
<td>H</td>
</tr>
<tr>
<td>Agriculture</td>
<td>M</td>
<td>L-M</td>
<td>L-M</td>
<td>H</td>
</tr>
</tbody>
</table>

Priority Ranking of Climate Risks
L-low, M-medium, H-high

Sources: World Bank Climate Change Portal; World Resources Institute CAIT (http://www.wri.org/project/cait); Ahmed and Rahman. n. d.
Bhutan

Bhutan is one of the smallest countries in South Asia, but has the most abundant forest and water resources in the region. Its economic growth and livelihood is dependent upon ecotourism, biophysical resources and hydropower its natural resources generate. Despite the fact that the country is landlocked, agriculture contributes to a fifth of its economy. Climate change presents many threats to Bhutan. The retreat of glacier cover in the recent decades has already led to the formation of supra-glacial lakes and to breach in critical geostatic thresholds of several glaciers. The risk of glacier lake outburst flood is impending as the rate of glacier melt accelerates in the future. Steep slopes and heavy monsoon rains also render the entire country susceptible to flash floods and landslides.

Source:

Nominal GDP: US$ 0.94 billion (2006)
Economic activities: Agriculture (22%), hydropower (%)
GNI per capita: US$ 1,430
Population: 0.649 million (2006) Urban (11.4 %)
Land Area: 47,000 sq. km, Agriculture land (% of total): 12.6

Observed Climate Trends
Average temperatures and precipitation in Bhutan increased by 7 percent in 1990-2000 from their levels in 1960–1970. The increase in the temperatures in recent decades has led to the reduction in Bhutan’s glacial cover. Glaciers in Bhutan have been receding at a rate of 30–60 meters per decade. While the risk of GLOF has increased in recent times, the country has been vulnerable to flood, cyclones, landslides and, most especially, drought.

Projected Future Climate Trends

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Dec-Feb</th>
<th>Jun-Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020s</td>
<td>+0.5 – +1.5 °C</td>
<td>+0.2 – +0.8 °C</td>
</tr>
<tr>
<td>2050s</td>
<td>+1.5 – +4 °C</td>
<td>+0.25 – +2.25 °C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Precipitation</th>
<th>Dec-Feb</th>
<th>Jun-Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020s</td>
<td>-15 – +18 %</td>
<td>+2 – +12.5 %</td>
</tr>
<tr>
<td>2050s</td>
<td>-15 – +20 %</td>
<td>+5 – +20 %</td>
</tr>
</tbody>
</table>

A significant increase in temperatures is predicted through the early to the middle of the 21st century and both coarser and higher resolution climate model predict an increase in precipitation over Bhutan. Precipitation will become more intense and erratic, while glaciers continue to melt, both exacerbating the risk of floods. A significant increase in runoff also results from the changes in rainfall intensity, leading to shifts in biodiversity and ecosystems.
**Current GHG Contribution**

<table>
<thead>
<tr>
<th>Emissions:</th>
<th>0.1 MtCO₂ eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions per capita:</td>
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</tr>
<tr>
<td>Emission intensity:</td>
<td>667.9 tCO₂ eq</td>
</tr>
<tr>
<td>Sources of Emissions:</td>
<td>Forestry (100%)</td>
</tr>
</tbody>
</table>

**Key Climate Change Concerns**

**Main Vulnerabilities**
- **Agriculture**
  - Reduced agricultural production
- **Water Resources**
  - Water shortage and or groundwater depletion
- **Ecosystem and Biodiversity**
  - Loss of forest area or production, threat of biodiversity loss
- **Natural Disasters**
  - Exposure to GLOF, flooding and drought

**Mitigation Issues:**
- Increased fuelwood consumption due to population growth

**Opportunities:**
- Renewable energy technologies: hydels, solar and biomass gasifiers

India

India is the largest country and leading economy in South Asia. Its unique geography produces a spectrum of climates and a rich array of biological diversity. Its climate regime varies from humid in the Northeast to arid in Rajasthan. Climate change presents many risks to such a geographically diverse country, from increased exposure to flood, drought, cyclones and sea temperature rise to new threats of sea level rise and ocean acidification. With a huge population that ranks second in size in the world, India will be highly vulnerable to climate change and influential to its future trajectory.

Projected Future Climate Trends

Climate changes are expected to vary regionally, but a general increase in temperature is expected to rise progressively through the early to middle of the 21st century. A remarkable increase in seasonal temperature is also forecasted over the 21st century, with significant warming of beyond 4°C already expected by 2050 in the North. In the South, warming will range around 2-4°C.

Observed Climate Trends

There have been no significant increases in temperatures observed over the country. Average monsoon rainfall across the country varied across its regions, with an increase in monsoon seasonal rainfall recorded along the west coast, north Andhra Pradesh and the northwest by 10 to 12 percent and a reduction in Madhya Pradesh, the north east and Gujarat and Kerala.

The country has also been at high risk to flood, drought and cyclones.

Nominal GDP: US$ 911.8 billion
Population: 1.11 billions
Urban (29%)
Land Area: 97 million sq. km
Agricultural land (% total): 61
Irrigated land (% of cropland): 33

Current GHG Contribution

Emissions: 1562 MtCO2 eq
Emissions per capita: 1.5 tCO2 eq
Emission intensity: 655.1 tCO2 eq
Sources of Emissions:
Energy (67%), agriculture (24%)

Note: GDP in current PPP
## Key Climate Change Issues

### Main Vulnerabilities

- **Coastal and Marine Ecosystems**
  Exposure to sea level rise, sea temperature increases, cyclone incidences
- **Water Resources**
  Impact of glacial melt, increased temperature, precipitation changes, exposure to extreme weather events and salinity intrusion on water resources quantity
- **Public Health**
  Increased heat-related illnesses and water-borne diseases and changes in epidemiological patterns
- **Agriculture**
  Exposure of agriculture to extreme weather events, more variable precipitation and changes in glacial cover
- **Natural Disasters**
  Increased exposure to flood, drought and cyclones
- **Terrestrial Ecosystems**
  Vegetation shift in forests and biodiversity, regime shifts in rangelands, decreased agricultural yields in tropics and sub-tropics, impact of glacial melt on biodiversity and low-lying agriculture
- **Urban**
  Impacts on urban infrastructure including drainage, water and sanitation

### Mitigation issues:

- Increased emissions from energy production and transformation, transport, urban, agriculture, industrial and residential sectors due to economic growth and urbanization
- Impact of climate change upon carbon sequestration capacity of forest ecosystems, other biomass and soils

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**Sources:** World Bank Climate Change Portal; World Resources Institute CAIT (http://www.wri.org/project/cait); Government of India, Prime Minister’s Council on Climate Change 2008.
Maldives

Maldives is comprised of coral atolls and hundreds of smaller islands and has more territorial sea than land. The coral reefs that surround the atolls are the seventh largest in the world and among the richest in terms of biodiversity and aesthetic value. About 70 percent of its GDP is based upon the tourism and fishery revenues derived from its marine resources. With about 80 percent of country lying 1 meter above the sea, the country is exposed to the risks of extreme weather events such as coastal inundation, flooding and saline intrusion and sea level rise. Deviation in sea temperature has also resulted to coral bleaching and mortality, most severe in areas affected by pollution and physical disturbance.

**Observed Climate Trends**

There are no significant long term trends in observed daily, monthly and annual rainfall in Maldives over the period 1975 to 2005. An increase in sea surface temperature however has been observed in the Maldives coast at S. Gan and Malé. Annual sea surface temperature trends at Malé and Gan are about 0.2°C and 1.1°C to 1.6°C per decade, respectively. Seasonal variation in sea surface temperature and mean tide level trends at Malé have consistently increased during all seasons, with the rate of increase very high.

Information on Hulhule, which provides general indication of current climate risks for Maldives, indicates a sea level increase of 1.7 millimeters per year. The maximum hourly sea level rise has been 7 millimeters per year, rate far in excess of local and global trends in mean sea level. Maximum storm surge height was 1.32 meters, which coupled with high tide could generate a storm tide of 2.3 meters. The northern part of the country is vulnerable to severe weather activities, particularly storms generated by cyclone activities in other regions.

**Projected Future Climate Trends**

Temperature is predicted to increase by 0.4°C to 1.0°C by 2025 and by 0.9°C to 1.7°C by 2050. Increase in precipitation could range from 12 percent to 19 percent in 2025 under HADCM3 scenario. Extreme daily precipitation and wind gust are likely to be twice as common by 2050 and 2025 respectively.

The return period of extreme daily rainfall and wind gust is expected to decrease, with extreme rainfall likely to occur twice as often on average by 2050. Global predictions of sea level rise of 0.48 meter to 0.88 meter could cause regular tidal inundation in most islands. Even under medium prediction, storm surges can create up to 2.78 meter waves, which could inundate even the largest islands. Under high predictions, wave height could submerge even the largest islands.
Predicted Changes in Temperature, Rainfall and Sea Level

<table>
<thead>
<tr>
<th>Model/Scenario</th>
<th>Year</th>
<th>Temperature (°C)</th>
<th>Rainfall (%)</th>
<th>Sea Level (cm)</th>
<th>Temperature (°C)</th>
<th>Rainfall (%)</th>
<th>Sea Level (cm)</th>
<th>Temperature (°C)</th>
<th>Rainfall (%)</th>
<th>Sea Level (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIRO-Mk2</td>
<td>2025</td>
<td>0.4</td>
<td>1.6</td>
<td>-</td>
<td>0.9</td>
<td>3.0</td>
<td>-</td>
<td>2.0</td>
<td>5.9</td>
<td>-</td>
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<td>12.1</td>
<td>9.3</td>
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</tbody>
</table>

Current GHG Contribution

- Emissions per capita: 1.5 tCO2 eq
- Emission intensity: 1045.30 tCO2 eq
- Emissions by Sector: Industrial processes

Focus Areas for Climate Change

**Climate Risks:**
- **Coastal and Marine Ecosystems**
  - Ecosystem damages and loss of protection afforded by coral reefs
- **Water Resources**
  - Increased salinity of groundwater resources
- **Public Health**
  - Risk of loss of life due to disasters and increased incidence of vector borne diseases
- **Tourism**
  - Reduced tourism revenues and livelihoods
- **Disasters and Hazards**
  - Physical damages from increased incidence of cyclones and flooding and inundation of islands due to sea level rise
- **Social impacts**
  - Possible migration and large scale relocation

**Mitigation Issues:**

*Sources:* Government of the Republic of Maldives, Ministry of Home Affairs, Housing and Environment 2001; World Resources Institute CAIT (http://www.wri.org/project/cait); World Bank Climate Change Portal.
Nepal

Nepal is a small landlocked mountainous country located between China and India. Its topography varies tremendously from the very high altitude in the Himalayan mountain range to the Gangetic plains in its southeast. Agriculture is the main source of its economic productivity, providing livelihoods to over 80 percent of population. The country is one of the richest countries in terms of water resources as about 16 percent of the Himalayan glacial cover is found in its mountain ranges. Its mountains also contain a remarkable biodiversity. About 8 of the 10 highest mountain peaks in the world are located in the country and nearly 4.3 percent and 8.5 percent of mammalian and bird species of the world are contained in this small country. Future climate changes could have serious implications upon the country’s agriculture, water and forest resources and biodiversity.


| Nominal GDP: | US$ 8.9 billion |
| Economic Activities: | Agriculture (40%) |
| Population: | 28 million |
| Urban (16.3%) |
| Land Area: | 143,000 sq. km |
| Irrigated land (% of cropland): | 47 |

Observed Climate Trends

There were no observed temperature increases over Nepal since 1960. There has been a small, but significant increase in the frequency of hot nights by 2.5 percent and a significant decline in the frequency of cold days and nights by 19 days and 32 nights.

Annual precipitation has significantly decreased by an average of 3.7 millimeters per month per decade. The magnitudes of 1- and 5-day rainfall maxima have shown significant increases during December to February and March to May since 1960.

The country has been exposed to high risks of flooding, with mortality outcomes observed to have increased from 1981 to 2000.

Annual Temperature Increase from 1977 to 1994

Projected Future Climate Trends

The country is expected to become warmer and wetter with more frequent heatwaves and fewer frost. Average temperature is predicted to rise significantly by 1.3°C to 3.8°C by 2060 and by 1.8°C to 5.8°C by 2090. The number of days and nights considered hot by current climate standards is projected to increase, most rapidly in June to August, occurring on 12 to 81 percent of days of the season and on 40 to 85 percent of nights in every season.

Precipitation changes will not be significant. Annual precipitation will rise by -14 millimeters (-31 percent) to +59 millimeters (58 percent). These changes in precipitation and the rapid decline in glacial cover will increase runoff by 14 percent by mid-century. Total rainfall during heavy events is however projected to decline.
## Current GHG Contribution:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Emissions</td>
<td>161 MtCO₂ eq</td>
</tr>
<tr>
<td>Emissions per capita</td>
<td>6.6 tCO₂ eq</td>
</tr>
<tr>
<td>Emission intensity</td>
<td>4977.7 tCO₂ eq</td>
</tr>
</tbody>
</table>

**Sources of Emissions:**
- Land-use change and forestry (77%),
- Agriculture (18%)

**Note:** GDP in current PPP

## Key Climate Change Issues

### Adaptation:

- **Water Resources.**
  - GLOF and future desiccation of water resources due to rapid glacial melt
- **Public Health**
  - Likely outbreak of malaria and similar diseases
- **Agriculture**
  - Decline in agricultural production in some areas
- **Terrestrial Ecosystem and Biodiversity**
  - Impact of glacial melt upon dependent ecosystems and agriculture, and vegetation shift to forest biodiversity

### Mitigation:

- Impacts on carbon sequestration of vegetation shifts and forest productivity changes
- Land-use changes due to future development
- Slash-burn agricultural practices

**Sources:** World Bank Climate Change Portal; UNDP Climate Change Country Profiles (http://country-profiles.geog.ox.ac.uk/); World Resources Institute CAIT (http://www.wri.org/project/cait); Ghana and Rai 2005.
Pakistan

Pakistan is the second largest country in South Asia and is mainly comprised of dry and cold areas with low production potential. Its geography varies across the country, shaping the great variation in its climate. Climate range from mild winters and hot, dry summers in the north to semi-arid and arid zones in the west and the south. The country is bounded by the Himalayas in the north, the mountain ranges of Safed Koh and Sulaiman in the east and the lowland plains of river Indus in its south, west and coastal. Climate change exposes these areas to risks of glacial melt, sea level rise and drought. As more than half of its land area is arid and semi-arid, expected changes in temperature and rainfall pattern in the future could impinge upon its food security and the welfare of its millions of herders and pastoralists.

Observed Climate Trends

Mean annual temperature has increased by 0.35°C since 1960, particularly during the months of October to December when temperatures rose by 0.19°C per decade. The frequency of hot days and hot nights has also increased significantly since 1960 by 20 and 23 days, respectively. There were no discernible changes however in the annual rainfall over Pakistan since 1960.

The country has been exposed to high risks of flooding, cyclone events and droughts which have been associated with elevated mortality outcomes since 1980s.

Nominal GDP: US$ 126.8 billion
Economic activities: Agriculture (24%), services (50%)
Population: 159 million, Urban (71.5%)
Land Area: 771,000 sq. km
Agricultural land (%): 35
Irrigated land (% of cropland): 85

Predicted Annual Temperature Increase

Projected Future Climate Trends

A significant increase in annual temperature is estimated for Pakistan, which could induce biodiversity losses, changes in land use and crop failure. The mean annual temperature is projected to increase by 1.4°C to 3.7°C by 2060s and by 1.9°C to 6°C in 2090s. Warming will particularly be more significant in the northern and high altitude regions.

Annual rainfall on the other hand will slightly increase, causing no significant changes in runoff. Projections on precipitation changes will be within the range of -9 to +20 millimeters per month by 2090s. Total rainfall occurring in heavy events will moderately increase particularly during July to September.
Current GHG Contribution

Emissions: 241.2 MtCO₂ eq
Emissions per capita: 1.8 tCO₂ eq
Emission intensity: 941.8 tCO₂ eq
Sources of Emissions:
Energy (45.6%), agriculture (30%), land-use change (14%)

Key Climate Change Issues

Main Vulnerabilities

○ **Agriculture and Food Security**
  Increased intensity and frequency of drought and effects on agriculture (pasture)
○ **Coastal Zones and Marine Ecosystems**
  Damages from sea level rise and increased storm events, exposure to changes in sea temperatures and water chemistry
○ **Water Resources**
  Initial flooding and future drying of water resources due to glacial melt and impact on water consumption
○ **Land Resources**
  Reduced soil productivity, land use changes
○ **Terrestrial Ecosystems**
  Impact of drought and future desiccation upon ecosystems (wetlands), particularly the glacier fed
○ **Natural Disasters**
  Increased incidence of storm events, droughts and short run flooding
○ **Biodiversity**
  Reduction in alpine cover, exposure of drought to wetland species
○ **Health and Social Development**
  Outbreak of heat related and insect-transmitted diseases, malnutrition, food and water insecurity, migration and conflict

Mitigation Issues:

○ Increased emissions from energy, transport and urban sectors
○ Emissions from agriculture and rangeland degradation

Sources: World Bank Climate Change Portal; World Resources Institute CAIT (http://www.wri.org/project/cait); UNDP Climate Change Country Profiles (http://country-profiles.geog.ox.ac.uk/).
Sri Lanka is endowed with rich biodiversity, formed by its mountain ranges and coasts. The Western Ghats which is one of the 36 global biodiversity hotspots is located in the country and coral reefs, mangroves and other wetlands surround its coastlines. The country is hot and humid and has extensive areas with water deficit. A great part of the country experiences dry spells that extend over several months. Agriculture and livestock, manufacturing and fishery are the main sources of its productivity (37 percent of GNP) and employment (53 percent). About 72 percent of its paddy production is situated in dry zones while 65 percent of industrial production and 80 percent of fish production are sourced from its coastal zone. The expected increase in temperature, frequency and duration of drought, intensity of rainfall and storm surges and sea level will present tremendous risk to the country’s economic productivity, human health, coastal settlements and biodiversity.

Source:

Nominal GDP: US$ 27 billion
Population: 20 million
Urban: (15%)
Land Area: 65,000 sq. km
Agricultural land (% total): 36
Irrigated land (% of cropland): 39
Observed Climate Trends

The country has experienced a warming of 0.48º C over the entire island during 1960-1990 and a shortfall in precipitation except in some isolated areas in the northwest. There has been an increase in variability in precipitation during 1960–990 compared to 1930–1960.

Sri Lanka is also prone to natural disasters, particularly cyclones and floods. From 1961–2004, cyclones and floods affected about 2 and 9 million people, respectively.

Changes in sea temperatures were observed in its territorial waters and have led to coral bleaching and loss of marine biodiversity.

Projected Future Climate Trends

Global warming is expected to lead to a rise in temperature, sea level, frequency and duration of drought, intensity of rainfall and extreme storm events. Using HADCM3 projections, annual rainfall is projected to increase between 5 percent (B2) and 14 percent (A2) by 2050. Both the annual runoff and extreme storm events are projected to rise due to the precipitation changes. The trend in spatial and seasonal precipitation, however, will vary, with dry zones expected to experience a reduction of 9 percent (B2) or 17 percent (A2) during the wet season when most of the paddy agriculture (70 percent) takes place. An increase in sea level of 0.3 meters could inundate as much as 41 square kilometers and cause damages to 1 percent of its population.

Predicted Rainfall Changes in 2050s

Current GHG Contribution

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<th>Emissions:</th>
<th>41.4 tCO₂ eq</th>
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<tbody>
<tr>
<td>Emissions per capita:</td>
<td>2.8 tCO₂ eq</td>
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<td>Emission intensity:</td>
<td>815.7 tCO₂ eq</td>
</tr>
<tr>
<td>Sources of emissions:</td>
<td>Land-use change and forestry (71%), energy (26%)</td>
</tr>
</tbody>
</table>

Note: GDP in current PPP
## Key Climate Change Issues

### Main Vulnerability:

- **Agriculture and Food Security**  
  Reduced crop yields due to temperature increase
- **Coastal Zones and Marine Ecosystems**  
  Sea level rise - damages upon settlements, industries and livelihoods in coastal areas, ecosystem degradation and biodiversity loss in coastal and marine ecosystems
- **Water Resources**  
  Salt water intrusion in freshwater and groundwater
- **Public Health**  
  Increased incidence of vector borne diseases and risks of loss of lives due to disasters
- **Fisheries**  
  Threat of ocean acidification and increased incidence of cyclones upon fishery livelihoods
- **Terrestrial Ecosystems**  
  Loss of forest biodiversity
- **Disasters**  
  Increased incidence of cyclone events and flood

### Mitigation Issues:

- Release of stored forest carbon due to land-use changes
- Increase in thermal power

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References


