East Asia

ENVIRONMENT MONITOR 2007

ADAPTING TO Climate Change

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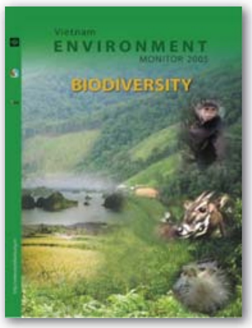

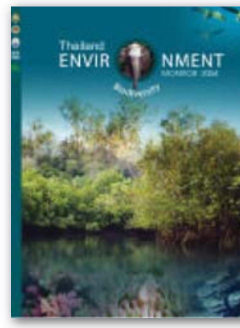

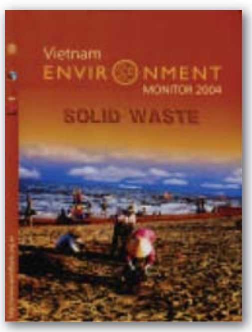

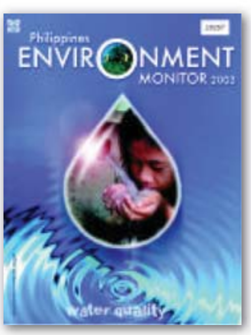

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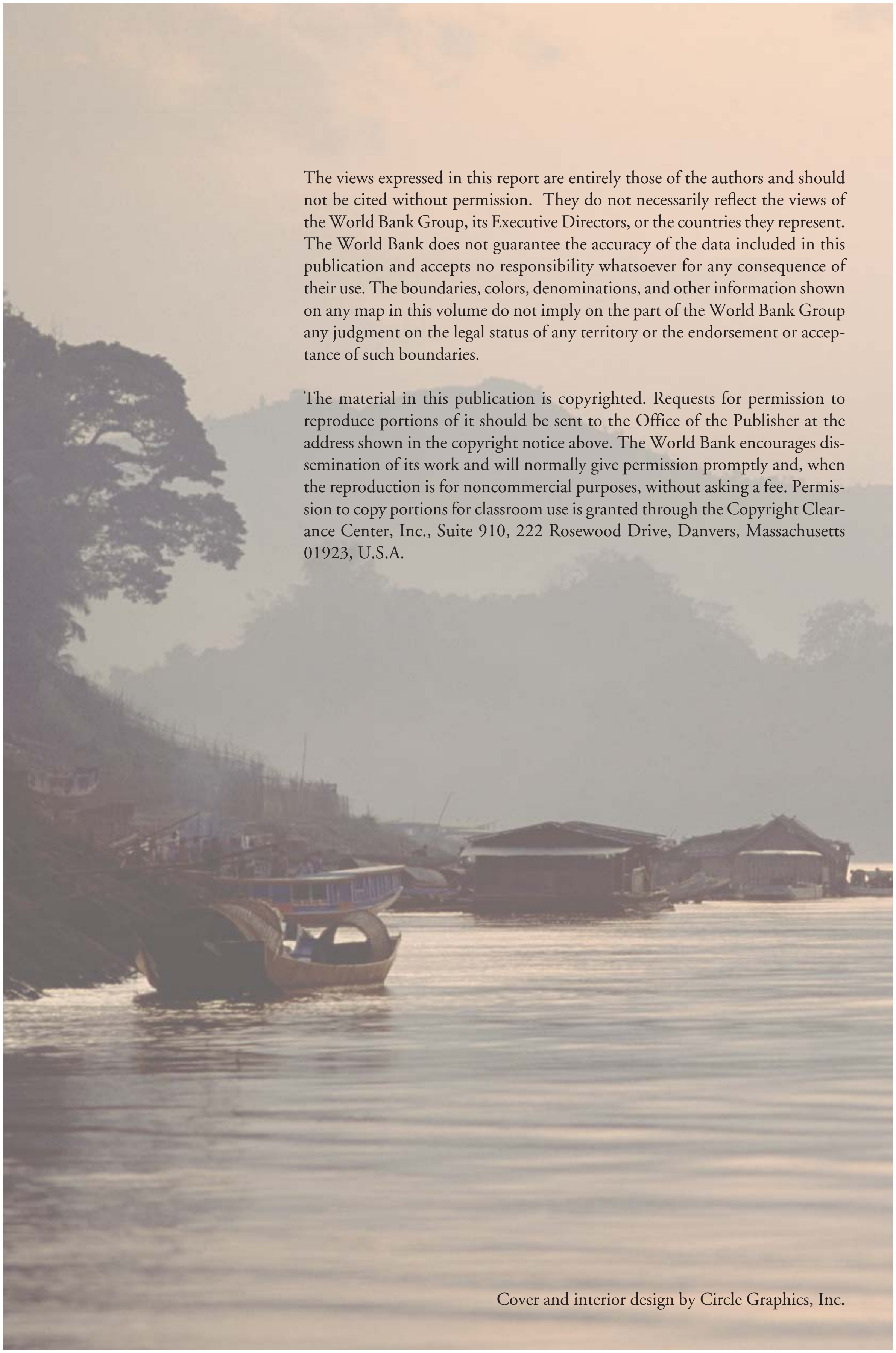

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ABBREVIATIONS

ADB	Asian Development Bank
CAIT	Climate Analysis Indicators Tool
CARE	Cooperative for Assistance and Relief Everywhere
CDIAC	Carbon Dioxide Information Analysis Center
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CF	carbon finance
CH_4	Methane
CO_2	carbon dioxide
CO_{2e}	carbon dioxide equivalent
COP6/7	Sixth/Seventh UNFCC Conference of Parties
DALY	disability adjusted life year
EAP	East Asia and Pacific
ENSO	El Niño southern oscillation
EU	European Union
FAO	Food and Agriculture Organization
GDP	gross domestic product
GEF	Global Environment Facility
GNI	gross national income
GNP	gross national product
GHG	greenhouse gas
HFC	Hydrofluorocarbons
ICM	integrated coastal management
IGES	Institute for Global Environmental Studies
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
KAP	Kiribati Adaptation Program
LDCF	Least Developed Countries Fund
NAPA	National Adaptation Programs of Action
NASA	National Aeronautics and Space Administration
NGO	non-governmental organization
N_2O	Nitrus Oxide
SCCF	Special Climate Change Fund
SRES	Special Report on Emissions Scenarios (IPCC)
TCO_2e	Tons of Carbon Dioxide equivalent
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WRI	World Resources Institute

FOREWORD

In the stark wording of the 2006 Stern Review on the Economics of Climate Change, "climate change threatens the basic elements of life for people around the world—access to water, food production, health, and use of land and the environment." The implications for the East Asia and Pacific (EAP) region, in terms of increasing temperatures, changing precipitation, and sea-level rise, need to be better understood.

The region is experiencing the world's most dynamic growth. Since 1998, its gross domestic product has grown by over 9 percent per year, and EAP is now the largest destination for foreign direct investment. Given its geographical characteristics, however, it is especially vulnerable to climate change impacts, which will eventually be felt throughout the region and affect virtually every major sector. It is, therefore, crucial that countries in the region understand the impacts of climate change and explore ways to anticipate and adapt to these changes.

The East Asia *Environment Monitor* on *Adapting to Climate Change* is the first regional report in the "Environment Monitor" series. It is also the first to focus entirely on climate change. It draws on a variety of sources and available scientific information to present a snapshot of trends and projections of the expected impacts of climate change, describe the vulnerability of the region to these impacts, and assess the likely major consequences for the region. Beyond the scenarios and their impacts on the region's sustainability, the Monitor looks at ways in which countries can better adapt to these impacts. The format is intended to be non-technical, easy to understand, and accessible to a wide audience. The annexes include a profile of the EAP region, useful links, and a reference list of selected World Bank publications relating to climate change.

The subject of climate change is now receiving substantial attention from policy makers, researchers and the public. Many of the trends highlighted in this report have been further reaffirmed and validated by the fourth assessment of the Inter-Governmental Panel on Climate Change released this year.

We hope that this publication will improve awareness of the complex issues surrounding climate change impacts and provoke public policy debate with respect to how countries might adapt to the predicted impacts on their populations—whether they inhabit coastal cities, interior dry-lands, major river basins, or small islands.

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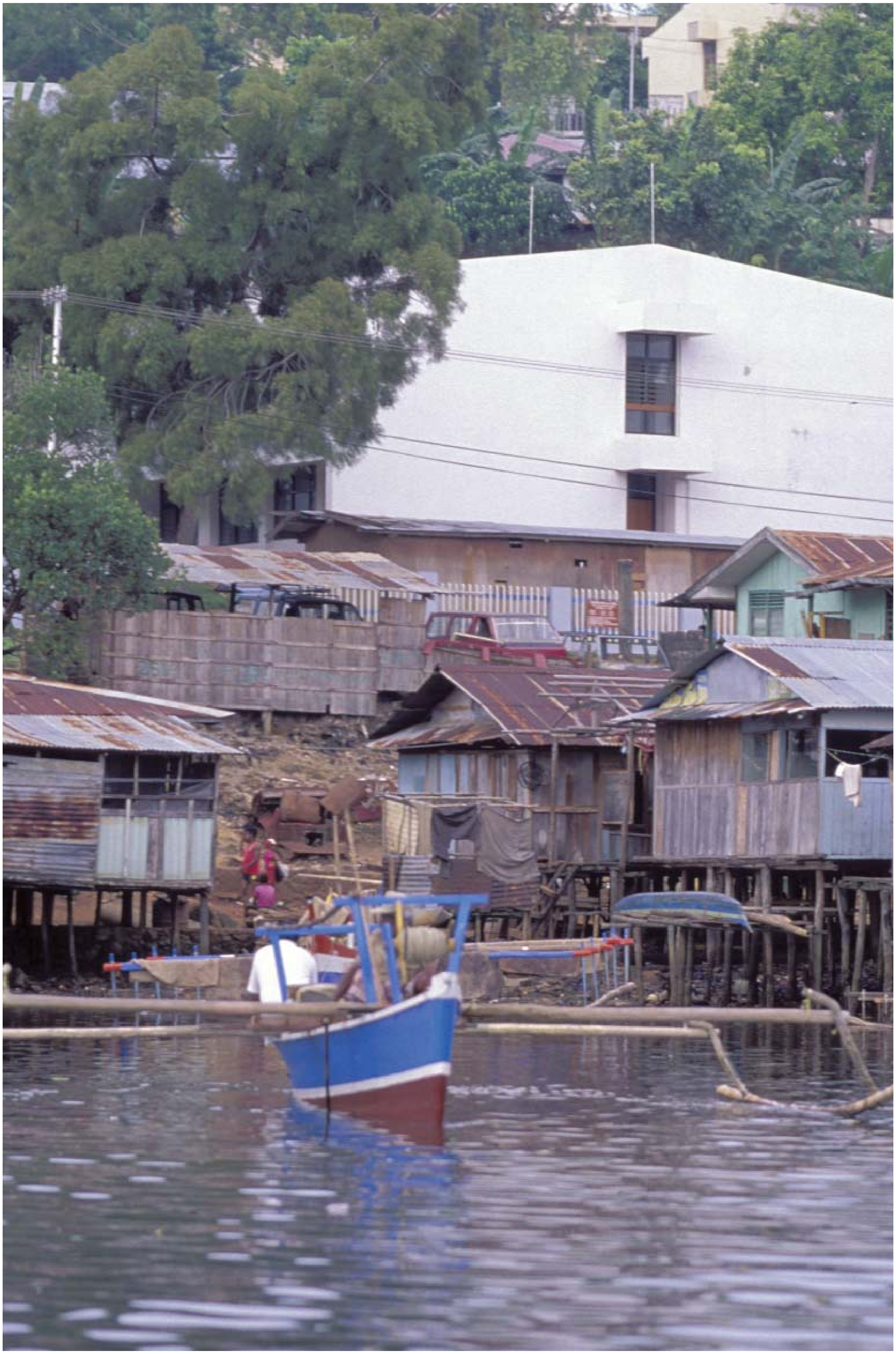


EXECUTIVE SUMMARY

Climate change is becoming one of the key development issues of our time. Although the last few years have seen globally polarized and divisive positions over the extent and causes of the phenomenon, the debate is clearly shifting from the question of whether or not climate change is happening to what can be done to address its effects. It presents a unique and unprecedented challenge that threatens to undermine the last century's gains in economic growth and poverty alleviation. Its impacts will not be fairly or evenly distributed. The poorest countries and people, who are least responsible for human contributions to climate change and least able to cope with it, are expected to suffer earliest and most.

Most countries, including those in the World Bank's East Asia and Pacific Region (EAP), have embarked on mitigation initiatives to reduce dependence on fossil fuels and greenhouse gas emissions. There is also increasing consensus on another issue—the need to adapt to the effects of climate change. Given the long-lived nature of greenhouse gases, many experts feel that adaptation is the only response available for the impacts that will occur over the next few decades before mitigation measures can have an effect. In fact, even skeptics agree that it is important to adapt to climate variability.

EAP contributed $4 trillion to the world's GDP in 2005, and is still growing at an amazing 9 percent per year, a record that was only briefly interrupted by the East Asian economic crisis in the late 1990s. It has had significant success in curbing poverty, and contains several powerhouses that have made impressive infrastructure and industrial investments, attracting foreign resources and fostering rapid economic growth. However, there is still much to be done to address the remaining challenges of poverty, to better manage the environment (sustainable natural resource use and pollution), and to promote broad-based sustainable growth. This mission will be compounded by the new challenge of climate change.

The EAP region is home to about two billion people, and comprises about 16 million square kilometers of territory. Its climate is diverse, with a wide range of temperatures and precipitation levels. Its lands are varied, encompassing arid deserts, mountains with glacial systems, rugged coasts, and fertile agricultural lands. It has thousands of islands, many just a few feet above sea level, and is home to some of the most important marine resources of the world, including coral reefs, a wide range of fish species, and other biodiversity. Many people in the region are economically and nutritionally dependent on these vast resources.

The region is particularly vulnerable to climate change. Over half of its population resides in coastal locations and in low-lying islands. Heavy reliance on agriculture and growing water use, high dependency on marine resources, and growing energy demand pose additional risk factors. The immediate manifestations of climate change—higher temperatures, followed by changes in precipitation patterns, greater intensity and frequency of extreme weather events, and rising sea levels—are expected to provoke further cascading impacts:

- ***Environmental:*** changes in coastal and marine systems, forest cover and biodiversity;
- ***Economic:*** reduced water security, impacts on agriculture and fisheries, disruption of tourism, reduced energy security, which may have negative impacts on GDP; and
- ***Social:*** population displacement, loss of livelihood, and increased health problems.

Although the consequences are expected to be unevenly felt in different parts of the EAP, all countries will be affected to varied degrees and combinations of the impacts. The region's public and private sectors will need to pursue a variety of anticipatory and reactive strategies to adapt to climate variability and change. This will require cross-cutting responses and approaches, including poverty reduction and economic reforms, improving the information base, strengthening planning and coordination, promoting participation and consultation, improving disaster preparedness, investing in technology development and dissemination, and establishing effective financial safety nets and insurance systems. In most cases, these cross-cutting responses and approaches will need to be applied through area-specific and ecosystem-level interventions focusing on coastal cities, major river basins, agricultural areas, forest and dryland areas, marine ecosystems, and small islands.

The adaptation measures discussed here mostly belong to the "no-regrets" category, as actions that would help under any future scenario. They can be financed by emerging special adaptation funding, by re-targeting mitigation financing already available, and by mainstreaming adaptation concerns in financing currently being used for development in the region.

There is an urgent need for EAP countries to recognize their vulnerability to climate change and to begin to systematically adapt to these future scenarios. Raising awareness among policy makers and the general public will enable them to make informed decisions on approaches to anticipating, preparing for, and minimizing the impacts of climate change on their sustainable development programs.

INTRODUCTION

What Is Climate Change?

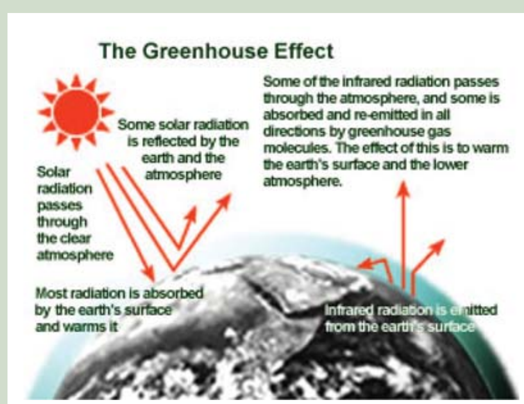
Simply put, the issue of climate change relates to variations in our climate which can be attributed directly or indirectly to human activity that increases the concentration of greenhouse gases (GHG) in the global atmosphere. Such human- induced change occurs in addition to natural climate variability observed over comparable time periods (IPCC, 2001) (Box 1.1).

The global community has been engaged on this subject for more than two decades. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization and the UN Environment Programme to "assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation." The 1992 United Nations Conference on Environment and Development (also known as the Rio Earth Summit) produced several landmark treaties, including the UN Framework Convention for Climate Change (UNFCCC), aiming to stabilize GHG concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system. After five years of negotiations, in 1997, the Kyoto Protocol to the UNFCCC assigned mandatory targets for the reduction of GHG emissions to signatory nations. The Protocol entered into force on February 16, 2005, and

Box 1.1 The Greenhouse Effect

When the sun's energy reaches the atmosphere, some of it is reflected back into space, while some (mainly light) enters the atmosphere and warms the Earth. The amount of the sun's energy that reaches the Earth's surface should normally be the same as the amount of energy radiated back into space, leaving the temperature of the Earth's surface roughly constant. However, over time, rising concentrations of GHGs increase the absorption of the outgoing radiation and the trapping of heat in the atmosphere, producing an increase in the Earth's average temperature—a phenomenon commonly referred to as the "enhanced greenhouse effect" or "global warming."

Many gases exhibit "greenhouse" properties. The 1997 Kyoto Protocol specifically targets six: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Some of these gases occur naturally; others are generated from both human activity and natural conditions; and some are produced entirely from human activities. Since GHG emissions are largely the result of the combustion of fossil fuels such as coal, oil and gas, developed countries have traditionally been major contributors to global warming.



Source of chart: US EPA.

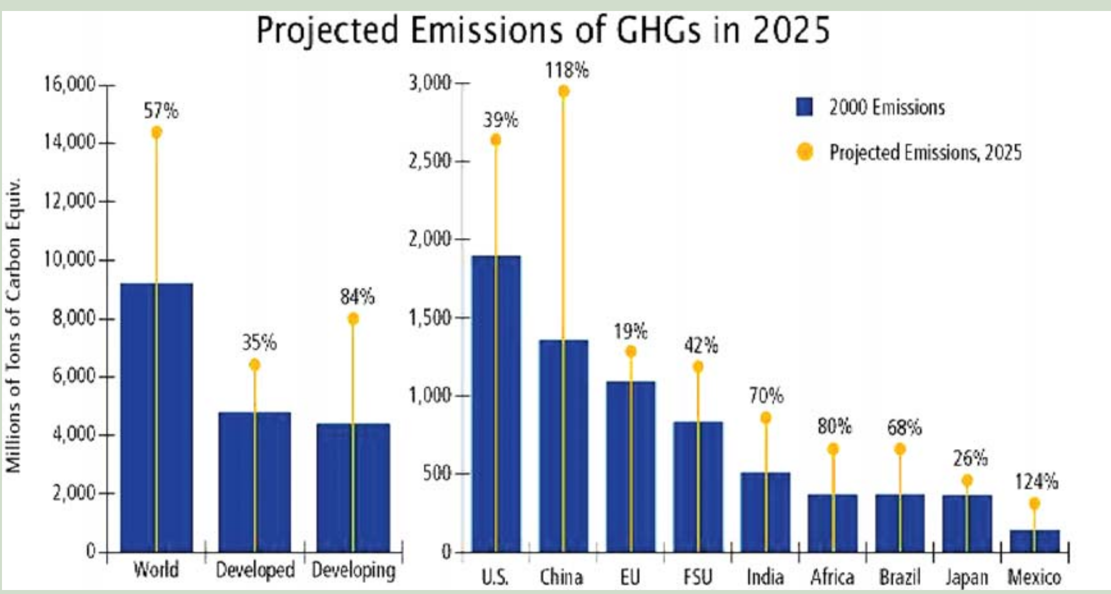
supports a number of initiatives to reduce emissions of CO_2 and other GHGs.

The IPCC has provided four periodic assessments, and its latest (Fourth) Report indicates that human activity over the past century has greatly increased the amount of GHGs in the atmosphere, contributing to an average temperature increase of 0.74°C. It has concluded that 11 of the last 12 years (1995–2006) rank among the 12 warmest years since 1850, when instrumental records of such temperatures started to be maintained. The IPCC has examined many plausible scenarios of climate change (based on the efforts made to control GHG emissions), and has estimated several scenarios of temperature rise, and its implications in terms of changes in precipitation patterns, sea level rise, and other impacts (discussed below).

Under the Kyoto Protocol, countries are separated into two general categories: developed countries (referred to as Annex 1 countries), who have accepted GHG emission reduction obligations; and developing countries (referred to as Non-Annex 1 countries), who have no GHG emission reduction obligations but must submit an annual GHG inventory. By 2008–2012, Annex 1 countries have committed to reduce their GHG emissions by an average of 5 percent below their 1990 levels. For many countries, such as the European Union (EU) member states, this corresponds to required reductions at some 15 percent below their expected GHG emissions in 2008. The Kyoto Protocol includes "flexible mechanisms" which allow Annex 1 economies to meet their GHG targets by obtaining GHG emission reductions from other countries. These can be bought from financial exchanges (such as the EU's Emissions Trading Scheme) or from specific projects where the cost of emission reduction may be lower in non-Annex 1 economies under the Clean Development Mechanism (CDM). Emission reductions can also be obtained from other Annex 1 countries under the Joint Implementation scheme for economies in transition (mainly the former Soviet Union and Eastern Europe).

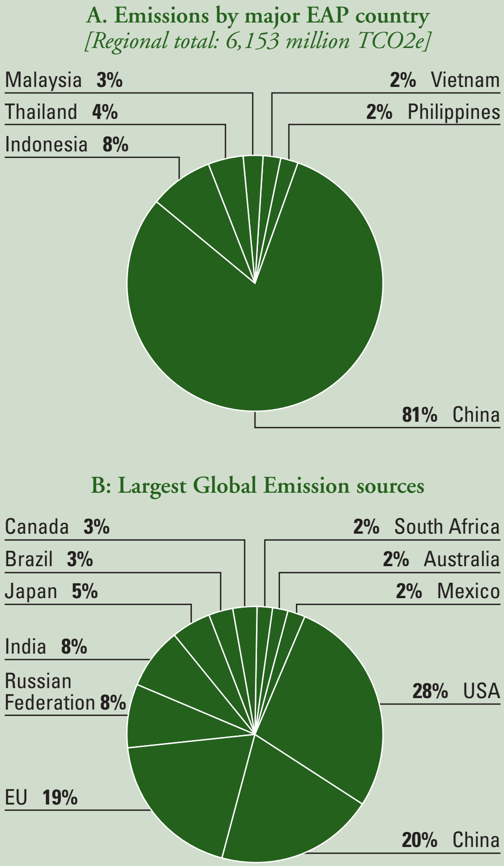
Developed countries have been major contributors to the creation of the stock of GHGs in the atmosphere since the 1850s. While developing countries, including EAP nations, have contributed very little to the stock of total GHG emissions in the past, this trend is expected to change over the coming decades, as shown in Figure 1.1. The region's rapidly industrializing countries, notably China, are responsible for a growing and significant share of the annual flow of current global emissions (Figure 1.2). For the period 1999–2000, 18.7 percent of global CO_2 emissions from fossil fuel combustion were estimated to originate in the developing countries of East Asia and the Pacific.

Figure 1.1 World Energy Related CO_2 Emissions, 2000–2025



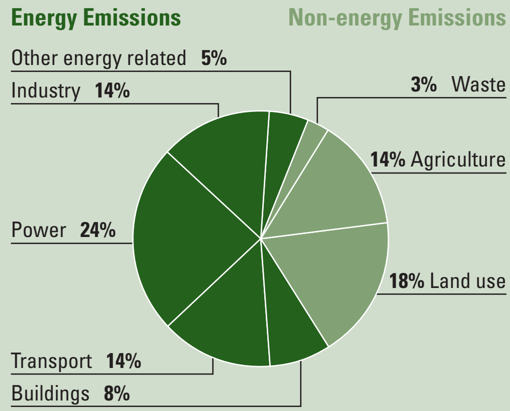
Source: World Resources Institute.

Figure 1.2 EAP's Share of Global GHG Emissions, 2000 (percentage)



Source: Climate Analysis Indicators Tool (CAIT) Version 4.0. (Washington, DC: World Resources Institute, 2007).

Figure 1.3 GHG Emissions by Source, 2000



Total emissions in 2000: 42 GICO2e.
Energy emissions are mostly CO_2 (some non-CO_2 in industry and other energy related). Non-energy emissions are CO_2 (land use) and non-CO_2 (agriculture and waste).
Source: Stern Review (using WRI-CAIT data).

GHG emissions result predominantly from energy use—the burning of fossil fuels in power generation, transport, industry and buildings—which jointly amounted to 65 per cent of total emissions in 2000 as shown in Figure 1.3. Agriculture, deforestation and other land use changes are also important contributors and will be of relevance in the global mitigation effort.

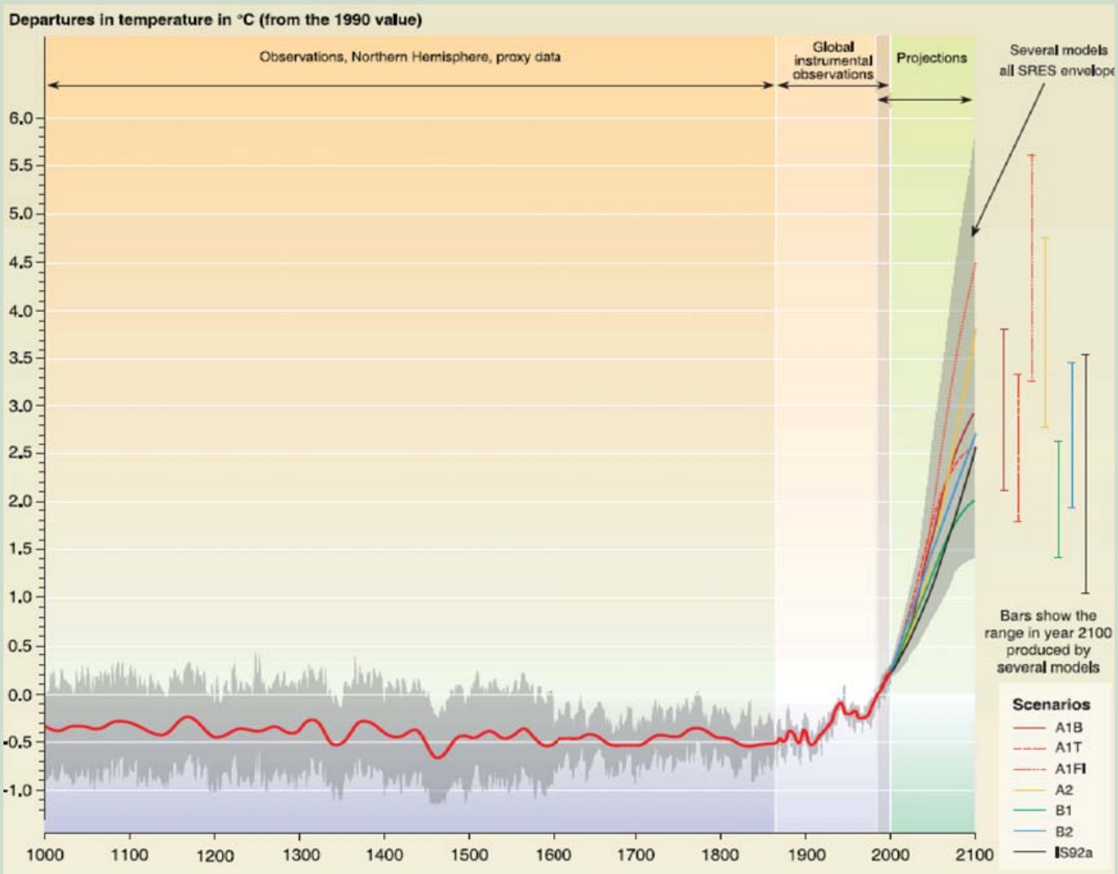
Expected Changes in the Global Climate

The initial manifestation of climate change is a rapid rise in temperatures over the globe. Figure 1.4 illustrates the steep spike in global temperatures, in the likely range of 1.1 to 6.4° C, which is expected to occur in the 21st century in accordance with the IPCC's Special Report on Emission Scenarios (SRES). As a result of this increase, precipitation patterns are expected to change significantly, as illustrated by projected changes in runoff by 2050, making some areas much more humid and others much drier (Figure 1.5). Extreme weather events (severe storms, floods, droughts and heat waves) are expected to become more intense and frequent. Sea levels are also expected to rise[1] by 18 to 59 cm by 2100 (Figure 1.6).

These changes can already be observed. The Fourth Assessment Report informs that there have been widespread changes in extreme temperatures, droughts have become longer and more intense, the frequency of heavy precipitation has increased over most land areas, and arctic sea ice has shrunk by 2.7 percent per decade. Figure 1.7 illustrates such changes in atmospheric CO_2 concentration, global surface air temperature, and sea

1. Sea levels can also change due to a combination of factors such as tectonic movement and oceanic currents. It is possible that a larger rise in sea level (>1m) could be observed by 2100, if there is enhanced polar ice and glacial melting (Overpeck et al., 2006), but this is considered by some analysts to be a low probability (Vaughan and Spouge, 2002).

Figure 1.4 Global Temperature Changes in the Last Millennium and Estimated Rise, 2000–2100



Source: IPCC, 2001.

level rise. Figure 1.8 shows changes in hurricane patterns over the past 30 years.

Cascading Effects

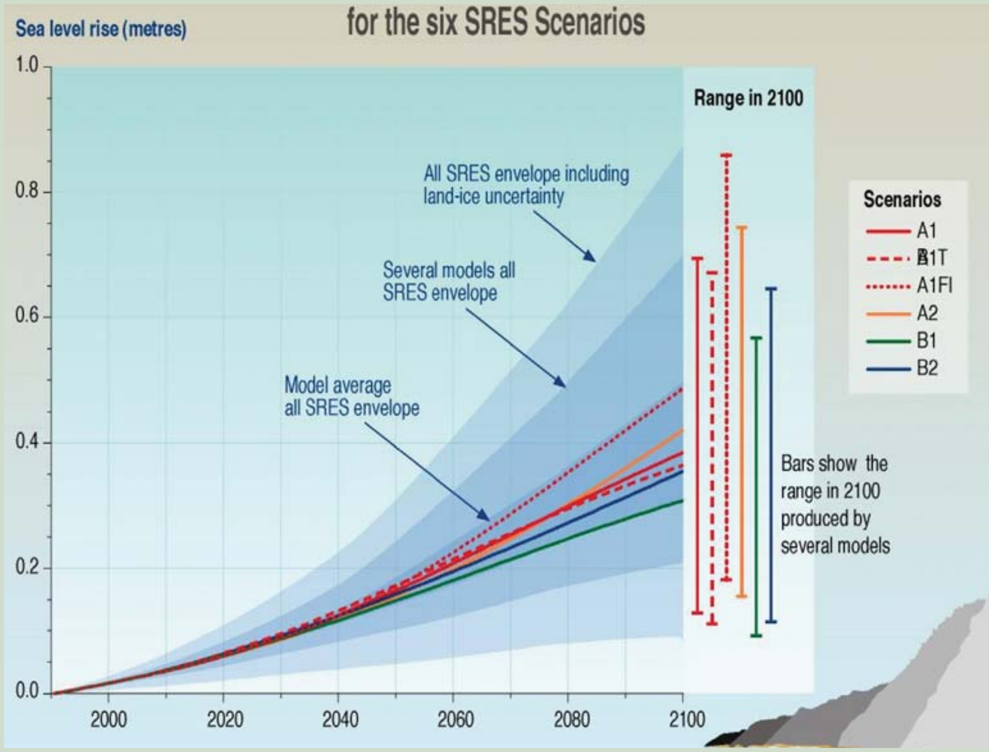
The rise in temperature, changes in precipitation patterns, increased intensity of extreme weather events, and sea level rise are expected to have further cascading impacts. These have been illustrated in the Stern Review.[2] As shown in Figure 1.9, expected climate change impacts rise with the concentration of GHG in the atmosphere. The current level of carbon dioxide equivalent (CO_2e)[3] accumulation in the atmosphere is 430 ppm. In a "business as usual" scenario, an accumulation level of 450 ppm CO_2e is expected to be reached by 2015. The scientific evidence currently available suggests that at 550 ppm, impacts would be very serious.

Figure 1.9 also illustrates the types of impacts that could be experienced as the world comes into equilibrium, at different levels of accumulation of CO_2e in the atmosphere, depending to a large extent upon the mitigation choices undertaken by governments. The top panel shows the range of temperatures projected at stabilization levels between 400 ppm and 750 ppm CO_2e concentrations. The bottom panel illustrates the range of impacts expected at different levels of CO_2e concentration.

In addition to the impacts referred to previously (changes in precipitation patterns, increase in the

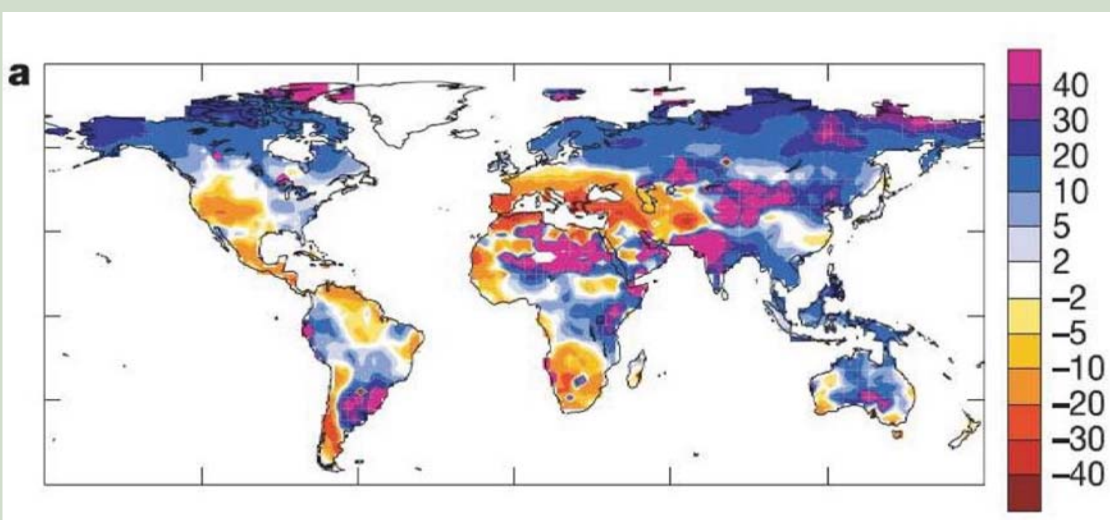
2. Stern, 2006, *Stern Review on the Economics of Climate Change,* Cambridge University Press, HM Treasury, Cambridge
3. The cumulative level from CO2, CH4, N2O and other GHGs

Figure 1.5 Estimated Global Average Sea Level Rise, 2000–2100



Source: IPCC, 2001c.

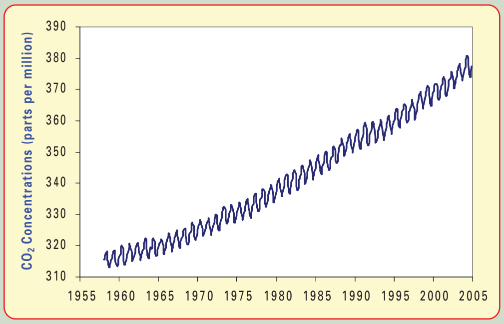
Figure 1.6 Percentage Change in Precipitation Runoff by 2050



Source: Milly et al., 2005.

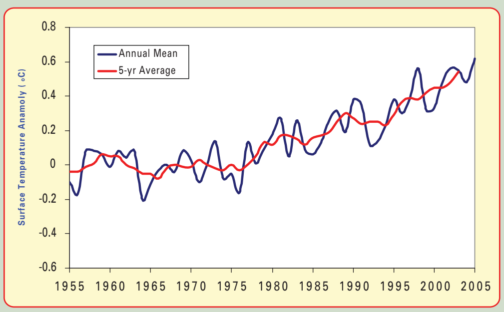
Figure 1.7 The Climate Has Been Changing

(a) Atmospheric CO_2 concentration record (ppm) 1958–2005



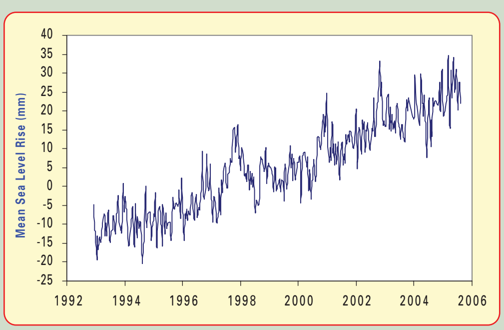
Source: Keeling et al., 2006.

(b) Global surface air temperature change (°C) in the same period



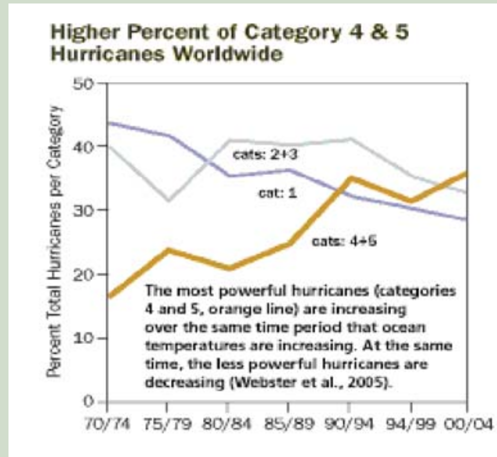
Source: NASA, 2006.

(c) Sea level rise from 1992–2006 using satellite measurements



Source: University of Colorado, 2006.

Figure 1.8 The Intensity of Extreme Climate Events Is Going Up



Source: Union of Concerned Scientists, 2006.

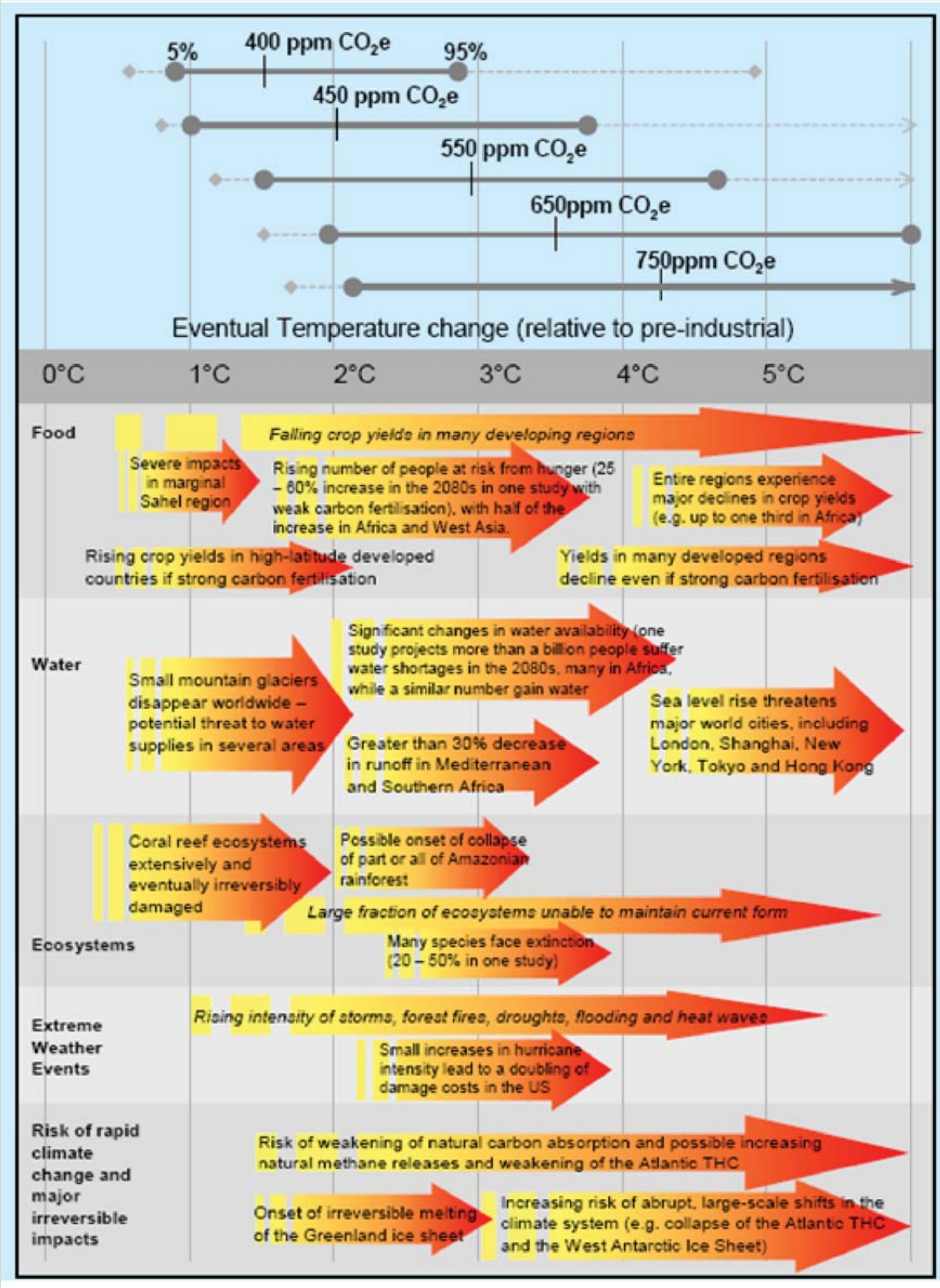
intensity of extreme weather events, and sea level rise), impacts are also expected to occur on food and water supplies and on ecosystems.

The impacts of climate change will be different across the globe, with developing countries being most significantly affected. The Stern review points out that with 5–6°C warming—which is a real possibility for the next century—the existing models estimate an average 5–10 percent loss in global GDP, with poor countries suffering costs in excess of 10 percent of GDP.

The poor are disproportionately vulnerable to climate change (as they are to other forms of environmental deterioration), because they depend on natural resources and have limited capital—human, institutional, and financial—to deal with and adapt to climate variability and extremes. Future climate change is likely to have a major impact on the dominant economic activities of the poor, threatening livelihoods and negatively affecting natural resources, and thus compounding poverty. Climate change is, therefore, a serious risk to poverty reduction programs currently underway, raising the need for prioritizing adaptation measures in developing countries' policy making processes.

The following chapters focus on the EAP region, discussing how its climate is expected to change, what impacts will be felt, and some of the measures that could be taken to address the adaptation challenge.

Figure 1.9 Stabilization Levels and Probability Ranges for Temperature Increases



Source: Stern, 2006.

CHAPTER 2

THE EAP DEVELOPMENT CONTEXT

Rapid Growth, Poverty Reduction and Environmental Degradation

The countries of the EAP region, with a population of 1.87 billion, have experienced remarkable economic growth. During the period 1990–2003, East Asia and the Pacific had the fastest growth rates in the world, with an average annual rate of 6.2 percent. After the economic crisis of the late 1990s, investments in infrastructure and other sectors have risen considerably, and commerce and trade have transformed the region's economy. At the national level, economies have diversified, with industry and services replacing agriculture as the primary engine of growth in many countries. In 2006, regional growth rates were expected to reach 8 percent, sustained by continued strong growth in China, and strong growth in exports throughout the region.

These decades of growth were accompanied by a major reduction in poverty. However, despite the achievements made over the past decades, there are significant remaining differences across the region and within countries. Even now, around 29 percent of the region's population of nearly 2 billion earns less than $2 a day (World Bank, 2006b), although if present trends continue, the World Bank estimates that East Asia could almost eliminate poverty within a decade (World Bank, 2006).

Economic growth has come at an environmental cost. Most of the countries in the EAP region are dependent on natural resources (World Bank, 2006a) that are already threatened by rapid growth even without computing the impacts of climate change. Indonesia's rate of deforestation almost doubled between 1985 and 1997, from 1 million to 1.7 million hectares per year, and has not abated since. In the Philippines, it is estimated that 58 percent of groundwater is contaminated. In China, damage caused to agriculture and health by SO_2 and NO_2 emissions from coal use, is currently estimated to result in costs reaching 3 to 7 percent of GDP, and could grow to as high as 13 percent of GDP by 2020 if environmental issues are not properly addressed (World Bank, 2005c). Annex A summarizes key indicators for the countries in the region.

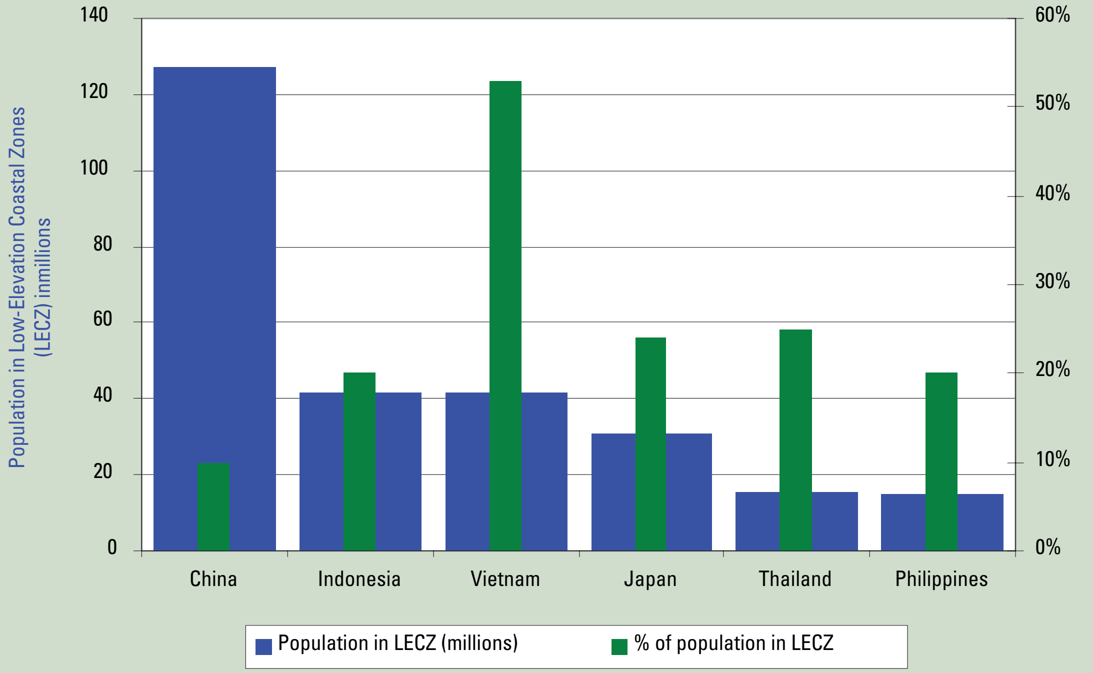
Why is EAP Vulnerable to Climate Change?

Climate change can undermine EAP's progress in advancing economic growth and reducing poverty, and can compound environmental degradation. The vulnerability of EAP can be attributed to the following key characteristics: large percentage of its population living along the coast and on many low-lying islands; heavy reliance on agriculture and growing water use; and high dependency on marine resources. In addition, the region's increasing energy demand and its heavy reliance on fuel-based solutions pose a potential constraint to future economic growth.

Large Coastal Populations and Large Number of Low-lying Small Islands

A quarter of EAP's total population of 1.7 billion resides in the coastal areas (Middleton, 1999; World Bank, 2006) (Figure 2.1). This number can be expected to increase significantly over the coming decades, given

Figure 2.1 Population at risk in Low Elevation Coastal Zones (LECZ)



Source: McGranahan et. al, 2006.

current rates of urbanization and the concentration of economic activities along the coast. While urban populations in countries such as Vietnam are especially vulnerable to the risks of climate change, sea level rise in particular, the numbers are also rapidly increasing in other countries. For example, in China, the urban population is now around 400 million, of which over 130 million people live on the coast. For the country as a whole, the urban population is expected to increase by over 125 percent in the next 25 years with greater concentration in coastal locations. In some areas, such as the Greater Pearl River Delta, urbanization and land use change is already occurring at a dramatic pace. (Figure 2.2)

As more people settle in coastal areas, increasing pressure is placed on both land and sea resources. Natural landscapes and habitats are altered, and destroyed to accommodate a growing population and new land uses. For example, lagoons and coastal waters are "reclaimed," wetlands are drained or polluted, habited floodplains near estuaries are degraded, and mangroves and other forests are cut down. All of these actions pose a threat to the resilience of human and environmental coastal systems, and increase the likelihood that the impact of natural calamities will be more strongly felt.

EAP has thousands of islands, many just a few feet above sea level, with several countries entirely formed by archipelagos, as is the case of Indonesia, the Philippines and Kiribati. In most small islands, the majority of the population's habitat, economic activity, and infrastructure are located within a few hundred meters of the coast. With some of the most important marine resources of the world, including coral reefs, a wide range of fish species, and other biodiversity, island populations are highly dependent, both economically and nutritionally, on these natural resources and on tourism.

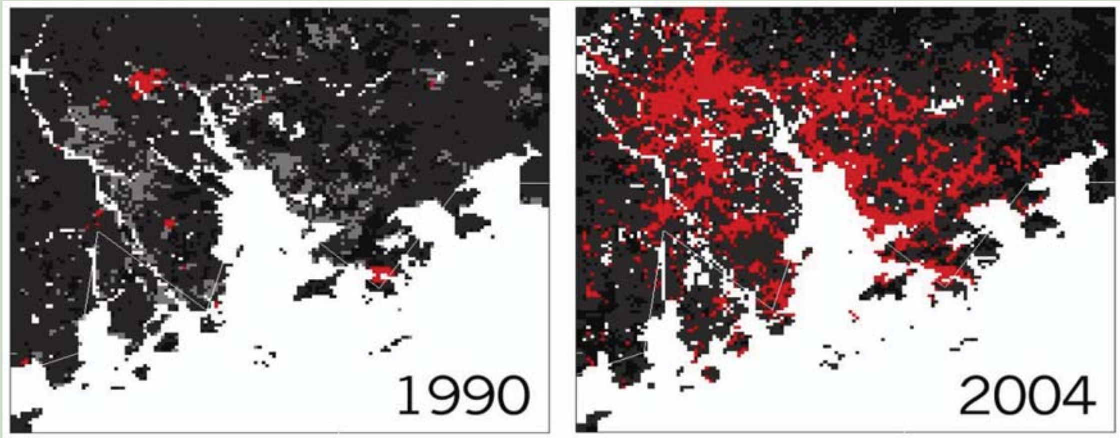
Vulnerability assessments suggest that climate change will impose diverse and significant impacts on these states (Leatherman, 1997).

Heavy Reliance on Agriculture and Growing Water Use

Agricultural activities represent 13 percent of EAP's GDP, but in some countries, they account for as much as one-third of GDP. An estimated 60 percent of people live in rural areas and 50 percent of land is dedicated to agriculture (World Bank, 2006c). These figures illustrate the important role agriculture plays as a source of both income and food for the population.

Agricultural land is being subjected to increasing degradation and pressure from population growth, urbanization, and economic development. In the next

Figure 2.2 Land Use in the Greater Pearl River Delta



Note: Urbanized areas represented in red
Source: Institute for the Environment, Hong Kong University of Science and Technology, and Civic Exchange.

fifty years, it is estimated that in Asia, every hectare of paddy fields, which currently feeds 27 people, will need to feed 43 people (IRRI, 2006). The transition from subsistence agriculture toward intensification, commercialization, and industrialization in response to increased population and changing consumption patterns has led to increased water pollution and degradation of the physical, chemical, and biological properties of the soil, resulting in lower productivity. Intensive use has often made land more vulnerable to natural disasters in coastal areas, floodplains, rangelands, mountains, and rural watersheds.

Rapid economic and population growth and migration from rural to urban areas are placing severe stress on urban water supply and sanitation systems, increasing competition for surface and groundwater resources and resulting in deteriorating water quality. Water scarcity problems are increasing in the northern part of China and in large- and medium-sized urban areas throughout the region. Water quality is deteriorating in both rural and urban areas throughout the region due to uncontrolled point-source and diffuse pollution and salt water intrusion (UNEP 2000). The damage and threats posed by floods and droughts are becoming more severe as development and population pressures increase and as the effects of climate change start to accelerate.

High Dependency on Marine Resources

Commercial and subsistence marine and freshwater fisheries and aquaculture are important for food security and the economies of many countries in the region. EAP dominates world aquaculture, producing 70 percent of all farmed fish, shrimp, and shellfish (FAO, 1997). For example, in the Philippines, the fisheries sector accounts for about 2.2 percent of GDP and employs nearly a million people. Of these, about 26 percent are engaged in aquaculture operations, 6 percent in commercial fishing, and 68 percent in marine and freshwater municipal fishing (i.e., small-scale, or traditional fisheries) (Lim et al., 1995).

However, commercial aquaculture requires land and water—two resources that are already in short supply in many countries in EAP. In addition, the fishery resources in EAP countries are being depleted by overfishing, excessive use of pesticides, industrial pollution, diseases, red tide,[4] and construction of dikes and other coastal structures (Zou and Wu, 1993; Sato and Mimura, 1997). Loss of inshore fish nursery habitats to coastal development as well as pollution from land-based activities causes significant change to ecosystems

4. Red tide: A common name for a phenomenon known as an algal bloom, an event in which estuarine or marine algae accumulate rapidly in the water column. These algae, more correctly termed phytoplankton are microscopic, single-celled, plant-like organisms that can form dense, visible patches near the water's surface characterized by a red or brown discoloring of surface waters, usually in coastal regions. The color occurs as a result of the reaction of a red pigment, peridinin, to light during photosynthesis. Poisonous substances produced by the algae result in a massive deaths and illnesses of fish and marine mammals, and the decomposition of algae robs the water of large amounts of oxygen These toxic algal blooms pose a serious threat to marine life and are potentially harmful to humans. (Science Glossary, Ocean Institute).

supporting fisheries. Marine productivity is also greatly affected by temperature changes that control plankton shift. For example, cyclical occurrence of the ENSO in low latitudes induces seasonal shifting of sardine populations in the Sea of Japan. (Chen and Shen, 1999; Piyakarnchana, 1999; Terazaki, 1999).

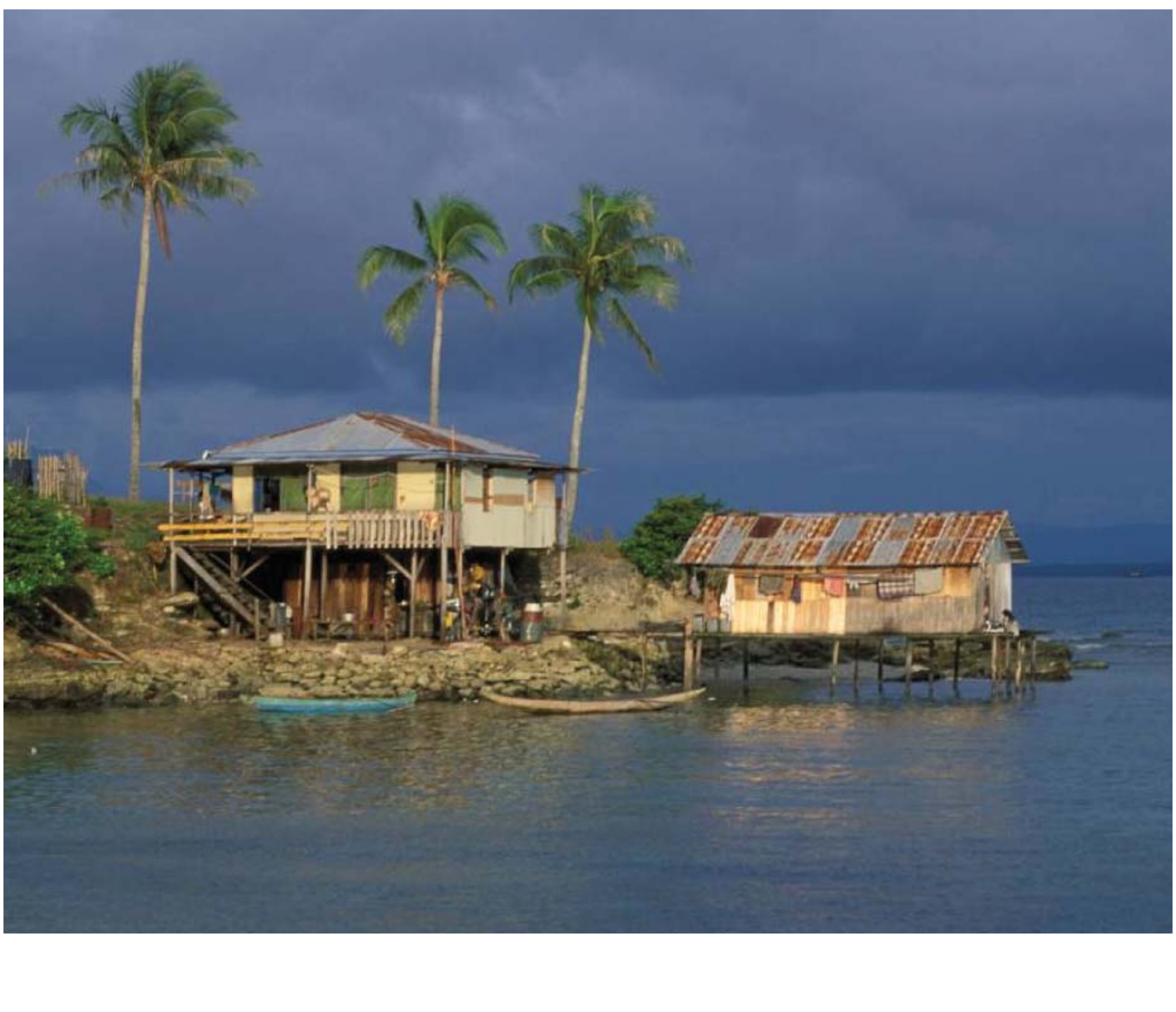
Growing Energy Demand

Most EAP countries are largely dependent on GHG-emitting fossil fuels to meet their energy needs. The demand for energy is growing rapidly, especially in China, and it is primarily driven by fossil fuel combustion. Overall energy consumption in EAP has risen by more than 40 percent in the last decade alone. Per-capita electricity consumption, however, is low in the region. For example, China consumes only about 1 Megawatt-hour (MWh)[5] per person per year (half of the world average), as compared to the United States, where consumption is 13 MWh per person per year.

In many EAP countries, energy intensity (energy used per unit of output) has not changed significantly over the last 25 years. The primary exception is China, where it has been reduced to 38 percent of the 1980 levels. This progress has been remarkable, even as compared to other large energy users, and is the result of policies geared towards reducing energy demand through energy saving regulations, changes in energy subsidies and incentives structures (Biller et al., 2006).

Security of supply is an issue for all EAP countries. Although in most countries the growth of industrialization has tended to polarize discussions about the need for energy security at the country level versus concerns for mitigating global warming, energy policy and investment choices today need to carefully consider the trade-offs between current and long-term needs.

5. Enough electricity to switch on three 60-watt light bulbs for six hours a day, 365 days per year.



HOW WILL EAP'S CLIMATE CHANGE?

Climate Change and Climate Diversity

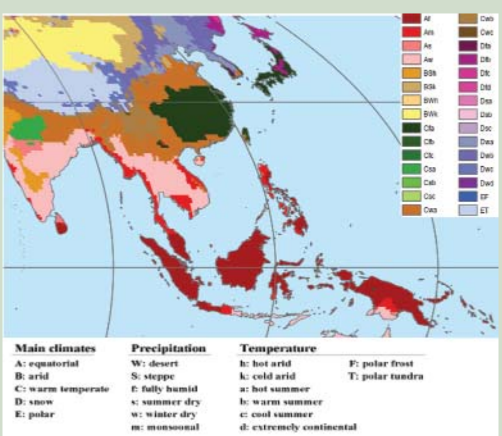
Over the course of this century, climate change is expected to have significant impacts in the East Asia and Pacific region, according to the IPCC.[6] The change could be quite complex, given the already considerable climate diversity in EAP as compared to other regions, and suggested by the Koeppen-Geiger climate classification (Figure 3.1).

Indicative of this diversity is the fact that, for EAP countries near the Equator, only small seasonal variations in temperature occur; while in other parts of the region, countries experience clearly marked cold and warm seasons. During winter, the spatial range of temperature in the EAP region is significantly large; during summer, variations are less extreme, although temperatures of over 45°C occur over the northwest part of the region during May-June (IPCC, 2001). Climate variability can also be significant within countries. For example, while climate in Indonesia and the Philippines is fairly homogeneous across each of these countries, China's land area includes four of the five climate classifications generated by the Koeppen-Geiger model.[7] This variability will have implications for national adaptation strategies.

In addition, climate in many EAP countries, specifically those located in tropical Asia is strongly influenced by the monsoon system that could in turn be significantly impacted by climate change. Temporal and spatial variations in rainfall are increasingly becoming more extreme. For example, the summer monsoon is reported to be stronger in northern China during globally warmer years (Ren et al., 2000). On the other hand, drier conditions have prevailed over most of the monsoon-affected areas during globally colder years (Yu and Neil, 1991).

6. IPCC, 2001b

Figure 3.1 Koeppen-Geiger Climate Classification



Note: The colors indicate combinations of climate, precipitation and temperature
Source: Kottels, et al., 2006.

Expected Changes in the Region's Climate

Temperatures Will Rise

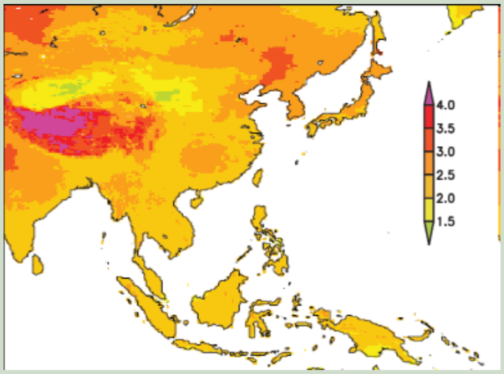
According to the IPCC's middle-range scenario,[8] the entire EAP region will experience a significant rise of about 2.5° C in temperature by the end of the century. The spatial distribution of estimated temperature changes is presented in Figure 3.2.

Manifestations of this change will include the following:

- Winter temperatures will change more than summer temperatures.

7. Available at http://koeppen-geiger.vu-wien.ac.at. This model for climate classification is based on the characteristics of the mean annual cycle of temperature and precipitation coupled with environmental characteristics (e.g., vegetation) for the definition of boundaries separating different climate types.
8. IPCC *SRES 2001.*

Figure 3.2 Annual Mean Temperature Change Expected in the 21st Century



Source: IPCC SRES A1B scenario, Uchiyama et al., 2006.

- Minimum daily temperatures will rise more than maximum daily temperatures.
- Land will warm more than oceans, causing stronger monsoon activity.
- Higher latitudes and altitudes will experience greater warming.
- The number of frost days will decrease and precipitation is more likely to be rain instead of snowfall.

On land, there will be both positive and negative impacts. Increased temperatures (sometimes even under conditions of increasing precipitation) may cause more evaporation, reducing runoff and soil moisture, and thus negatively affecting agriculture. However, the length of the agricultural growing season is expected to increase, expanding into the colder season. Spatial and temporal temperature changes can alter animal migration and vegetation patterns. In the sea, changes will include increased bleaching of coral reefs and distributional impacts on marine species. These impacts are described further in Chapter 4.

Precipitation Patterns Will Change

The relationship between global average temperature changes and regional climate change is very uncertain, especially with regard to changes in precipitation. However, in general, warmer air holds more moisture; thus a rise in temperatures will tend to accelerate water uptake, disrupting hydrological cycles and precipitation patterns. Studies suggest that changes are already observable, and are likely to intensify with additional warming.

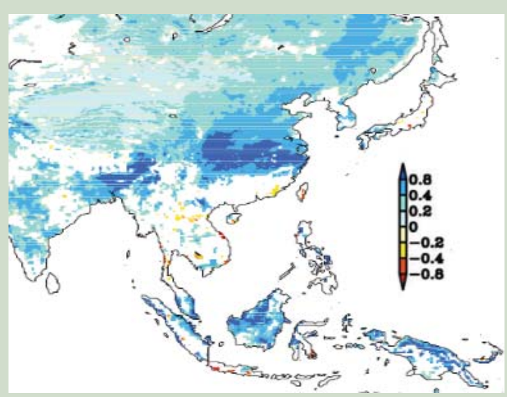
Recent climate models provide conservative future scenarios for changes in precipitation, albeit with a high level of uncertainty (Kamiguchi et al., 2006). Annual mean precipitation is expected to increase about 14 and 4 percent respectively, in East Asia and in South East Asia (Figure 3.3). In general, present arid and semi-arid regions are expected to become drier, and wet regions will become wetter (IPCC, 2001b). Thus, a more pronounced water resource shortage in the dry regions is expected, while increased precipitation in temperate and tropical Asia during the summer monsoon will likely cause more frequent and severe floods. The temperature changes are also expected to lead to increased losses of water through evaporation, reducing runoff and soil moisture in many areas.

Extreme Weather Events Will Increase

Many scientists also predict a change in extreme weather events, with an increase in stronger and more frequent cyclones and stronger summer monsoons due to changes in ocean heat and water vapor.[9] Sea-level rise would magnify the impacts of such cyclones, with floods from higher storm surges and strong winds increasing the vulnerability of low-lying coastal settlements. Further inland, a significant increase in extreme precipitation is expected in areas such as the Yangtze River basin in China, suggesting the likely occurrence of severe floods. Based on trends observed over the past 25 years, the IPCC models suggest that, overall, the Asia-Pacific region will experience more El Nino-

9. http://www.ucsusa.org/global_warming/science/hurricanes-and-climate-change.html

Figure 3.3 Precipitation Changes Expected by 2100



Note: Annual mean of daily precipitation: mm/day
Source: Kamiguchi et al., 2006.

like conditions (Box 3.1) and that these events will become stronger and more frequent. (IPCC, 2001b) (Figure 3.4).

Sea Level Will Rise

Using a mid-range from IPCC's scenarios, a sea level rise of 18 to 59 cm can be projected in the next century. This will significantly affect EAP's coasts, deltas, and islands and could have severe impacts on coastal ecosystems and communities (Figure 3.5). Affected areas are likely to

Box 3.1 How El Niño Affects the Southern Pacific

The El Niño event is a climatic phenomenon caused by high sea-surface temperatures in the eastern equatorial Pacific Ocean. It occurs about every 2 to 7 years and lasts typically for 12 to 18 months. The El Niño-Southern Oscillation (ENSO) cycle, is a term for the year-to-year variations in sea-surface temperatures, surface air pressure, convective rainfall, and atmospheric circulation that occur across the equatorial Pacific Ocean. El Niño and La Niña represent opposite extremes in the ENSO cycle.

Under normal conditions, the trade winds blow toward the west across the tropical Pacific. These winds pile up warm surface water in the western Pacific, so that the sea surface is about 0.5 meters higher at Indonesia than at Ecuador. During an El Niño event, the direction of trade winds changes from westward to eastward. The eastward displacement of the atmospheric heat source overlaying the warmest water results in large changes in the global atmospheric circulation, which in turn force changes in weather in regions far removed from the tropical Pacific.

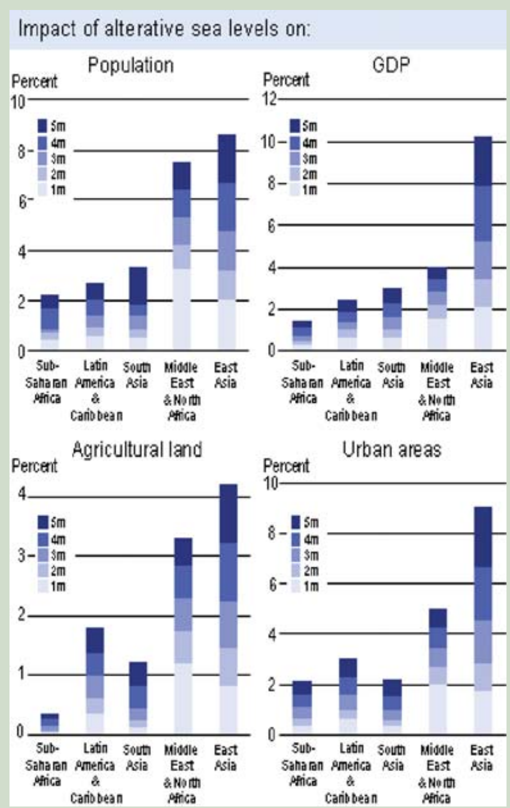
El Niño refers to the above-average sea-surface temperatures that periodically develop across the east-central equatorial Pacific. It represents the warm phase of the ENSO cycle, and is sometimes referred to as a Pacific warm episode. La Niña refers to the periodic cooling of sea-surface temperatures across the east-central equatorial Pacific. It represents the cold phase of the ENSO cycle, and is sometimes referred to as a Pacific cold episode. El Niño contributes to more eastern Pacific hurricanes and fewer Atlantic hurricanes. La Niña contributes to fewer eastern Pacific hurricanes and more Atlantic hurricanes.

Source: NOAA 2006.

Figure 3.4 Area at Risk from a 0.5m Sea-Level Rise in Asia

Source: Bardach, John E., Coastal Zone Activities and Sea Level Rise. East-West Center. Environmental and Policy Institute. Working paper no. 11, 1988, p8. Adapted from Dupont and Pearman (2006).

Figure 3.5 Global Impacts of Sea Level Rise



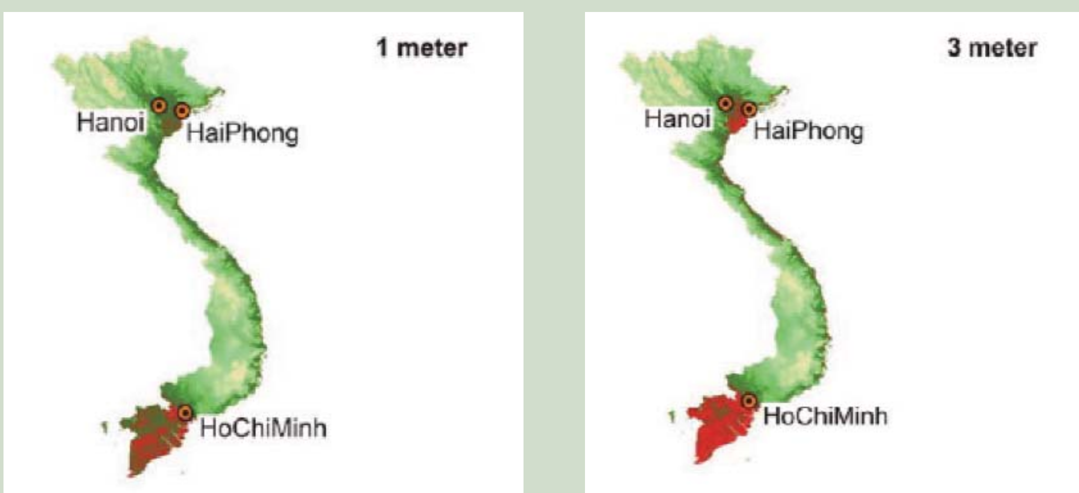
Source: Dasgupta, et al., 2007.

include cities such as Shanghai, deltas such as that of the Mekong, and islands such as Micronesia, French Polynesia and Tuvalu. Impacts will occur on both urban and rural settlements along the coast and will affect housing, infrastructure and economic facilities. This is expected to be exacerbated by the subsidence or sinking of delta land, coastal wetland degradation, and loss of coral reefs. If the sea level rises by one meter or more (near the higher end of the IPCC projections), the impacts would be significantly higher in several EAP countries.

A recent World Bank study[10] reviews new data on rates of deglaciation in Greenland and Antarctica and projects sea level rise at two to five times higher than the IPCC estimates. If these more extreme scenarios were to come about, Vietnam and other countries in South East Asia may be very significantly impacted. Particularly in Vietnam, areas south of Ho Chi Minh City would face inundation (Figure 3.6).

10. Dasgupta et al., WPS 4136, 2007

Figure 3.6 Inundation Scenarios for Vietnam for 1 and 3 Meters SLR



Source: Dasgupta, et al., 2007.

CHAPTER 4

EXPECTED IMPACTS OF CLIMATE CHANGE IN EAP

The changes discussed in Chapter 3 will have diverse and potentially significant impacts on the people, the environment and the economy of the EAP region. The cascade impacts of climate change are expected to vary significantly depending on the magnitude of changes in climatic factors such as temperature, precipitation, and sea level, when these are superimposed on existing physical, environmental and socioeconomic conditions. The major implications of climate change can be structured in three distinct but highly interrelated categories:

- ***Environmental:*** changes in coastal and marine systems, forest cover and biodiversity;
- ***Economic:*** threat to water security, impacts on agriculture and fisheries, disruption of tourism, reduced energy security, which may have negative impacts on GDP; and
- ***Social:*** population displacement, loss of livelihood, and increased health problems.

It is expected that the EAP region could be significantly impacted by climate change in all of these three dimensions.

Environmental Impacts

Climate change in EAP will have adverse impacts on coastal and marine systems and on forests and biodiversity.

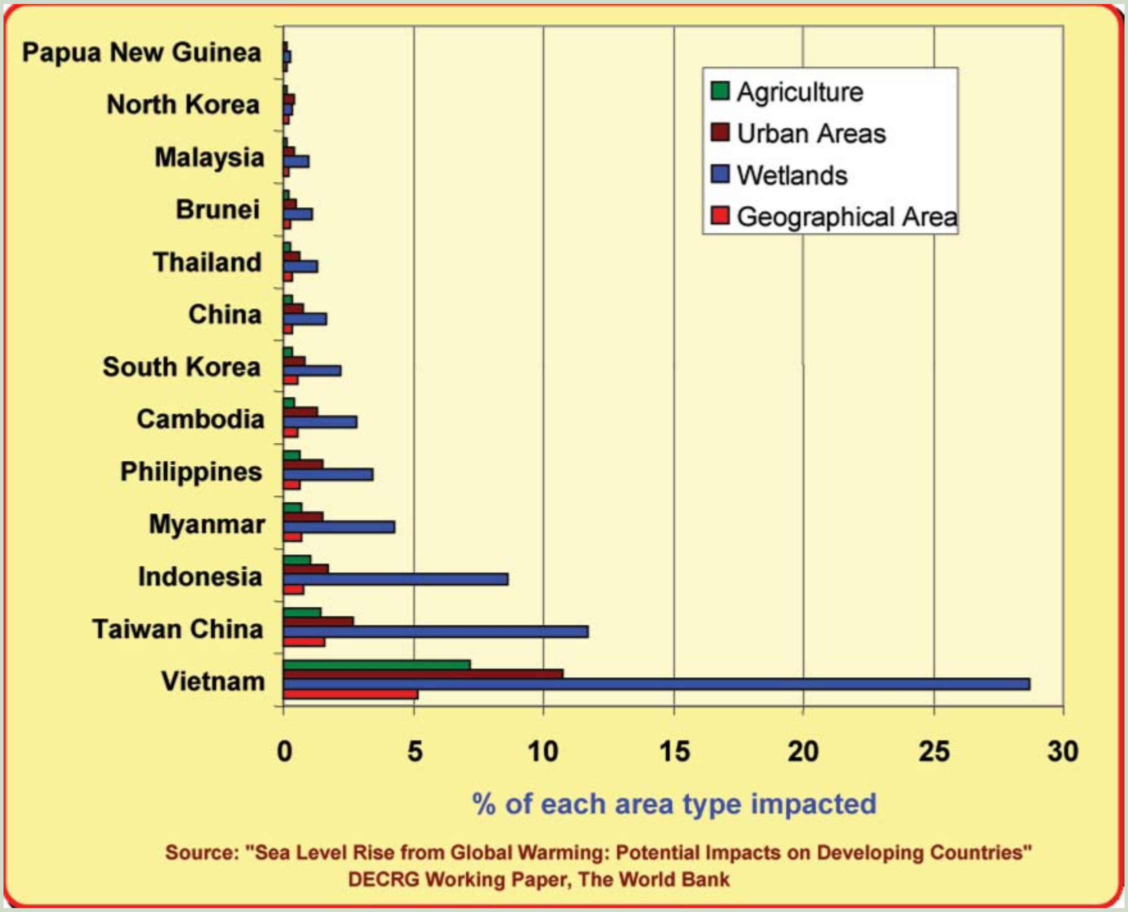
Changes to Coastal and Marine Systems

Climate change is likely to affect coastal and marine areas, and small islands through the following: (i) sea level rise that would lead to increased erosion and inundation; (ii) more intense cyclones and storm surges; and (iii) higher sea surface temperatures and changes in ocean chemistry.

- ***Damage to delta ecosystems.*** Delta and estuarine ecosystems are especially sensitive to sea level rise and increasing shoreline wave action, and are more prone to saltwater intrusion as a result. For example, in the Greater Pearl River Delta, it is estimated that the tidal boundary will move, bringing salt water upstream, a further 3 km with a sea level rise of 40 to 60 cm. In Guangzhou, China even during periods of low tide, salt water is expected to intrude into water bodies, negatively affecting drinking water supply (Tracy, 2006). Mangrove forests, which exist at the interface of fresh and salt water, are highly vulnerable to climate change-induced sea-level rise due to changes in salinity distribution. However, while sea-level rise will threaten some existing mangroves, the new coastal boundaries will cause a shifting of zones suitable for new mangroves. Large-scale changes in species composition in mangrove forests can be expected as a result of changes in sedimentation and organic accumulation, the nature of the coastal profile, and species interaction (Aksornkaoe and Paphavasit, 1993).
- ***Impacts on small islands.*** Coastal retreat and erosion resulting from sea level variability and sea level rise is a major problem, affecting tourism building stocks and beaches in low-lying areas, and is of special concern to small island states. Coastal retreat over the last few decades may have been around 15 to 20 meters in certain locations (Mimura & Nunn, 1998). Low-lying atoll islands such as Beachcomber and Treasure Island could be completely lost as a result of sea level rise.

The World Bank assessed the impact of sea level rise at four different sites in Viti Levu: Suva Peninsula, Korotogo on the central coast (Viti Levu's major tourist area), Tuvu in the north, and the Western Rewa River Delta. The study estimated that at Korotogo, the shoreline could retreat by 1–3 meters by 2050 and up to 9 meters in 2100 (Figure 4.1) (World Bank, 2000).

Figure 4.1 Projected Impacts of a 1m Sea-Level Rise Scenario

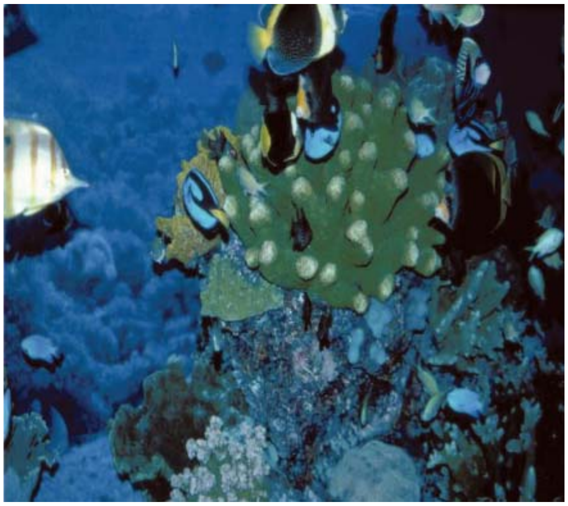


Source: World Bank, 2007a.

- ***Loss of coral reefs.*** Coral reefs in South East Asia have been steadily degrading over the past 100 years. The reefs surveyed regularly over the past 10 years had live coral cover of less than 75 percent; and nearly a third had less than 25 percent cover (Wilkinson, 2004). Reef-building corals depend on symbiotic algae to photosynthesize much of their food. Surface waters that are warmer than normal can "bleach" corals by depleting their photosynthetic pigments, or can even make them expel their algae. Rising ocean temperature and growing acidity are the main causes of coral mortality. ENSO events have been associated with extensive coral bleaching in the Pacific in the early 1990s. In the El Niño/La Niña global coral bleaching event of 1998, 16 percent of the world's coral reefs were destroyed, with the most damage in the Indian and the western Pacific Oceans. Although many coral reefs are showing some signs of minimal recovery, with stronger recovery in well-managed and remote reefs, studies have suggested that global warming will reduce the world's coral reefs in an extremely short timeframe (Wilkinson, 2004). By the end of the century, the trend could decimate coral reefs seriously reducing associated tourism incomes, as well as reducing their ecosystem services including their value as coastal protection, reducing food security, and fostering biodiversity (Box 4.1)

Changes in Forest Cover and Biodiversity

Biodiversity is at particular risk in the EAP region. Already threatened by habitat loss, pollution, and over-



Box 4.1 Economic Importance of Coral Reefs and Threats to Their Survival

Coral reefs are important for food security and tourism revenues. They function as protective barriers for beaches and coasts by reducing incident wave energy through the processes of wave reflection, dissipation, and shoaling. They are also significant contributors to the economic resource base of many small island states. The potential economic value of well-managed coral reefs in South East Asia is estimated at 42.5 percent of the global total of $29.8 billion, and can be disaggregated as follows: reef fisheries are estimated to have an economic value of $2.2 billion; reef tourism is valued at $4.8 billion; reef benefits to coastal protection are estimated to be $5 billion; and their potential biodiversity value (based on possible pharmaceutical uses) is $0.5 billion (Wilkinson, 2004).

Corals have narrow temperature and salinity tolerance. If the temperature increase is relatively small (e.g., 1–2° C) for a short period, bleached corals may recover, though with reduced growth and impaired reproductive capabilities (IPCC, 2001b). But if the temperature elevation is substantial over an extended period (for example, 3–4° C for over 6 months), significant coral mortality is likely. Increasing levels of carbon dioxide in the atmosphere are also making the world's oceans more acidic, making it harder for corals and plankton to form their body parts.

Source: Wilkinson, 2004.

exploitation, species and natural systems are now faced with the need to adapt to new regimes of temperature and precipitation, or face extinction. Sea temperature increases associated with El Niño events have been implicated in reproductive failure in seabirds, and major shifts in island food webs (IPCC, 2001b).[11] A wide range of other changes might be expected, including alterations in absolute and relative population size, altitudinal distribution of vegetation types, changes in fish distributions due to changed river flows, and bird migration patterns as the stop-over resources such as seasonal lakes and marshes change in character. The impacts could include the following:

- ***Tropical and temperate forests.*** Changes in forest cover in EAP will be associated with changes in water availability and shifts in temperature and precipitation, as well as persistence or extinction of pollinating and fruit-dispersing animals. This in turn may result in altered growing seasons and boundary shifts among grasslands and seasonal forests. The impacts generated by these changes include the local extinction, replacement and migration of species; increased or decreased soil nutrient availability and soil water-holding capacity; increased emissions of GHGs (particularly methane) from wetlands; and increased probability of outbreaks of pests, particularly insects, to drought-stressed trees (IPCC, 2001b). With an increase of average temperature of 1° C, it is estimated that the wild fire season would lengthen by 30 percent in North Asia leading to further mortality and habitat loss (Vorobyov, 2004).
- ***Expansion of semi-arid drylands.*** The Asia-Pacific region is responsible for about 75 percent of all human-induced salinization in arid, semi-arid, and dry sub-humid areas—the susceptible drylands of the world (UNEP, 1997). The region has a large proportion of semi-arid drylands that threaten to turn into fully arid areas under climate change. For example, a new desert is reportedly forming on the eastern edge of China's Qinghai-Tibet Plateau, which has traditionally been a plentiful grassland area that herders rely on for their survival (Li, 2007).
- ***Changes in species distribution, abundance, and habitat.*** The distribution of species in ecosystems in Asia is projected to shift to higher elevations and

11. The sex ratio of hatchlings of many reptiles depends on the incubation temperature. For example, at higher temperatures crocodile embryos tend to become male, while turtle embryos tend to become female. Crocodiles tend the nest and attempt to maintain a moderate temperature, but other reptiles leave the temperature to nature.

latitudes as a result of global warming. The rates of vegetation colonization are expected to be slow and constrained by increased erosion and overland water flows. It is estimated that many species would be exterminated due to the synergistic effects of climate change and habitat fragmentation (Ishigami, et al., 2005). Furthermore, many species of animals and plants are restricted to high mountain tops. As the climate warms, ecological zones will shift upwards and, unlike species lower down, mountain-top species will have nowhere to go.[12]

- ***Invasive species.*** These are species 'alien' to the ecosystems to which they are introduced and which find conditions so conducive that they spread rapidly, often causing economic and environmental impacts or harm to human health.[13] Invasive animals can cause ecological havoc by preying on local species and outcompeting native species for limited resources. The effect on native biodiversity can be severe. It is estimated that, globally, 42 percent of the species on the threatened or endangered species lists are at risk primarily because of invasive aliens species.[14] However, in EAP, it appears that most terrestrial impacts are in human-modified habitats. Climate change may aid in the appearance and survival of new invasive species (e.g., increased temperatures can enable disease-carrying mosquitoes to expand their ranges), while inhibiting the ability of local and indigenous species to adapt to a rapidly-changing climate.
- ***Changes in migratory patterns.*** EAP is indicated as the region with the highest density of globally threatened bird species.[15] Like many plants and animals, birds' life cycles and behavior are closely linked with the changing seasons. For neotropical migrant species, changes in weather help signal when they should begin their long flights southward in the fall and back again in the spring. Global warming may cause migration and nesting to get out of step with food supplies. Variables such as temperature and precipitation also affect the timing and availability of flowers, seeds, and other food sources for the birds when they reach their destinations. Moreover, birds that rely on very specific habitats for at least part of their life cycle could become extinct if their habitat disappears. For each of these reasons, many bird species are considered to be particularly vulnerable to global warming and associated climate change (Both and Visser, 2001).
- ***Reduced ecosystem services.*** Species diversity aids in regulating ecosystem services such as erosion control, maintaining soil fertility, filtering pollutants and delivering clean water to streams and rivers, cycling nutrients, pollinating plants (including crops), buffering against pests and diseases, and providing cultural and amenity services, as well as food and traditional medicines. It is possible that, as the climate changes and as species are eliminated from an area, there may be changes in some ecosystem functions. This could mean more land degradation, changes in agricultural productivity, and a reduction in the quality of water delivered to human populations.

Economic Impacts

Climate change can make the impressive economic gains of the EAP region less sustainable. The need to divert scarce finances to climate change adaptation, away from other investments for economic growth and poverty alleviation, will be discussed in Chapter 5. This section focuses on the key impacts on assets and livelihoods associated with climate change in EAP, which include threats to water security, impacts on agriculture and fisheries, disruption of tourism, and reduced energy security.

Threat to Water Security

Water, critical to economic growth and poverty alleviation in EAP, is especially vulnerable to climate change. There are already many existing threats to water security (increasing demand and pollution; unsustainable groundwater extraction, waterlogging, salinization, watershed degradation and siltation; droughts, floods and other disasters; limited shared vision planning, lack of cooperation and water rights conflicts). Significant and complex water security changes are expected to be associated with changes in temperature and precipitation, as well as changes in the delta regions of major river basins, associated with sea level rise, coastal storms, and saltwater intrusion. The economy and livelihoods in the region could be fundamentally impacted by these changes. Key incremental threats to water security from climate change include:

12. This effect has already been observed in Central America. (Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Ann. Rev. Ecol. Evol. Syst. 37: 637–669). Unfortunately there are few, if any, detailed biological monitoring or active research program focusing on EAP's mountains.

13. Relevant examples in Asia are the golden apple snail, red-eared slider turtle, tilapia, black-striped mussel, cane toad, African catfish, Louisiana crayfish, lantana, water hyacinth, salvinia, mile-a-minute, spiraling whitefly, diamond-backed moth, epizootic ulcerative syndrome on fish, and avian influenza virus. GISP 2004. *Tropical Asia invaded: the growing danger of invasive alien species.* GISP, Cape Town.

14. Smithsonian Tropical Research Institute, 2005.

15. Millennium Ecosystem Assessment, 2005.

- ***Too much and too little water.*** In general, EAP will receive more precipitation. This could have both positive effects (such as more cereal production in rainfed areas in northern China) and negative effects (increased floods threatening livelihoods, infrastructure, and productivity), as illustrated in Box 4.2. However, the complex interaction of precipitation and temperature changes could actually result in less runoff to streams in several regions of EAP, even where precipitation is expected to increase. This could cause increased water stress, prolonged droughts, and increase in water conflict situations in the absence of effective and flexible trans-boundary and multi-sectoral management mechanisms to respond to dynamic changes in water supplies. Hydropower production could drop as a result of the reduction in river flows in the long term. Water supplies for drinking, agriculture, and industry could also be threatened by reduced river flows and reduced groundwater recharge. For example, the complex nature of the sectoral and spatial impacts of climate change on water security in the Mekong Basin is illustrated in Box 4.3.
- ***Glacial melt.*** Glaciers in the Tibetan Plateau are smaller and less stable than those of other regions and are particularly susceptible to climate change, having shrunk by almost 6,600 km^2 since the 1960s. Chinese glaciers have decreased by 7 percent in size, losing about 500 billion cubic meters of stored water annually (Institute of Tibetan Plateau Research, Chinese Academy of Sciences, August, 2006).[16] Flows in rivers fed by glaciers could be expected to increase in the short term as melting accelerates (e.g., the additional runoff from Chinese glaciers today is estimated to equal the Yellow River flow), also increasing the possibility of glacial lake outburst floods (or GLOFs). However, after peaking at the beginning of this century, the flows are expected to drop precipitously as glaciers are largely depleted. This will be an important issue in areas that are fed by glaciers, such as the Yangtze basin (Box 4.4).
- ***Seawater intrusion.*** Sea level rise—in combination with increasing coastal storms, inland hydrologic changes, pollution, and land subsidence (caused by over-extraction of groundwater such as in many Chinese delta regions)—could severely impact the water security of coastal areas. This could be manifested as seawater inundation of productive land areas, seawater intrusion into coastal aquifers, and resulting water scarcity in these coastal areas. In small islands, there is a special threat from these changes to the small freshwater lenses that are vital to island communities.

Box 4.2 Climate Change Impacts on Water Scarcity in China

The average surface air temperature in China has increased by between 0.5 and 0.8°C over the 20th century, with more increases marked in North China and the Tibetan Plateau compared to southern regions. Temperature rise will lead to northward movement of China's temperate zones as well as an extension of the arid regions. Overall water scarcity is a critical problem in China, with existing water shortages, particularly in the north (exacerbated by economic and population growth). Climate change is expected to increase water scarcity in northern provinces such as Ningxia, Gansu, Shanxi, and Jilin. An increase in average rainfall in southern provinces such as Fujian, Zhejiang, and Jiangxi is anticipated over the next 50 to 100 years leading to more instances of flooding. From 1988 to 2004, China experienced economic losses from drought and flood equating to 1.2 percent and 0.8 percent of GDP respectively.

Source: Stern Review—Part II: The Impacts of Climate Change on Growth and Development.

Impacts on Agriculture

Agricultural productivity is likely to suffer severe losses due to high temperatures, drought, flooding, coastal inundation, soil degradation, and associated factors. Changes in agricultural output will vary significantly across the region, and will be closely linked to the availability of water for irrigation. Pest populations and crop pathogens are also expected to increase, with negative impacts on

16. http://www.itpcas.ac.cn

Box 4.3 Water Security in the Mekong River Basin

The Mekong River Basin encompasses an area of approximately 795,000 square kilometers and is home to about 60 million people from over 100 different ethnic groups. The Mekong is the longest river in South East Asia, flowing for 2,161 kilometers in China through Qinghai, Tibet, and Yunnan provinces, before traveling an additional 2,719 kilometers through Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam, and finally entering the South China Sea. Agriculture, fisheries and forestry employ 85 percent of the basin population. The basin produces enough rice to feed 300 million people annually, including from 12,500 irrigation schemes. It is estimated that there are over 1300 species of fish in the Mekong River, providing livelihoods and food to basin residents. Over 1.5 million tons of fish are annually consumed in the basin. The basin also has significant hydropower potential and provides inland navigation (with about 25 major ports distributed along the Lower Mekong).

Some models have predicted that the implications of climate change for this basin may include:

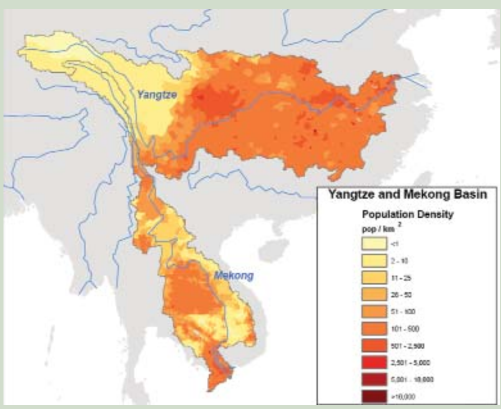
- ***Increased temperatures.*** The daily maximum daytime temperature is expected to be higher by 1° to 3° C, especially in January to May. Effects in the eastern highland part of the Mekong are estimated to be the most pronounced (Snidvonds et al., 2003). A 2–3° C rise in ambient temperature can increase evaporation and transpiration losses in the Mekong system by 10–15 per cent (World Wildlife Fund, 2005).
- ***Increased floods.*** Greater flow variability and increased flooding is expected generally through a combination of climate variability and land use changes. The Korat Plateau (which lies in Northeast Thailand and adjacent parts of Lao PDR) and the southern lowland areas (which form much of the northern half of Cambodia and extend into small portions of southern Lao PDR and eastern Thailand) will generally experience a shorter rainy season and a longer dry season (by approximately 2 months). However, the total rainfall over the year will be slightly higher, particularly in the southern and central provinces of Lao PDR. In September, these areas will experience a dramatic increase in rainfall, from 15 billion cubic meters (bcm) per month to 26 bcm per month. The overall rainfall on the Korat Plateau will increase from 124 to 137 bcm per year. With increasing urbanization and construction of human settlements, the natural hydrological storage sinks of the Mekong (such as backwater swamps) are threatened. Reverse flow from the main stream, along with additional rainfall, will increase the threat of flooding in the wet season (Snidvonds et al., 2003).
- ***Decreased water supply.*** A significant reduction is expected in the supply of water in the upper Mekong (Yunnan) region. In the Lancang region in China, rainfall during the dry-season months (September to April) will be generally the same but will be significantly lower over the wet season (May to August). Annual rainfall will be reduced from 109 bcm per year to 87 bcm per year, or about a 20 percent reduction (Snidvonds et al., 2003). Water shortages and deteriorating water quality associated with the longer dry season and reduced flows are also expected. Changes in flows and seasonality could also have adverse impacts on sensitive and economically productive wetlands such as the Tônlé Sap in Cambodia.
- ***Sea level rise.*** Sea level rise and coastal intrusion could have substantial impacts on delta area productivity and sustainability. Coastal cities such as Ho Chi Minh City in Vietnam could be impacted significantly.
- ***Impact on productive systems.*** Changes in climate will have significant effects on agriculture and food production in many parts of the basin, particularly on low-income populations that depend on isolated agricultural systems—due to a combination of frequent floods, droughts, cyclones, and sea-level rise (Hoah et al., 2003). It could also negatively affect the potential for hydropower production.

Sources: Hoah et al., 2003; Snidvonds et al., 2003; World Wildlife Fund, 2005.

Box 4.4 Water Security in the Yangtze River Basin

The Yangtze River is 6,300 kilometers long. Its basin covers nearly 2 million square kilometers, one-fifth of China's total land area, from mountainous inland regions to low-lying coastal areas. The basin is also home to more than 500 million people, nearly half of China's total population, making it one of the most densely populated river basins on Earth. It produces more than 40 percent of China's GDP, and accounts for over 40 percent of the country's total investment in fixed assets.

The Yangtze originates on the Qinghai-Tibet Plateau in the Sanjiangyuan region of Western China. These highland areas provide approximately one-fourth of the water in the Yangtze; the rest is added from rainfall and tributaries downstream. The Yangtze basin could experience impacts in both upstream and delta areas.



- ***Upstream*** the basin areas could face issues of changing hydrology, glacier melt, and degradation of grasslands. The average temperature in Sanjiangyuan has increased by 0.88° C in the past 50 years, causing glacial retreat and permafrost melt in the snow-covered regions that feed the upper Yangtze. This glacial melt is bringing short-term increases in water flow, but over time the flow will diminish, decreasing water supplies. As temperatures rise, more evaporation will take place. Precipitation impacts are uncertain.
- ***Downstream,*** the Yangtze River Delta is also at high risk from the effects of climate change. A 40 centimeter rise in sea level by 2050 would have serious effects on infrastructure in urban areas such as Shanghai, as well as on fertile agricultural lands, coastal aquifers, and tidal flats. In addition, there would be losses to wetland habitats and increased pollution due to flow changes, as well as more vulnerability to coastal storms requiring additional investment and construction of man-made barriers.

The El Niño event in 1997/98 brought excessive rains to the basin, resulting in the worst flooding in half a century. This and other floods have been exacerbated by intensified human activities, such as factory and road construction. With less land area to absorb rainfall, storm water runoff into the Yangtze has increased and contributed to flooding. The problem is not isolated to urban areas. Livestock husbandry is a major source of income in the upland regions. Grasslands are supporting far more animals than they can sustain, resulting in grassland degradation and further devastation of the ecosystem's water-trapping capabilities. Since the 1997/98 floods, the central government and water resources agencies have begun to address water supply issues upstream that could serve as examples for future adaptation measures. However, additional resources will be needed to adapt the entire basin to the effects of climate change.

Source: Worldwatch Institute, 2006; Worldwatch Briefing, 1998; Ye and Glantz, 1998; Yafeng et al., 2000.

productivity in the sector. Impacts on trade and thus on economic growth overall could be substantial.

- ***Reduced agricultural production in the Southern regions.*** Substantial decreases in cereal production are expected as a consequence of climate change in Asia by 2100. Net cereal production is projected to decline by at least 4 to 10 percent under the most conservative climate change projections (IPCC, 2001b). With the combination of thermal stress and water scarcity in some regions, under the projected scenarios, rice production in Asia could decline by 4 percent by 2100. Studies have also indicated that a 2°C increase in mean air temperature could decrease rain-fed rice yields by 5 to 12 percent in China. Various studies have also suggested that substantial losses are likely in rain-fed wheat in South and South East Asia.
- ***Increased agricultural production in Northern areas.*** In contrast to the above, in other areas, cereal production may increase due to additional precipita-

tion. Climate change can affect not only crop land productivity, but also the land area of production. Most of the arable land that is suitable for cultivation in Asia is already in use (IPCC, 2001b). There has reportedly been a decline in potentially good agricultural land in East Asia (including Japan), and substantial increases in suitable areas and production potentials in currently cultivated land in Central Asia (Fischer et al., 2002). With increased temperatures, a northward shift of agricultural zones is likely, potentially expanding the agricultural frontier. For example, the dry steppe in the eastern part of Mongolia would push the forest steppe to the north, resulting in shrinking of the high mountainous and forest steppe zones and expansion of the steppe and desert steppe. In northern China, studies suggest that the tri-planting boundary will shift by 6–10 kilometers per year (300 to 500 km by 2050)—from the Changjiang River Valley to the Yellow River Basin. Double-planting regions would move toward the existing single-planting areas, while single-planting areas will shrink by 23 percent (Wang, 2002).

- ***Increased demand for irrigation.*** How the effects of climate change on agricultural output and productivity vary across different regions is closely related to changes in water availability. Demand for irrigation for agriculture in arid and semi-arid zones in East Asia is estimated to increase by 10 percent for every 1° C increase in temperature (Box 4.5). Excess demand for irrigation water would severely limit the potential for growing two or more crops per year (the current practice in the more fertile areas of EAP). One of the often-suggested coping mechanisms is for farmers to diversify or shift to crops that require less water. However, most farmers are constrained by limited access to technology and inputs. This reinforces the importance of involving government agriculture departments in designing coping mechanisms.

Box 4.5 Meeting Irrigation Needs in China

On average, in China, productivity of irrigated land is expected to decrease between 1.5 to 7 percent, with rain-fed land productivity dipping by between 1.1 to 12.6 percent from 2020 to 2080 under various scenarios. Water resources for irrigation from available surface and groundwater sources in northern China will meet only 70 percent of the water requirement for agricultural production. Overall, a net decrease in agriculture production is anticipated with seven provinces in the north and northwest of China particularly vulnerable (accounting for one fourth of total arable land and 14 percent of China's total agricultural output by value).

- ***Increase of pest populations and crop pathogens.*** Higher temperatures and longer growing seasons would result in an increase in pest populations in temperate regions of Asia. Warmer winter temperatures would reduce winter kill of insects, leading to an increase in insect populations. Overall increases in temperature may influence crop pathogens by speeding up pathogen growth rates, which increase reproductive generations per crop cycle.
- ***Impacts on trade.*** The projected decline in potential yield and total production of rice in some Asian countries caused by climate change could have a significant effect on trade in agricultural commodities, hence on economic growth and stability (Matthews et al., 1995).

Impacts on Fisheries

Climate change is also expected to have significant impacts on fisheries. Climatic factors affect the elements that influence the number and distribution of marine fish species in two ways: *biotic* (food availability, breeding habits, and the presence and species composition of competitors and predators) and *abiotic* (water temperature, salinity, acidification, nutrients, strength of upwelling, mixing layer thickness, sea level, wind speed and direction, ocean currents). The impact on Asian fisheries depends on how climate change affects both sets of factors, as noted below, with cascading impacts on livelihoods and employment in the sector (IPCC, 2001b).

- ***Marine fisheries.*** According to recent studies, projected changes in ocean currents will affect marine fisheries negatively, suggesting a reduction of primary production in tropical oceans because of changes in the ocean circulation in a warmer atmosphere. The tuna catch of East Asia is nearly one-fourth of the world's total. A modelling study showed significant large-scale declines of skipjack tuna habitat in the equatorial Pacific under projected warming (Loukos et al., 2003). Principal marine fishery species, like ribbon fish and yellow croakers in China, have zoned distribution and seasonal feeding and spawning migration patterns. Migration routes and patterns—and hence the regional catch—may be greatly affected by climate change. An increased frequency of El Niño events associated with a warmer atmosphere could lead to measurable declines in fish abundance in coastal waters of South East Asia, although moderate warming may actually improve the conditions for some fish, such as cod and herring, by increasing productivity of their prey and providing more extensive habitats. Increased sea surface temperature also has the potential to increase the intensity and frequency of disease outbreaks.

- ***Inland fisheries.*** Saline water fronts may penetrate further inland, which could increase the habitat of brackish-water fisheries. In addition, fisheries in higher elevations are likely to be affected by lower availability of oxygen due to a rise in surface air temperatures. In the plains, the timing and amount of precipitation may affect the migration from rivers to floodplains for spawning, dispersal, and growth (FAO, 2003).

Disruption of Tourism

Tourism is a growing source of revenue for many countries in the EAP region. Thailand's natural attractions, for instance, have pulled in tourists since the 1960s, and other countries such as Cambodia have recently entered the sector. In fact, Thailand's tourism surpassed rice as the largest source of foreign exchange in 1983, and is estimated to generate more than $9 billion in income, representing about 7 per cent of GDP in 2001 (Raksakulthai, 2003). Climate change will have both direct and indirect effects on the tourism industry. As noted above, sea level rise will result in loss of beaches, degradation of coastal ecosystems, saline intrusion, and damage to critical infrastructure. The resulting economic impacts on tourism could be high.

In addition, a high proportion of tourism in small-island states is motivated by the desire of visitors from colder climates to seek warmer destinations. These states are becoming increasingly concerned that projected milder winters in the tourist market countries would reduce the appeal of these islands as tourist destinations (Martin and Bruce, 1999). Tourism could be further harmed by increased airline fares if GHG mitigation measures (e.g., levies and emission charges) were to result in higher costs to airlines servicing routes between the main markets and small island states (Wall, 1996).

Reduced Energy Security

Energy demand in EAP is related to economic and industrial activity and population growth. At present, most of that energy is provided by burning fossil fuels, which release large amounts of GHGs. Damage costs due to fossil fuel CO_2 emissions in the EAP region are estimated to be 1.2 percent of regional GNI, equivalent to $38 billion (World Bank, 2006b). It is expected that the region's economies will continue to see increased energy demand from industrialization, urbanization, and increased use of motor vehicles. They will also need more energy to address climate change impacts.

Security of supply is an issue for all countries, and eventually moving to a low-carbon economy is an emerging issue for the fastest-growing, industrializing countries, notably China and Vietnam. Some countries are proactively taking steps to diversify their energy sources. EAP has great potential for investing in hydropower and renewable energy and changing its dependence on fuel sources that intensively emit GHGs. In 2003, China's hydropower generation was 23 percent of the country's economically exploitable potential. The corresponding numbers for Indonesia and Vietnam were 25 percent and 24 percent, respectively. However, glacial melt in the Himalayas and uncertain rainfall downstream may curtail the potential for hydropower in the long term. Flooding from storms and glacial melt is expected to increase sedimentation, adversely affecting drainage and efficiency of hydropower projects. Moreover, hydropower projects reduce sediment discharge to river deltas downstream, making them more susceptible to erosion and the effects of sea level rise.[17] Thus some of the plans to increase energy security could be affected by climate change.

Negative Impacts on GDP

The likelihood of damage to infrastructure and loss of human life because of unexpected extreme events will rise. A rise in sea level would impact the region's GDP generally; Vietnam and China would be affected the most, with impacts also being felt in Indonesia, Thailand and Cambodia (Dasgupta et al., 2007). In the absence of adaptation, a high island such as Viti Levu could experience average annual economic losses equivalent to 2 percent of

17. Non-hydropower renewables, such as solar and wind, present additional alternatives to fossil fuels, especially in isolated regions in EAP. In 2002, these sources accounted for 1.3 percent of EAP's generated electricity (World Bank, 2005b).[0]

Fiji's GDP. A low group of islands such as the Tarawa Atoll in Kiribati could face average annual damages of roughly 16 percent of its GDP by 2050.

These costs could be considerably higher in years of extreme weather events such as cyclones, droughts, and large storm surges. In years of strong storm surge, up to 54 percent of South Tarawa could be inundated, with capital losses of up to $430 million (World Bank, 2000). An idea of the aggregate economic impacts of extreme weather events resulting from changes in regional climate can be drawn from estimates of the damages caused by the 1997–98 El Niño in various countries in EAP, as summarized in Box 4.6.

Box 4.6 Economic Impacts of the El Niño Events in EAP: A Preview of What Could Lie Ahead?

The largest El Niño event in the last century occurred in 1997–98. Malaysia and Indonesia were hit by severe droughts, which exacerbated forest fires over 9.7 million hectares, and the resulting smog caused a major public health crisis spreading to neighboring countries—Singapore, the Philippines, and southern Thailand. In Indonesia, such fires affected economic growth with estimated losses of $10 billion. The resulting air pollution caused 500 deaths and nearly 3 million lost work days, costing more than $17 million in 1999 [(ADB and National Planning Development Agency of Indonesia (BAPPENAS)]. There were also impacts in neighboring countries—Malaysia and Singapore suffered damages worth about $0.5 billion from the Indonesian fires. On the other side of the Pacific, Ecuador and Peru suffered more than 10 times the usual rainfall, causing several floods. Coral bleaching, a direct impact of increased sea temperature above a threshold (about 28°C), was particularly pronounced during 1997–98, because a very strong El Niño occurred that year. Recently, the El Niño cycle has been associated with disease outbreaks such as malaria, dengue, and Rift Valley Fever (WHO, 2000). The bulk of the financial loss came from adverse health impacts. Tourism is another important consideration. It can be significantly affected, as was the case with the 1997 fires. The loss from reduced tourist visits was estimated at $111 million (Glover and Jessup, 1997).

Source: Asian Development Bank 1999; WHO, 2000; and Glover and Jessup, 1997.

It is generally more cost-effective to protect coastal assets and infrastructure ahead of a severe weather event than to repair the damage after it occurs. For example, the damage caused by cyclone Heta, which hit Samoa in 2004, translated into 9 percent of GDP, compared with 230 percent of cyclone Val in 1991. Although the two cyclones are not directly comparable, the effects of cyclone Heta would have been far worse without an investment in risk management of natural hazards undertaken during the 1990s (World Bank 2004). Shoreline protection systems designed to cyclone standards performed well, with relatively minor damage, compared to sub-standard coastal protection in adjacent areas (Bettencourt et al., 2006).

Social Impacts

The dense rural and urban populations of EAP are at particular risk from climate change. The impacts described above on coastal, marine and terrestrial ecosystems, and associated impacts on water security, agriculture, fisheries, tourism and other dimensions of economic activity, depending on their intensity and scope, may lead to serious social stress.

Displacement and Livelihood Loss

Sea level rise is a significant threat to populations residing in populated coastal areas and deltas, as well as on islands. In the absence of coastal protection measures (e.g., sea walls), this threat may involve large-scale displacement of populations (including those from many densely populated cities) away from coastal areas toward the interior, in a planned or unplanned retreat depending on local preparedness. This is especially problematic for small island countries, where virtually the whole territory may be at risk of being engulfed by rising oceans. In addition, gradual progress of adverse climate conditions (e.g., expansion of drylands, loss of water security, etc.) could displace many others over time. The increase of shorter-term phenomena (e.g., floods, droughts, storms) could also increase the displacement of populations due to loss of assets, as well as cause the separation of families, as members seek work elsewhere, creating national and international environmental refugees. Coping with these stresses would require communities to develop a shared vision of the nature of the enhanced displacement threats they face, consensus on the options they have, and the development of agreed long-term strategies to adapt to such threats.

In addition to the losses from displacement, traditional livelihoods that have always been subject to some of the vagaries of nature (e.g., in agriculture, forestry, hunting, and fisheries) will be even more vulnerable. These impacts will be spatially heterogeneous, with some countries or regions within countries being better off than others. As noted, some livelihoods may actually improve (e.g., in areas that receive more rainfall for agriculture) in parts of the region. On the other hand, enhanced probability of extreme natural disasters may cause frequent dips in local economies and poverty alleviation efforts. In addition, across the region, the demand for food will continue to grow with economic growth, placing stress on agricultural and fishery systems. When climate change impacts are superimposed on current threats to the sustainability of agricultural systems, such as hydrologic extremes (droughts and floods), overfishing, and destruction of mangroves, the impacts are likely to be magnified. The need to cope with such challenges makes it imperative for countries to take measures to become resilient to climate change.

Human Health Impacts

The WHO (2003) identifies seven broad categories of health impacts linked to a change in climatic conditions: temperature-related illness and death; extreme weather-induced health effects; air pollution-related health effects; water- and food-borne diseases; vector-borne and rodent-borne diseases; effects of food and water shortages, and mental trauma, infections, nutritional, psychological, and other factors that occur in impacted or displaced populations in the wake of climate-induced economic dislocation, environmental decline, and conflict situations.

In 2000, climate change was estimated to be responsible for approximately 2.4 percent of worldwide diarrhea, 6 percent of malaria in some middle-income countries, and 7 percent of dengue fever in some industrialized countries. In total, the attributable mortality was 154,000 (0.3 percent) deaths and the attributable burden was 5.5 million (0.4 percent) disability adjusted life years (DALYs). South East Asia has been disproportionately impacted answering for 47 percent of the burden (WHO, 2002).

Human communities in EAP are already at risk from the health implications of degraded ecosystems. Cholera and other waterborne diseases are on the rise in coastal countries and may be related to declining water quality, climate, and algal blooms. There is also an increase in the incidence of diseases of marine organisms and the emergence of new pathogens, some of which are harmful to humans, such as ciguatera, which causes seafood poisoning (UNEP, 2006). Kiribati already has one of the highest rates of ciguatera poisoning in the Pacific. The rise in temperatures is expected to increase the incidence of ciguatera poisoning from 35–70 per 1,000 people to about 160–430 per thousand in 2050 (World Bank, 2000).

Higher temperatures will be more pronounced in large cities because of the "urban heat island effect" (concrete and asphalt absorb more heat than natural settings). The direct health impact of high temperatures on human health is heat stroke morbidity and mortality, especially for older age groups (above 65), an effect which has been clearly measured for cities such as Nanjing and Tokyo. Severe summer heat waves in the future are likely to increase the risk of mortality in older age groups and urban poor populations in temperate and tropical Asia. A reduction in mortality by warming of winter temperatures may compensate for some of the losses from heat stroke during the summer months (IPCC, 2001b).

Cumulative Impacts

Climate change impacts will not occur in isolation. The concurrent impacts on different social, economic, and environmental dimensions will combine in often unforeseeable and sometimes counterintuitive ways. For example, it was noted earlier that even if precipitation is higher in certain areas, the increased temperature could result in much higher evaporation and transpiration, leading to reduced runoff into streams and rivers and increased water stress.

Many of these effects can further exacerbate existing problems. For example, there is a possibility of an increase in the number of "environmental refugees" displaced by climate variability and change, which could place greater stress on certain urban areas. But there are many combinations of impacts that may emerge, and these should be anticipated for potential adaptation. The inundation caused by sea-level rise may be exacerbated by delta land subsidence due to over-pumping of coastal aquifers; in this case, policy and management failures could have contributed to the problem. It is inevitable that a combination of factors will cause each impact described above, and that each region will face a combination of impacts to which it will have to adapt.

The level of development in a region strongly affects its overall social, economic, and environmental vulnerability, and determines its ability to adapt to climate change. More developed countries and more affluent communities have the capacity to develop and implement improved monitoring and preparedness systems, invest in adaptation infrastructure, maintain flexibility in production systems, and mobilize financial support to assist affected communities. On the other hand, the poor often have a limited planning horizon, and have little insurance or access to safety nets against the loss of income from any climate-related changes. The poor often cultivate crops on marginal lands that are the most vulnerable to climatic variations. In EAP these impacts are further exacerbated by overpopulation, resource degradation, and social conflicts.

WHAT EAP CAN DO TO ADAPT

Approaches to Adaptation

The most recent evidence produced by the IPCC confirms that it is not possible to avoid climate change that will be taking place in the next two or three decades, since such change is the result of GHG accumulation that has occurred in the past.[18] Adaptation to climate change is therefore essential to protect communities, ecosystems and economies and to help them to cope with its most extreme manifestations. Adaptation to climate change is a multi-dimensional process, integrating components such as awareness raising, priority setting, sound planning, capacity building, research and technology development and transfer, and resource mobilization. Addressing climate risks and taking adaptive action will require both individual and collective action, involving firms, communities and government agencies.

As highlighted in the Stern Review, development itself is a key to adaptation in developing countries. Promoting growth and diversification of economic activity, investing in health and education, enhancing resilience to disasters and improving disaster management, and promoting social safety nets for the poor are good development practice and should contribute to reducing vulnerability to climate change.

In addition, it is important that governments provide a clear policy framework to guide adaptation in the following key areas:

- high quality climate change information, including improved regional climate predictions, particularly for rainfall and storm patterns;
- land-use planning and performance standards to encourage private and public investments in buildings, capital and infrastructure that are resilient to the effects of climate change, as well as protection of vulnerable utilities and facilities;
- long-term climate sensitive policies such as natural resource and coastal protection, disaster and emergency preparedness, relocation of vulnerable human settlements; and
- financial safety nets to help the more vulnerable sections of society who are the least likely to be able to afford protection.

These are critical building blocks that must be tackled through comprehensive, coordinated approaches, which need to be taken at the national, sectoral and local levels. Adaptation to climate change will need to be a core component of development planning, and will require initiatives that are often referred to as "mainstreaming" or "climate proofing" development (Hay et al., 2004).

It is widely accepted that adaptation does not have a "magic bullet" response, that it will require a range of public and private sector actions, and combined efforts to both improve coping capacity and promote short- and long-term sustainability. Although there is still much debate over the most appropriate approaches for developing and implementing adaptation strategies, there are also many actions that the EAP region can take immediately to adapt to climate change. Many of these actions fall into the "no regrets" category—that is, actions that make sense under current conditions of climate variability and that would have even greater value in anticipation of future climate change. This chapter explores opportunities for adaptation through: (i) cross-cutting responses; and (ii) area-specific and ecosystem-level intervention.

Cross-Cutting Responses

These responses include poverty reduction and economic reforms, improving the information base, strengthening planning and coordination, promoting participation and consultation, improving disaster preparedness, investing in technology development and dissemination, and establishing effective financial safety nets and insurance systems.

18. IPCC, 2007.

Poverty Reduction and Economic Reforms

While climate change is a threat to economic growth and poverty reduction (Chapter 4) as well as the achievement of the Millennium Development Goals, many measures important to achieving wider development goals—such as strengthening governance, public finance, and institutional structures—are also essential steps in reducing vulnerability to climate risks (Sperling, 2004). All government programs that foster poverty reduction in the region, in targeted and potentially cost-effective ways, also contribute to adaptation by preparing the poor to cope with adversity. Pro-poor institutions are a prominent component of development plans in several countries in the region. In China, for example, the new Five-Year-Plan reflects a significant shift in development priorities toward agriculture in the rural areas, where the majority of the poor still live. Similarly, in Vietnam, the five-year planning process is accompanied by efforts to make resource allocation more pro-poor. In Indonesia, the government has moved decisively toward abolishing fuel subsidies, a measure which can also be expected to contribute to a reduction of GHG emissions. Replacing this traditional but very costly and regressive approach to providing a measure of social protection for the poor, the government is moving toward an approach of targeted cash transfers to help shield the poor from the impact of higher fuel prices (World Bank et al., 2004). Sectoral reforms designed to accelerate economic growth and alleviate poverty can also help build capacity to cope effectively with climate-related uncertainty, especially if they are properly tailored.

Developing national strategies that promote reduction of GHG emissions will be increasingly important in some EAP countries. In the power sector measures include energy demand management and conservation aimed particularly at temperature-driven peak demand, interval pricing, energy standards for household air conditioners and industrial boilers, as well as moving to low-carbon energy supply through increased use of renewables, improved carbon technology, and the use of carbon capture and storage. Measures will also be needed in the transport, industrial and agricultural sectors. An important though insufficiently acknowledged measure, which is especially relevant in EAP, is the avoidance of deforestation. In all these areas, climate change mitigation and adaptation will need to be mainstreamed into sectoral development plans and programs.

Improving the Information Base

Good quality climate information, such as improved weather forecasts and longer-term regional climate projections, are critical tools for climate risk management in both urban and rural settings. Such information, if produced and disseminated in a timely manner, is essential for decision makers, who need to plan ahead to avoid or reduce the impacts of climate-related events and to respond promptly to crises. Public awareness raising, increasing the understanding of potential climate risks, and targeting information to communities that are at greater risk are also important. Vulnerability mapping tools can help communities and governments build consensus on ways to minimize public and private asset risks, by better targeting policies, investments, and insurance. For coastal cities, the vulnerability to storm surges, king tides, and cyclones should be assessed through hazard mapping, vulnerability assessments and assets-at-risk inventories, as the basis for the development of building consensus around risk management strategies and climate-sensitive investments undertaken at the local level. For rural areas, assessments should focus on food and water shortage risks and on the dissemination of climate-resilient crops and agricultural inputs, and the use of climate-adjusted technology and practices. These will need to be a critical part of the approach to adaptation, requiring an early start and, in most cases, action at the national level (World Bank 2000).

Strengthening Planning and Coordination

Given the complexity of climate change impacts, adaptation will require the adoption of comprehensive planning processes involving a broad array of institutions. Central, regional, and local government institutions as well as sectoral agencies will need to work together to address adaptation. Coordination will be essential, especially in the case of coastal areas and in flood prone regions. In some countries, such as the Philippines, initiatives that are already in place also constitute partial building blocks of a comprehensive adaptation strategy (Box 5.1).

Promoting Participation and Consultation

Based on vulnerability assessments and assets-at-risk inventories, the public sector can develop alternative courses of actions. The range of public sector interventions to reduce climate risks can comprise measures such as changing building regulations, imposing land-use restrictions, undertaking investments to protect public and private assets in areas at risk, upgrading infrastructure design standards to withstand climate impacts, improving the capacity of the public health sector to respond to changes in the burden of climate-sensitive diseases, and more. These imply different implementation time frames and budgets, as well as costs and benefits for different stakeholder groups, which, added to the uncertainties involved, make public discussion of the desir-

Box 5.1 Integrated Coastal Zone Management in the Philippines

Executive Order (EO) No. 533, adopted in June, 2006, stresses the role of integrated coastal management (ICM) in promoting sustainable development of the country's coastal and marine environment and resources in order to achieve food security, sustainable livelihoods, poverty alleviation, and reduction of vulnerability to natural hazards, while preserving ecological integrity. The ICM approach is crucial in addressing linkages among watersheds, estuaries, wetlands, and coastal seas. EO 533 specifically mandates the Department of Environment and Natural Resources (DENR) to develop in one year a national ICM program, in consultation with other concerned agencies, sectors, and stakeholders. The national ICM program will identify relevant principles, strategies, and action plans after balancing national development priorities with local concerns. It will then define national ICM targets, and develop a national ICM coordinating mechanism. It is expected to provide direction, support, and guidance to local government units and stakeholders in the development and implementation of their local ICM programs (Partnerships in Environmental Management for the Seas of East Asia—PEMSEA, 2006). This approach, if implemented effectively, could be a solid basis for the incorporation of climate-related issues in coastal development programs in the Philippines.

Source: PEMSEA, 2006.

ability of different courses of action especially important to establish support and ownership. An example of such a participatory planning process is given in Box 5.2.

Improving Disaster Preparedness

Disaster preparedness entails activities and measures that are planned in advance to ensure effective response to the effects of hazards, including timely early warnings and the temporary evacuation of people and property from threatened locations. Disaster preparedness activities include simulations, demonstrations, and drills, as well as training and education in specific skills (Box 5.3).

Early warning systems must be integrated into disaster planning to link scientific and technical indicators to authorities who can interpret and communicate the

message to a general audience. In addition, a well-planned communication strategy with a simple and timely message to inform a large stakeholder group must be in place taking into account the communication infrastructure available in different locations.

Box 5.2 Community Participation in Cambodia

With support from the Australian Agency for International Development (AusAID), CARE's Disaster Preparedness Action Planning Project (DPAP) was implemented in 115 villages in four districts of Cambodia (Baphom, Kampong Trabek, Peam Chore, and Preah Sdach) during 2001–03 in response to the 2000 floods. DPAP focused on (i) mitigation action planning (MAP), which involved local communities developing and implementing their own mitigation plans using small grants; (ii) disaster preparedness action planning (PAP), based on a participatory analysis of vulnerability and capability, also implemented using small grants; and (iii) disaster management through savings (based on an earlier CARE pilot for mobilizing savings to help minimize the worst effects of disasters). In addition, a disaster preparedness and mitigation project—"Living Above the Floods" (DPM—LAF) has been developed for Prey Veng, Cambodia. Funded by AusAID and Norway, and implemented by CARE in 2004–06, DPM-LAF shifts the focus to household-level interventions. It also incorporates the humanitarian accountability principles being introduced by prominent NGOs, including the Cambodian Red Cross, CARE, Concern, Lutheran World Federation, Oxfam GB, and World Vision.

Source: ADB 2005.

Box 5.3 Awareness Raising in Papua New Guinea

In Papua New Guinea, the National Disaster Management Act of 1984 provided for the establishment of a National Disaster Management Office to develop policies and plans, in collaboration with line agencies, for natural disaster risk management preparedness and response. Based on recent experience, awareness programs have been developed to educate people on the risks of natural disasters and how to avoid them, or be prepared to manage situations after disasters. The lessons learned from various natural disasters have enhanced the understanding of the impact of these natural disasters. These recent experiences have helped the institutions and line agencies to improve surveillance and develop the capacity to manage natural and man-made disasters.

Source: World Bank, 2003.

Governments must take responsibility for guiding the preparedness activities. Political will, leadership, and good governance, a binding legal framework, and policies are essential in the process of effective disaster preparedness planning and the development and implementation of early warning systems. (Box 5.4)

Technology Development and Dissemination

While the private sector is the major driver of innovation and transfer of technology worldwide, governments can play a major role in facilitating international collaboration (Stern, 2006). The development and diffusion of improved crop varieties, efficient irrigation systems and cultivation methods will improve agricultural and rural productivity. In the same vein, improvements to design and construction techniques will improve the resilience of infrastructure and urban development overall. However, most of these costs will be incurred locally, mostly by the private sector. In this respect, international cooperation to accelerate the development and spread of low-carbon technologies will have global benefits in achieving overall emission and stabilization objectives at lower costs. This is particularly relevant for sectors where the market is slower to react to needs (such as pooling risks and rewards on research and development for breakthrough technologies), or where market instruments are linked to verification protocols and high volumes (such as for carbon emission reductions).

Box 5.4 Preparing for Extreme Weather Events in Iloilo, Philippines

Many provinces in the Philippines already have well-developed institutional mechanisms for responding to floods and droughts. For example, in Iloilo, the Provincial Disaster Coordinating Council, under the Office of the Governor, serves as the overall coordinating body. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) provides forecasts to the Council, which then coordinates with a range of provincial and national-level agencies to develop mitigation plans. Local governments set aside 5 percent of estimated local government revenues for a Calamity Fund. State level plans involve both preparedness and response activities to reduce impacts. For example, in some states such as Iloilo, it is now possible to access the Calamity Fund before a disaster, if an El Niño/La Niña forecast exists. Mayors and the Provincial Agriculture Office disseminate weather forecasts and the agriculture office works closely with farmers' associations to plan for switching to drought-resistant varieties and the promotion of other livelihood activities. Other actions incorporate both preparation and response measures such as local irrigation associations that provide additional clearing of canals when typhoons or heavy rains are expected.

Source: Asian Disaster Preparedness Center.

Providing Financial Safety Nets and Insurance Systems

Financial safety nets may be required for the poorest in society, who are likely to be the most vulnerable to impacts of climate change and the least likely to afford protection. Extending the reach of insurance instruments to provide poor people with the risk-spreading mechanisms similar to those available in developed countries is an innovative form of adaptation which needs to be further explored. Micro-insurance can be very effective to address the need for post-disaster housing reconstruction. Pilots on insurance instruments for agricultural losses are being developed in several countries with World Bank assistance. This includes the parametric (also called indexed) weather insurance pilot in Thailand, where flood data is collated through remote sensing and a mechanism is being developed to compensate for rice yield loss due to floods. In Mongolia, the Bank has pioneered an innovative and multi-layered risk management system to reduce the impact of livestock losses during extremely cold winters.

Worldwide, overall losses due to natural disasters have increased steadily over the last century. In the last decade, losses reached approximately $580 billion, seven times larger than observed in the 1960s. Consequently, insured losses also reached unprecedented dimensions—$180 billion in the last decade. This has led some re-insurance companies to revisit and adapt their business models to emerging trends, as illustrated in Box 5.5. The International Finance Corporation's Global Index Reinsurance Facility, which was established to provide coverage for natural disasters, and the Caribbean Catastrophe Risk Insurance Facility led by the World Bank to respond to the devastation caused by natural hazards in the Caribbean in 2004, are recent examples of similar initiatives which have allowed the use of risk-spreading mechanisms to partially defray the costs of adaptation.

Box 5.5 Adaptation in the Re-Insurance Business

Some reinsurance firms, such as Munich Re and Swiss Re, now actively promote scientific research to determine the impact of climate change. Swiss Re has linked their loss model to estimates of the impact of climate change on European winter storm damage, which forecasts indicate may increase by 16–68 percent over the period 1975–2085 (Swiss Re, 2006). Both companies are adjusting their product offerings as well as their management practices. "Risk-adequate premiums" are essential for sustainable operation of insurance in the medium and long term. The "cost of goods sold" is implied to increase, and appropriate pricing models are evolving (Munich Re, 2006; Swiss Re, 2006). These firms recommend non-traditional, alternative forms of risk transfer, including consideration of mega-loss potential in climate change-related disasters (UNEP, 2002). Munich Re (2006) introduced two new products: risk-swap (e.g., exchange of risks between insurance companies, such as windstorms in Europe against earthquakes in Japan) and bonds (e.g., transfer of risks to the capital market).

Source: Munich Re, 2006; Swiss Re, 2006; UNEP, 2002.

Area-Specific and Ecosystem-Level Interventions

Adaptation and policy responses, including the cross-cutting approaches and tools discussed above, will be applied in the context of specific areas and ecosystems. Situations of special relevance include coastal cities, major river basins, agricultural areas, forests and drylands, marine ecosystems, and small islands.

Coastal Cities

With an estimated 46 million people per year at risk of flooding from storm surges, (IPCC, 1996), coastal cities in EAP potentially face severe sea-level rise problems as a consequence of subsidence induced by tectonic and anthropogenic changes (such as pressures on groundwater sources in rapidly developing areas). They are also subject to the complex inter-related problems associated with climate extremes.

A heat wave can trigger a cascade of consequences that disrupt economic and social activities. For example, as temperatures rise, energy demands increase, as do the likelihood of electricity outages that reduce access to air conditioning and other services. As a result, industrial output declines and the incidence of heat stress and other negative health impacts increases.

The adaptation framework will require a comprehensive awareness-raising and planning effort, comprising the preparation of vulnerability assessments; the identification of regulatory, investment, institutional capacity building, and awareness-raising options; implementation timeframes, budgets, modes of delivery and financing, as noted above. Options for coastal cities should focus on key infrastructure sectors, such as water supply, and on basic quality-of-life measures and indicators, with mechanisms to examine synergistic impacts (IPCC, 2001b). Major interventions to address coastal urban adaptation include the following:

- ***Information systems.*** Building reliance on information technology, such as geographic information systems, to aid development and implementation of coastal management and disaster preparedness strategies;
- ***Improved structures.*** Upgrading existing and building new hard structures (e.g., dikes, levees, floodwalls, and barriers) and soft structures (e.g., beach nourishment, dune restoration, and wetland creation) to prevent erosion and protect shorelines;
- ***Energy efficiency.*** Moving to low carbon, higher efficiency transport and energy systems, which generate both global and local benefits (e.g, reduce air pollution and avoid heat pressure);

- ***Building standards.*** Introducing improved, climate-sensitive standards for construction of residential, commercial and industrial facilities;
- ***Planned development.*** In less-developed areas, introducing regulation establishing setbacks to control future development.

Box 5.6 illustrates how the tourism industry in Thailand is taking steps to adjust to climate-related threats.

Major River Basins

The impacts of climate change on water regimes are of special concern as noted in Chapter 3. Major river basins may be subject to complex changes in hydrology, as well as floods, droughts and storms; pressures on groundwater, sea level rise, and saltwater intrusion. The adaptation response to these changes, as in the case of coastal cities, may require comprehensive approaches and many of the same processes discussed above. It would, however, include a variety of measures suited to the specific condition in the upstream watershed, along the river, and in delta areas. These measures might include:

- ***in upland areas,*** improving watershed management, flood management, drought protection, and dam safety measures;
- ***in delta areas,*** protecting against salt water intrusion and groundwater contamination and depletion;
- ***along the river,*** diversifying food production and income generation options by moving to flexible irrigation and cropping systems, especially in the case of vulnerable groups (for example, by introducing livestock management, rain-fed agriculture, fisheries, depending on predicted water impacts);
- ***seasonal forecasting,*** including long-term climate projections as an input into design specifications in multi-sector water resource planning and management; and
- ***disaster preparedness,*** through improved early warning systems and response plans.

China's Loess Plateau is an important example of the efforts to develop sustainable watershed management programs (Box 5.7). This social, economic, and environmental transformation of a region, based on a shared vision with good planning, implementation, and monitoring, illustrates how a transition from a relief to a development focus can be accomplished even in a short timeframe. Focusing on improving sustainable development through actions that are compatible with projected climate change is often the most effective strategy for implementing adaptation for specific areas.

Box 5.6 Tourism in Phuket, Thailand

Thailand's growing tourism industry is one of the key economic sectors under threat due to impacts from climate variability and severe weather (i.e. the southwest monsoon, storms, droughts and El Niño). Phuket, Thailand's largest island and one of its primary tourist destinations, has recently experienced the impacts not only of the 2004 tsunami, but also of various climate-related events, such as shortage in rainfall, the main source of tap water on the island. For example, during 2003, due to less rainfall than usual, Bang Wat reservoir operated with as little as a 10-day supply. The tourism industry has developed numerous methods of coping with climate risks. These methods range from closing down for the monsoon season and living off of approximately six months' income for the entire year, to developing attractions that are "climate proof" (e.g., medical tourism, entertainment parks, convention centers, and shopping malls). In addition, new reservoirs, pumping stations, and pipelines are being built to ensure the island's water supply over the next few decades. Other adopted measures include (i) implementing integrated coastal zone management in order to promote coordination among agencies and between the public and private sectors; and (ii) building capacity to enhance the ability of people working in local businesses to anticipate and prepare for the variety of risks that can affect their livelihoods.

Source: Raksakulthai, 2003.

Agricultural Areas

Food security and income generation for rural communities is a fundamental concern owing to the climatically-sensitive nature of agriculture. Historically, agriculture has evolved and adjusted to increasing population and to changing economic conditions, technology, and resource availability. Climate change could have multiple impacts: in areas where growth is limited by frost, warming may bring a longer growth season, allowing earlier planting and sometimes more crops per year; in subtropical to tropical areas, the longer growing season will have less of an impact, but may increase vulnerability to changes in precipitation patterns, especially with respect to the onset or reliability of monsoon seasons. Studies suggest that proactive adaptation and adjustment will be important

Box 5.7 Improving Rural Livelihoods Through Sustainable Watershed Management in China's Loess Plateau

The Loess Plateau covers about 640,000 square kilometers (about 45 percent farmed) in the upper and mid reaches of the Yellow River basin (so named after its high sediment load). The area has low rainfall (250–550 mm/yr), and population pressures, unsustainable farming practices, and natural conditions have caused severe soil erosion (one of the highest in the world), low agricultural productivity, downstream sedimentation (1.6 billion tons/yr in the Yellow River), flooding, and widespread poverty. Since 1994, the World Bank-supported Loess Plateau Watershed Rehabilitation Project (covering over 1.5 million hectares in over 2,000 villages in nine basins in over 20 counties of Shanxi, Saanzi, Inner Mongolia, and Gansu provinces) has helped reverse environmental degradation and enhance rural livelihoods through improved soil and water conservation measures. The enabling environment to support the technical interventions was provided by widespread stakeholder participation, strong political commitment, land tenure reform, spatial land use planning, and institutional strengthening.

These activities have been recognized as one of the most successful erosion control programs in the world. Over one million people have been helped out of poverty. Erosion has been substantially reduced (by about 57 m tons/yr) through afforestation and sediment control, grazing restrictions, and the transformation of farming on steep slopes to large-scale terracing. Grain output almost doubled and fruit production quadrupled, raising farmers' annual incomes from about $44 to $154 per capita (substantially more than in non-project areas) plus additional downstream benefits.

Source: World Bank reports and Chen et al., 2004.

to minimize losses and maximize potential gains under future climate change. Promising strategies for the technological adaptation to climate change (FAO, 1996) include the following:

- ***Different crop varieties or species.*** Most major crops vary in terms of climatic tolerance and maturity, hence allowing adaptation to changing climate. Crop diversification is a strategy for adaptation. but poor farmers will need assistance in learning about and accessing more suitable options.
- ***New crop varieties.*** Genetic engineering and gene mapping may bring more climate-tolerant traits.
- ***Water supply and irrigation systems.*** Generally speaking, irrigated agriculture is less affected by climate change than dryland agriculture. However, land degradation and competition for water is expected to increase regardless of climate condition in the future, requiring improvements in water management and pricing of water.
- ***Tillage.*** Minimum and reduced tillage technology, along with cover crops, can reduce moisture loss during the critical early growing season and reduce soil erosion and nutrient loss overall.
- ***Improved short-term climate prediction.*** Improved seasonal climate prediction—such as with respect to the onset of El Niño events—can significantly help agricultural adaptation to climate change.

Other adaptation measures are promising in areas such as cost-effective insurance, extension services, disease and pest control, storage facilities, livestock management, food reserves, marketing, road access, land tenure regimes, and rural livelihood diversification. In some cases, traditional management methods are sustainable and deserve reinforcement, as in the case of pasture management practices in Mongolia (Box 5.8).

Forests and Drylands

Forest and dryland ecosystems will need to adapt to changes in temperature, hydrology, land degradation, and an increasing number of fires. Measures to assist this process include:

- ***Stocktaking.*** identification of which forest areas are at most risk, and which species are unique in these areas.
- ***Implementing conservation and management systems.*** control of deforestation through the establishment and enforcement of effective concession systems; reforestation and rehabilitation of barren areas through tree planting and agroforestry; initiating and strengthening forest fire monitoring, preparedness, communications, and response (Box 5.9); biodiversity protection, including designation and effective management of protected areas and protecting vulnerable species (e.g., helping them to migrate).
- ***Improved agricultural practices.*** increased support to community forestry schemes and assistance for local communities to shift from forest products to more flexible agricultural practices; investments in

Box 5.8 Disseminating Traditional Pasture Management in Mongolia

Various traditional methods of pasture management are known to be resilient to climate variability. They include the traditional management of pasture land, grazing animals, and shifting camps. This method depends on the condition of the terrain, season, weather, and water availability. The National University of Mongolia, the Institute of Agriculture, and the Environmental Education and Research Institute initiated a project to teach these traditions to secondary students from Khangai soum in Arkhangai province. Four pasture management techniques were covered during this project (i) spring camping in the higher mountains, (ii) winter camping in the inner mountains, (iii) categorization of grasslands according to terrain, and (iv) categorization of grasslands according to season. Students learned how to use a specific area of pasture land; how to choose camping areas; how to use appropriate areas close to water bodies; and how to accumulate, understand, and analyze information about their surroundings. This type of knowledge dissemination and training will be increasingly important to prepare rural populations for climate change.

Source: IGES, 2002.

Box 5.9 Community Forestry Can Reduce Fire Damage

Burn pattern analysis during the fires of 1983, 1997, and 1998 in Kalimantan, Indonesia, has shown that areas under community control experienced considerably less burning than areas where industrial cropping was common. In 1997, fire damaged 30,000 hectares of plantations north of Balikpapan in Kalimantan, yet only 30 hectares of community forest was burned (Rowell et al., 1999).

Within the Kutai National Park in East Kalimantan, while fires burned elsewhere in the park in 1997–98, no forest was damaged by fires on the territories of the Teluk Pandan community. The village head had experienced the 1982–83 fires and realized that they could recur at any time in the future. He thus proposed the setting up of community rules for controlled burning, including:

- notifying the village head of intention to burn
- ensuring that all able-bodied men from the household and adjacent properties are present and armed with tools and other gear, to prevent the fire from going out of control once it has been started
- ensuring that landowners, who need to burn, supply the necessary food and drinks to participants
- imposing a compensation schedule varying with the type of property (e.g., orange trees, cocoa, other crops, and personal property) damaged by out-of-control fires

An analysis of the distribution of hotspots by satellite imagery indicated that areas used for traditional or shifting cultivation experience the lowest fire incidence. This suggests that fire management by such groups is reasonably effective.

Source: FAO, 2001.

water security to promote long-term diversification of livelihoods to less water-intensive activities; sustainable watershed management, including flood, land-slide, and erosion control; conservation of natural vegetation and construction of drainage systems; managing vegetation for climate resilience and improved livestock management; and increasing the resilience of arid and semi-arid ecosystems and promoting drought early warning systems.

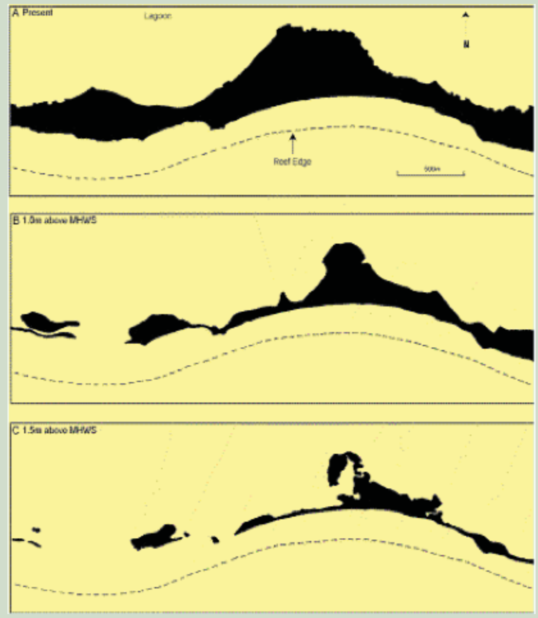
Box 5.10 The Kiribati Adaptation Program

Small island states in the Pacific such as Kiribati, a low lying country with most of its land at an elevation of less than two meters above sea level, will be particularly impacted by climate change. As much as 55 to 80 percent of land areas in Kiribati's North Tarawa, and 25–54 percent of areas in South Tarawa could be inundated by 2100 from sea level rise and storm surges. The figure at right indicates the normal scenario, the worst-case scenario in 2100 and the worst-case scenario when also accounting for storm surges.

The economic impact could be substantial, with estimated total damages between 17 to 34 percent of Kiribati's GDP being lost by 2050. The projected losses in infrastructure and roads would be substantial. Under the worst-case scenario, the village of Buariki, in Tarawa, could be inundated, as could 59 percent of the structures and 77 percent of the roads. In Bikenibeu (as illustrated), significant impact on infrastructure is not expected to occur until 2100 under a worst-case scenario, but it could then become substantial, with 66–100 percent of all roads lost under the combined effects of storm surge and sea level rise.

Though the Kiribati Adaptation Program (KAP) financed by the World Bank in 2006, island representatives identified major hazards, ranked adaptation options, and classified them into four categories:

- Urgent adaptation options which can be done by communities
- Urgent adaptation options for which communities need assistance from the Government
- Adaptation options that are less important/urgent
- Adaptation options that are not yet needed



Key lessons learned from the project thus far are that:

- adaptation is a major economic risk, not just a long-term environmental concern;
- addressing short-term vulnerabilities is the best way to prepare for long-term impacts;
- adaptation needs to be housed in a high-level coordinating Ministry;
- adaptation plans need to be an integral part of national development planning; and
- adaptation needs a long-term programmatic approach linking bottom-up consultation with top-down planning and policies.

Source: World Bank, 2000.

Marine Ecosystems

Marine and coastal ecosystems are especially vulnerable to increased storms, sea level rise, and other threats to coral reefs and marine fisheries. Adaptation measures include:

- ***Management and protection of coral reefs and mangroves.*** Adaptation strategies should involve awareness raising, targeted research in coral reef management, capacity building to enable communities and institutions to manage threats, enforcing penalties for reef and mangrove destruction, controlling pollution, promoting sources of construction material other than coral to reduce reef mining, and replanting mangroves. Structural coastal adaptation measures—such as groins to control sand erosion or seawalls—should be screened for their compatibility with coral reef management.
- ***Sustainable fishing management measures.*** Measures include stronger regional collaboration in the negotiation of multilateral agreements with fishing nations; less destructive fishing practices (e.g., bans on blast fishing and cyanide fishing); income-generating mechanisms such as license fees; improving fishing

entitlement systems and other ways to better regulate fishing; diversification and eventual reduction of domestic fishing fleets to adjust to increased fluctuations in fish populations; better use of ENSO forecasting to help prepare for spatial and temporal changes in fisheries distribution; and improving insurance systems to protect fishermen and the aquaculture industry from drastic shocks.

Small Islands

Low-lying islands or atolls are especially vulnerable to climate change due to sea level rise and extreme weather events. Strategic planning, the establishment of early warning systems and contingency response plans, including the planned retreat and relocation of vulnerable populations is critical to these locations. In addition, specific protection measures should largely focus on the retention of overwash sediments. Options may include replanting of mangroves, pandamus, and other coastal vegetation to promote shoreline accretion; promoting dune maintenance; closing or narrowing selected passages between lagoons and the ocean; and making selective use of groins in key locations, such as the passage edges of islands, to help minimize the transfer of sediments from the ocean to lagoons, while avoiding downstream erosion. Also important is the protection of freshwater aquifer systems by regulation of uses, entitlement frameworks, pollution control and physical recharge by pumping.

The Kiribati Adaptation Program provides a good example of the types of interventions that will be needed in many EAP locations. It aims to develop and demonstrate approaches to the systematic diagnosis of climate-related problems and the design of cost-effective adaptation measures, while promoting the integration of climate risk awareness and responsiveness into economic and operational planning (Box 5.10).

FINANCING ADAPTATION

The Global Adaptation Challenge

As countries grapple with ways to mitigate climate change, there is also growing consensus that adaptation will inevitably be needed to cope with impacts of climate change that are already observable, and are foreseen under any future mitigation scenario. Assessments of adaptation-related challenges by the Climate Policy Project of the Institute for Global Environmental Strategies (IGES) suggest that, while there is growing awareness of the risks of climate change and the importance of addressing adaptation challenges, many countries lack the capacity to cope with future impacts (IGES, 2005). Although some climate change adaptation will happen "autonomously" in response to market forces and environmental pressures, governments will need to develop a policy framework and undertake investments in public goods to encourage additional adaptation to be undertaken by firms and communities.

The emerging consensus is that the benefits of adaptation will significantly outweigh the costs. The Stern Review (2006) argues that more quantitative information needs to be developed on the costs of economy-wide adaptation needs. However, as in the case of GHG mitigation measures, the benefits of strong and early adaptation action far outweigh the economic costs of not acting. The review also concluded that adaptation policy is crucial for dealing with the unavoidable impacts of climate change, but that it has been under-emphasized in many countries. The report found that the resources needed for economy-wide adaptation were poorly understood, but estimated that they may fall in the range of $15B to $150B per year globally. This will pose a considerable challenge for most developing countries. Earlier assessments suggested that the global costs of adaptation could comprise 7 to 10 percent of the cost of total damage likely to result from climate change.[19]

Table 6.1 summarizes the major challenges noted by participants in the 2005 IGES consultations in EAP, regarding formulation and implementation of adaptation measures. The shortage of funding both domestically and at the international level was seen as a major bottleneck.

Given the competing demands faced by developing country governments, funding for adaptation will not be easy to secure, and currently falls significantly below the Stern Review's estimates of what will be needed. Fortunately, there are possibilities to finance adaptation measures both by specially earmarked funds, as well as by enhancing regular sustainable development investments with a climate change perspective.

Funding Options

Climate Change Adaptation Funding

There are a number of specific funding sources to support adaptation to climate change (Table 6.2). The GEF is the principal agency responsible for facilitating actions under the UNFCCC including support for interventions that increase the resilience of countries and their vulnerable citizens, businesses, and ecosystems to the adverse impacts of climate change. The UNFCCC adopted a three-stage-approach to adaptation. The first dealt mainly with awareness raising and capacity building.

19. Tol, Frankhauser, and Smith, 1998

Table 6.1 Challenges to Adaptation in the Asia-Pacific Region and Suggested Improvements

	Challenges	Ways of Improvement
Domestic challenges	**Science-related challenges** • Scientific uncertainty on the impacts of climate change. • Limited research on local vulnerability and assessments. **Policy-related challenges** • Limited awareness among key political actors. **Resource-related challenges** • Shortage of relevant technologies. • Shortage of finance.	• Capacity development of scientists and experts in vulnerability assessment and adaptation planning. • Provision of information and data, with international assistance, relevant to the above. • Information dissemination and public awareness promotion on needs of long-term planning and investment. • Strengthening of international funding mechanisms for adaptation, and enhancing their flexibility. • Provision of additional "adaptation-focused" ODA. • Promotion of understanding and agreements on prioritisation in international financing. • Integration of available "adaptation" funds into conventional "development" funds. • Further focus on development and transfer of adaptation technologies. • Elaboration of CDM projects which might contribute to adaptation, and new CDM scheme that can incorporate combination of various funds, such as private investment, ODA, and other benevolent funds. • Enhancing the flexibility for accessing GEF funds allocated for adaptation.
International challenges	**Shortage of funds for adaptation** • Contributions to the Special Climate Change Fund (SCCF) and the Least-Developed Countries Fund (LDC Fund) are far from adequate and below their commitments. • Two percent of the CDM proceeds for the Adaptation Fund are seen as inadequate. • Immaturity of the CDM market made the Adaptation Fund meaningless so far. **Poor operation of international mechanisms** • Complexity and rigidity of conditions for GEF funding especially with regard to "incremental costs" and "global benefits."	

Source: IGES, 2005.

The second focused on support to preparation and submission of national communications to the UNFCCC, including national GHG inventories and vulnerability and adaptation assessments.

Recently, the GEF has begun moving into the third phase of this approach, supporting pilot and demonstration projects. These projects will provide real benefits that have been useful for developing, testing, and institutionalizing rational approaches to local problems such as flooding, erosion, and water scarcity. For example, the Pacific Islands Adaptation to Climate Change Project will address water resources management, food production and food security, and coastal zone and associated infrastructure. The GEF also provides small grants of up to $5M to support community-based adaptation initiatives.

As the table illustrates, a number of other funds are being set up specifically for climate change adaptation, as the international community gears up to address this key development challenge. Three such funds—the *Special Climate Change Fund,* the *Least Developed Countries Fund,* and the *Adaptation Fund*—were established in 2001 at the Sixth Conference of Parties (COP6) to help developing countries address the adverse effects of climate change. Resources from the first two, amounting to a proposed $120M are to be disbursed through the GEF.

Table 6.2 Adaptation Funding

Name of the Fund	Funding Source	Total Funds Mobilised (US$)	Legal Basis for Funding (COP and GEF decisions)	Operational Criteria	Main Activities of Support	Remarks
I. Funds established under the Convention (Articles 4.1, 4.3, 4.4, 4.5, 4.8, and 4.9)						
(a) Global Environment Facility (GEF) Trust Fund	GEF		UNFCCC Article 4.3 1/CP.11, 5/CP.7 GEF/C.23/ Inf.8	• Incremental cost to achieve global environmental benefits	• Vulnerability and adaptation assessments as part of national communications and enabling activities	
(b) Strategic Priority on Adaptation (SPA)	GEF	50 million	6/CP.7 GEF/C.23/ Inf.8	• Incremental cost guidance with some flexibility, especially for Small Grants Programme	• Pilot and demonstration projects on adaptation • Small Grants Programme ($5 M) to support community-based adaptation	
(c) Special Climate Change Fund (SCCF)	Voluntary contributions from 11 developed countries (Canada, Denmark, Finland, Germany, Ireland, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom)	**45.4 million** (Contributions: 36.7 M Pledged: 8.7 M)	5/CP.7, 7/CP.7, 5/CP.9 GEF/ C.24/ 12; GEF/C.25/ 4/ Rev.1	• Additional cost of adaptation measures • Sliding scale for co-financing	• Addresses adaptation as one of the four funding priorities	GEF allocation of 2.0 M was used for projects and administrative support.

(continued)

Table 6.2 Adaptation Funding (*continued*)

Name of the Fund	Funding Source	Total Funds Mobilised (US$)	Legal Basis for Funding (COP and GEF decisions)	Operational Criteria	Main Activities of Support	Remarks
(d) Least Developed Countries Fund (LDC Fund)	Voluntary contributions from 13 developed countries (Canada, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, New Zealand, Norway, Spain, Sweden, and Switzerland as of 30 April 2006)	**75.7 million** (Previous contributions: 29.9 M Pledged: 45.8 M GEF allocation to date: 11.8 M)	5/CP.7, 7/CP.7, 27/CP.7, 28/CP.7, 29/CP.7, 6/CP.9 3/CP11, 4/CP11 GEF C/24/Inf.7; GEF/C.24/ Inf.8/ Rev.1; GEF/C.25/ 4/Rev.1	• Guiding principles: country-driven approach, equitable access by LDCs, expedited support and prioritisation of activities • Provision of full cost funding for adaptation increment as identified and prioritised in NAPAs • Sliding scale for co-financing	• Implementation of NAPAs (all projects for the preparation of NAPAs in 44 countries approved with a budget of US$ 9.6 M)	GEF allocation of US$ 11.8 M to LDCF was approved for projects, administrative budgets & special initiatives
II. Fund established under the Kyoto Protocol (Article 4.10)						
(a) Adaptation Fund	2% Share of proceeds from CDM	Not yet operational	5/CP.7, 10/CP.7, 17/CP.7 28/CMP1	• Guiding principles: country-driven and a "learning-by-doing" approach, sound financial management & transparency, separation from other funding sources	• Concrete adaptation projects & programmes identified in decision 5/CP7	

Source: IGES, 2005.

The Least Developed Countries Fund (LDCF) has already started to support the preparation and implementation of National Adaptation Programmes of Action (NAPAs), through which the most urgent adaptation priorities for the most vulnerable countries are identified. Programs have been taken up for countries such as Kiribati and Cambodia. The Special Climate Change Fund (SCCF) will fund a wider range of adaptation activities in all developing countries. In the case of LDCF and SCCF, resources are mobilized through voluntary contributions by about a dozen developed countries. The Adaptation Fund will be funded by a 2 percent share of certified emission reduction revenues from CDM projects. The managing agency and types of adaptation projects to be financed by the fund have yet to be agreed upon.

Climate Change Mitigation Financing

Many of the options under the Clean Development Mechanism (CDM), which are becoming available to countries for climate change mitigation, may also help in adaptation. These may include financing to reduce emissions in the energy, transport, industrial and agricultural sectors, as well as financing to improve sequestration (e.g., afforestation and watershed management). These measures promote more sustainable development paradigms, improving local livelihoods, and reducing pressures on land, water, and energy supplies (Box 6.1).

Mainstreaming Mitigation into Sustainable Development Investments

There are a number of options for countries to pursue in financing adaptation to climate change that could have short-tem benefits while keeping a longer-term sustainability perspective. For example, EAP governments, donors, the private sector, and international agencies routinely invest large sums in financing development (e.g., transportation, energy, irrigation, service delivery, water and natural resources management). Mainstreaming climate change adaptation goals into these investments could make a substantial difference in financing adaptation.

Box 6.2 describes a new program focusing on water resources management and rural development in China.

As consensus builds that climate change is critical to the EAP region's sustainability, and that there are already manifestations of this change today, there is a need for the region to factor climate change into development plans and investments. Continuing with a "business-as-usual" scenario may result in rolling back the gains the region has made on economic growth and poverty alleviation, as reflected in progress to achieve the Millennium Development Goals (MDGs).

A concerted effort to address climate change adaptation will also have the co-benefits of developing a longer-term planning perspective, improved response to threats and opportunities related to climate variability, and accelerated sustainable economic growth and poverty alleviation.

Box 6.1 Financing Climate Change Programs from Market Mechanisms in China

Unprecedented economic growth in China has been accompanied by a significant increase in GHG emissions, especially from industrial processes. One of the most potent GHGs emitted in China is Trifluoromethane (HFC-23), a by-product released in the production of HCFC-22, an industrial chemical used in refrigeration and other applications. HFC-23 has 11,700 times the global warming potential of carbon dioxide, measured in tons of carbon dioxide equivalent, or TCO2e. The World Bank's China HFC-23 Emissions Reduction Project supports China's participation in the CDM, and led to the world's largest CDM transaction to date, with the purchase of certified emission reductions (CERs) corresponding to approximately 18 million TCO2e per year, worth more than $930 million, from two Chinese chemical manufacturing companies.

In the context of the HFC-23 operation, the Government of China has established regulations that set aside 65 percent of the revenues of HFC-23 CDM transactions to constitute a CDM Fund. The fund will promote climate change mitigation projects and will also receive shares from the sale of CERs from other GHGs. This fund is likely to exceed $1.25 billion by 2012, and would be a significant source of support for climate initiatives.

Asian countries (excluding China and India) now account for nearly ten percent of the CDM market. As the use of market mechanisms to reduce GHG emissions expands, governments in EAP could design similar programs to fund both mitigation and adaptation activities.

Source: World Bank, 2006.

Box 6.2 Mainstreaming Adaptation to Climate Change into Water Resources Management and a Rural Development Project in China

China's huge and growing population and its heavy dependence on irrigated agriculture mean that its agricultural productivity, food supply and water availability are highly vulnerable to climate change. China recognizes the threats that climate change poses and is preparing a National Strategy for Climate Change. It is so far, however, relatively ill-equipped to respond to the threats because of overlapping and unclear institutional mandates, limited understanding of what priority to adaptation actions to take, and limited capacity to take them.

The North China Plain produces 50 percent of China's grain output, and is crucial for food security. As it is a relatively low rainfall area, its grain output is heavily dependent on irrigation. Unfortunately, average rainfall is declining, water use efficiency is relatively low, and underground aquifers are being rapidly depleted. Action is, therefore, urgently needed and will be even more vital in the long term to raise irrigation efficiency and switch over to less water-dependent crops.

A planned World Bank/GEF project "Mainstreaming Adaptation to Climate Change into Water Resources Management and Rural Development" will help the local governments on the North China Plain to make those changes and disseminate their experience and lessons nationwide. The project will: (i) quantify the area's climatic change risks; (ii) select the most cost-effective water management and cropping measures to adapt to them; (iii) test and record their effectiveness; (iv) promote the replication of those measures that show the most promise; and (v) disseminate the experience gained nationwide. Collaboration among the key institutions responsible for water and agriculture services and their capacity to promote adaptation will be developed while undertaking the pilot adaptation activities.

Source: World Bank, 2007.

EAP KEY INDICATORS

Region/Country	Population (millions)	Urban Population (%)	GDP (US$ billions)	GNI Per Capita (US$)	Land Area (1000 sq km)	Agricultural Land (% of tot. land)	Forest Area (% of tot. land)	Energy Use per capita (kg oil equiv.)	GDP/Energy Use (2000 PPP US$/kg oil equiv.)	CO_2 Emissions per capita (metric tons)	CO_2 Emissions/ GDP (kg/2000 PPP US$)	CO_2 Damage (% GNI)
World	6,365	48.8	41,290	6,329	129,663	38	30.5	1,734	4.7	3.9	0.5	0.4
EAP	1,870	40.6	2,651	1,416	15,885	51	28.4	1,007	4.6	2.4	0.5	1.2
China	1,296.20	39.6	1,931.70	1,500	9,327	59	21.2	1,094	4.5	2.7	0.6	1.4
Indonesia	217.6	46.7	257.6	1,140	1,812	25	48.8	753	4.3	1.4	0.4	0.7
Vietnam	82.2	26.2	45.2	540	325	30	39.7	544	4.4	0.8	0.4	1.1
Philippines	81.6	61.8	84.6	1,170	298	41	24	525	7.8	0.9	0.3	0.6
Thailand	63.7	32.2	161.7	2,490	511	36	28.4	1,406	5	3.7	0.5	1
Myanmar	50	30	—	—	658	17	49	276	—	0.2	—	—
Malaysia	24.9	64.4	118.3	4,520	329	24	63.6	2,318	3.9	6.3	0.7	0.9
Korea DR	22.4	61.4	—	—	120	24	51.4	896	—	6.5	—	—
Cambodia	13.8	19.2	4.9	350	177	30	59.2	—	—	0	0	0.1
Laos PDR	5.8	21.2	2.5	390	231	8	69.9	—	—	–0.2	–0.1	0.4
Papua New Guinea	5.8	13.2	3.9	560	453	2	65	—	—	0.4	0.2	0.5
Mongolia	2.5	56.9	1.6	600	1,567	83	6.5	—	—	3.4	1.9	3.8
Timor-Leste	0.9	7.7	0.3	550	15	23	53.7	—	—	—	—	—
Fiji	0.8	52.5	2.6	2,720	18	25	54.7	—	—	1.6	0.3	0.4
Solomon Islands	0.5	16.8	0.3	560	28	4	77.6	—	—	0.4	–0.2	0.4
Samoa	0.2	22.2	0.4	1,840	3	46	60.4	—	—	–0.8	–0.2	0.3
Vanuatu	0.2	23.3	0.3	1,390	12	12	36.1	—	—	0.4	0.1	0.2
American Somoa	0.1	90.7	—	—	0	25	90	—	—	—	—	—
Kiribati	0.1	48.7	0.1	970	1	51	2.7	—	—	0.3	—	0.2
Marshall Islands	0.1	66.6	0.1	2,320	0	78	—	—	—	—	—	0
Micronesia FS	0.1	29.7	0.2	2,300	1	67	90	—	—	—	—	0
N. Mariana Islands	0.1	94.4	—	—	—	—	—	—	—	—	—	—
Tonga	0.1	32.8	0.2	1,860	1	42	5.6	—	—	1	0.2	0.4
Palau	0	68.5	0.1	6,870	—	—	—	—	—	—	—	1.3

Source: World Bank Little Green Data Book 2006.

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USEFUL LINKS

International Organizations Related to Climate Change
Intergovernmental Panel on Climate Change (IPCC) http://www.ipcc.ch/
United Nations Framework Convention on Climate Change http://unfccc.int/
World Meteorological Organization http://www.wmo.ch/
Food and Agriculture Organization of the United Nations http://www.fao.org/

Research on Climate Change
Hadley Centre http://www.metoffice.com/research/hadleycentre/models/modeldata.html
Real Climate http://www.realclimate.org/
World Resources Institute http://earthtrends.wri.org/index.php
International Disaster Database http://www.em-dat.net/
World Development Indicators http://devdata.worldbank.org/wdi2006/contents/index2.htm
Center for Global Environmental Research http://www-cger2.nies.go.jp/moni-e/index-e.html
International Institute for Applied Systems Analysis http://www.iiasa.ac.at/

Adaptation
Global Environment Facility http://www.gefweb.org/
The International Research Institute for Climate and Society (IRI): http://iri.columbia.edu/asia/project/AdaptationSEAsia/
World Health Organization http://www.who.int/globalchange/climate/en/
Institute for Global Environmental Strategies (IGES) http://www.iges.or.jp/
Assessments of Impacts and Adaptations to Climate Change (AIACC) http://www.aiaccproject.org/
The National Adaptation Programs of Action (NAPAs) www.undp.org/cc/napa.htm
The Special Climate Change Fund (SCCF) http://unfccc.int/cooperation_and_support/funding/special_climate_change_fund/items/2602.php

Networks/Alliances Addressing Climate Change in EAP
Asia Pacific Network for Global Change Research (APN) http://www.apn-gcr.org/en/aboutapn/whatisapn.html
Asia-Pacific Network on Climate Change http://www.ap-net.org/index.html
Alliance of Small Island States (AOSIS) http://www.sidsnet.org/aosis/
South Pacific Regional Environment Programme (SPREP) http://www.sprep.org.ws/climate_change/index.asp

Millennium Development Goals
United Nations http://www.un.org/millenniumgoals/

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