



# **The Economics of Climate Change in Southeast Asia: A Regional Review**

April 2009

Asian Development Bank



# Preface

The Economics of Climate Change in Southeast Asia: A Regional Review is the result of a 15-month long Asian Development Bank (ADB) technical assistance project, funded by the Government of the United Kingdom, which examines climate change issues in Southeast Asia, with a particular focus on Indonesia, Philippines, Singapore, Thailand, and Vietnam.

The study is intended to enrich the debate on the economics of climate change that includes the economic costs and benefits of unilateral and regional actions. It seeks to raise awareness among stakeholders of the urgency of the grave challenges facing the region, and to build consensus of the governments, business sectors, and civil society on the need for incorporating adaptation and mitigation measures into national development planning processes.

The study involves reviewing and scoping of existing climate studies, climate change modeling, and national and regional consultations with experts and policy-makers. It examines how vulnerable Southeast Asia is to climate change, how climate change is impacting the region, what adaptation measures have been taken by the five study countries to-date, how great the region's potential is to reduce greenhouse gas (GHG) emissions in the future, how Southeast Asia can step up adaptation and mitigation efforts, and what the policy priorities are.

Although Southeast Asian countries have made significant progress on their own in addressing climate-related issues, there is need for closer cooperation and increasing use of existing mechanisms, both regional and global, for funding, technology transfer and capacity building to address future threats. Governments need to do more to fully integrate climate change concerns into their sustainable development policies. And further steps need to be taken to encourage all sector and stakeholders in mitigation and adaptation efforts.

As one of the world's most dynamic regions, the study shows that rapid economic growth in past decades has raised large numbers of people out of the extreme poverty trap in Southeast Asia. But incidence of income and non-income poverty is still very high, and achieving Millennium Development Goals (MDG) remains a daunting task. If not addressed adequately, climate change would have serious negative consequences for the region's sustainable development and poverty eradication policies and agenda.

The study observed that climate change is already affecting Southeast Asia, with rising temperature, decreasing rainfall, rising sea levels, increasing frequency and intensity of extreme weather events leading to massive flooding, landslides and drought causing extensive damage to property, assets, and human life. Climate change is also exacerbating the problem of water stress, affecting agriculture production, causing forest fires, degrading forests, damaging coastal marine resources, and increasing outbreaks of infectious diseases.

The report urges that Southeast Asian countries should treat adaptation as an extension of sustainable development practices. Its key elements include: adapting agricultural practices to changes in temperature and precipitation; adapting water management to greater risk of floods and droughts; adapting coastal zone management to higher sea levels; safeguarding forest areas from forest fires and degradation; adapting people to threats of vector-borne infectious diseases. Southeast Asia countries need to take timely action to adapt to climate change, build resilience, and minimize the costs caused by the impact driven by GHG emissions that have been locked into the climate system.

The report also argues that Southeast Asia should play an active role in global mitigation efforts. Compared to developed countries, the region's emissions on a per capita basis are relatively low. But they are considerably higher than the global average. In 2000, the region's major sources of emissions were the land-use change and forestry sector at 75%, energy sector at 15%, and the agricultural sector at 8%.

The report suggests that mitigation actions in Southeast Asia should put priority on efforts to avoid deforestation, encourage reforestation and afforestation, and promote sustainable forest management in the forestry sector; improve energy efficiency, promote renewable energy sources, increase investment in new and clean energy technologies in the energy sector; and improve land, livestock and waste management in the agriculture sector.

Climate change together with bio-diversity should not be treated in isolation from the general economic, social and environmental systems and must be dealt with in the context of sustainable development. It requires growth with economic stability, development with social equity and poverty eradication, and the continued functioning of eco-systems as life support systems to sustain development.

The world is experiencing the worse financial and economic crisis since the Great Depression, with serious consequences not only for the global economy, but to the economies of Southeast Asia and the five study countries as well. Growth is slowing, unemployment is rising, and the poor under the poverty line is increasing.

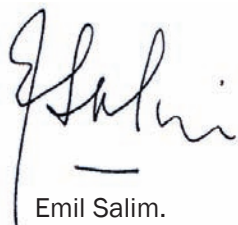
Under such circumstances, the priorities of development policy will shift away from addressing climate change, bio-diversity and other environmental issues. Allocating resources to cope with the economic slowdown may be considered more important. This, however, needs not be the case. Many countries are introducing green fiscal stimulus that creates jobs, shores up economies, and reduces poverty and, at the same time, spin-off activities of adaptation and mitigation to combat climate change. There is great scope for Southeast Asian countries to adopt such green stimulus programs.

This report is the outcome of a consultation process to agree on the scope and approach of the study, to discuss existing knowledge on climate change in the region, and to review policy developments. Seven national and regional dialogue sessions were held from April to November 2008, along with a Senior Policy Dialogue Meeting in October 2008.

Wide ranging ideas and valuable inputs were received from government officials, climate change researchers and experts, representatives of ADB's development partners, the civil society, business sector and other stakeholders. Feedback was received and formed an integral part of the study. We would like to convey our deepest appreciation and thanks to all those who have taken part in this endeavor.

We also extend our sincere thanks to the members of the advisory panel and steering committee that took part in this project. Without their valuable inputs, this study would not have been possible.

We hope that this review will provide impetus to all stakeholders of the five Southeast Asian countries and inspire other countries to cope with the challenges of climate change and other environmental issues through efforts that simultaneously address the daunting tasks of climate change, unemployment and poverty eradication through sustainable development.



Emil Salim.  
Lead Economist of the Review  
Jakarta, April 2009.

# Foreword

Climate change will affect everyone but developing countries will be hit hardest, soonest and have the least capacity to respond. South East Asia is particularly vulnerable to the impacts of climate change with its extensive, heavily populated coastlines, large agricultural sectors and large sections of the population living under \$2 or even \$1 a day.

The study by the ADB on the economics of climate change for South East Asia is the first regional report on the impacts, vulnerabilities, costs, opportunities and policy options for South East Asia, and, on this regional scale, globally. It is a very welcome contribution for policymakers, businesses, academics and civil society. It increases the national understanding in each country of the challenge of development in the face of a more hostile climate. It provides important perspectives on the regional interdependencies of climate change impacts and policies and thus can help in the pooling of regional resources to address shared challenges; for example, the development of public goods for adaptation (including new technologies, disaster and risk management and water resource management) in the region. This is particularly important, given that the climate is likely to change significantly in South East Asia in the next 20 or 30 years.

But while it is right to develop our understanding of the economics of climate change for countries and regions of the world, it is important to keep the global context in mind. The science is continuing to develop rapidly and as it does further possible impacts will be revealed and risks re-assessed. Interactions between impacts can multiply their effects. Many of the impacts from climate change are not in traditional economic sectors with the result that valuations of their effect is difficult and many are likely to be missed. Further, some of the economic and social valuations, such as loss of life or ecosystem, can be contentious. It is important that the economic analysis on climate change measures what counts rather than merely counting what can easily be measured. It is a global deal, and not an Asian deal, that will be negotiated at the UNFCCC meeting in Copenhagen at the end of this year therefore, whilst Asia's role is crucial, it will be important to read this report with the wider, global science, costs and opportunities in mind.

That the governments of the Indonesia, Philippines, Singapore, Thailand and Viet Nam have supported this study, indicates that the policymakers in the region are increasingly clear, that not only is climate change, if left unmanaged, a severe, or insuperable challenge to their growth and poverty reduction goals, but also that action will lead to a wide range of business opportunities for growth and development. In the transition to a low-carbon growth path the markets for low-carbon, high-efficiency goods and services will expand, creating opportunities for farsighted policy makers and businesses to benefit from innovation and investment. The study both makes a major contribution to the understanding of climate change in the region, and greatly strengthens the global case for strong action.

I congratulate those who have commissioned and supported the study and those who carried it out. And I look forward to the leading role that I am convinced the region will play in action on climate change.



Nicholas Stern  
IG Patel Professor of Economics & Government  
London School of Economics and Political Science

\* ————— \*

Southeast Asia is one of the most dynamic, fast growing regions in the world today. But with long coastlines, population and economic activity concentrated in coastal areas, reliance on agriculture in providing livelihoods for a large segment of the population—especially those living in poverty—and dependence on natural resources and forestry to drive development, it is highly vulnerable to the harsh impact of climate change.

Over the past few decades the region has seen higher temperatures and a sharp rise in the frequency of extreme weather events including droughts, floods and tropical cyclones. Without urgent action to address this pressing issue, the region will face a difficult future marked by declining freshwater and crop yields (affecting food security), increasing loss of forests and farmlands, rising sea levels threatening island dwellers and coastal communities, and a surge in infectious diseases such as dengue and malaria.

This study of five countries—Indonesia, Philippines, Singapore, Thailand and Viet Nam—involving extensive consultations with a wide range of stakeholders from the public and private sectors, examines in depth the climate challenges facing the region and makes policy suggestions.

Temperatures will continue to rise because of greenhouse gas (GHG) emissions already locked into the climate system. It is therefore of the utmost importance that Southeast Asian countries continue to take action to adapt to climate change. This is particularly important for poverty reduction and the achievement of Millennium Development Goals, since the poor are the most vulnerable.

But even with aggressive adaptation efforts, the negative impacts of climate change on economies, environment and health will continue to worsen. Only concerted global action to mitigate GHG emissions can ultimately steer the world off its current calamitous course. This requires all countries, developed and developing, to work together under the principle of common but differentiated responsibility. An essential component of a global solution to climate change would involve adequate transfers of financial resources and technological know-how from developed to developing countries for both mitigation and adaptation. The global climate change challenge cannot be effectively tackled without the participation of developing countries.

Southeast Asia produced 12% of the world's greenhouse gases at the turn of the century and, with the region's expanding population and economies, its global share of GHG emissions is likely to increase

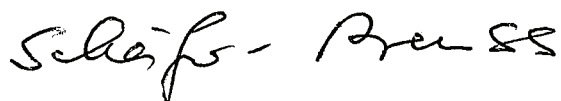
under “business-as-usual”. Yet, Southeast Asia is among the regions of the world with the greatest potential for mitigating carbon dioxide by reducing deforestation and improving land management practices. It also has vast, untapped opportunities for energy efficiency improvements and for increasing the use of renewable energy sources, including biomass, solar, wind, hydro and geothermal—all leading to GHG emission reductions.

This study urges Southeast Asian countries to play their part in a global solution to climate change by introducing sustainable development policies that incorporate mitigation and adaptation activities. They should also do more to tap the wide array of global, regional and bilateral funding sources and initiatives that exist to help developing countries respond to climate challenges. Among these are ADB’s Energy Efficiency Initiative and Carbon Market Initiative, as well as global-level programs such as the Clean Development Mechanism and the Global Environment Facility (GEF). These existing funding sources, albeit inadequate in view of the vast task at hand and need to scale up, provide initial support and can be used as a catalyst to raise co-financing.

Under the Bali Road Map concluded at the 2007 conference of parties to the United Nations Framework Convention on Climate Change, the international community agreed to step up efforts to combat climate change, and is now working toward a long term global climate change solution embracing mitigation, adaptation, technology development and transfer, and the provision of financial resources in support of developing countries’ actions, with a view to stabilizing GHG atmospheric concentration at a safe level. Given its high vulnerability to climate change, Southeast Asia has a high stake in such a global solution.

Despite the global and regional economic downturn, the Earth is still warming and sea levels are rising. The world can no longer afford to delay action on climate change, even temporarily. Countries must act decisively. The global economic crisis provides an opportunity for the world, and Southeast Asia, to start the transition toward a climate-resilient and low-carbon economy.

ADB has put tackling climate change at the heart of its poverty reduction and development agenda and serves as a facilitator for active partnerships to meet the climate change challenge. It welcomes this comprehensive study as a valuable tool for policymakers and others, seeking to understand the issues, and how to respond to them.



Ursula Schaefer-Preuss  
Vice-President, Knowledge Management and Sustainable Development  
Asian Development Bank



# Acknowledgments

This report is the outcome of an Asian Development Bank (ADB) technical assistance project, “A Regional Review of the Economics of Climate Change,” with funding from the Government of the United Kingdom. An Advisory Panel and a Steering Committee, both chaired by Emil Salim (Member of the Advisory Council to the Indonesian President as Adviser for environment and sustainable development issues, and former Minister of Indonesia Ministry of Environment), provided strategic direction to the study.

An ADB Study Team, led by Tae Yong Jung (Senior Economist, Economics and Research Department [ERD]), implemented the project under the overall guidance of Juzhong Zhuang (Assistant Chief Economist, ERD) who was also fully involved in drafting the report. Other members of the study team included Suphachol Suphachalasai, Jindra Samson, Lawrence Nelson Guevara, Franklin de Guzman, Elizabeth Lat, Rina Sibal, Juliet Vanta, and Anneli S. Lagman-Martin.

The Advisory Panel members included Upik Sitti Aslia Kamil (Head of Sub-Division for Climate Change Mitigation on Energy Sector, Ministry of Environment, Indonesia); Medrilzam (Head of Environmental Services and Conservation Division, Directorate for Forestry and Water Conservation, BAPPENAS, Indonesia); Demetrio Ignacio (Undersecretary for Policy and Planning, Department of Environment and Natural Resources, Philippines); Datu Zamzamin L. Ampatuan (Undersecretary, Department of Energy, Philippines); Teo Eng Dih (Senior Assistant Director [Climate Change], Strategic Policy Division, Ministry of the Environment and Water Resources [MEWR], Singapore); Cynthia Lim (Senior Assistant Director, Energy Division, Ministry of Trade and Industry, Singapore); Natthanich Asvapoositkul (Environmental Officer, Office of Natural Resources and Environmental Policy and Planning, Thailand); Le Nguyen Tuong (Director, Research Center for Climate Change and Sustainable Development, Institute of Hydrometeorology and Environment, Ministry of Natural Resources and Environment (MONRE), Viet Nam); from ADB, Nessim Ahmad (Director, Environment and Safeguards Division, Regional and Sustainable Development Department [RSDD]), Urooj Malik (Director, Agriculture, Environment and Natural Resources Division, Southeast Asia Department), and Juzhong Zhuang; and their representatives, Daryl Sng (Deputy Director [Climate Change], MEWR, Singapore); and Tran Thi Minh Ha (Director General, Department of International Cooperation, MONRE, Viet Nam).

The Steering Committee members included two Economic Advisors to the UK Stern Team, Su-Lin Garbett-Shiels (UK-Office of Climate Change) and Chris Taylor (UK-Department for International Development) who also provided support to the study at various stages; Masakazu Ichimura (Chief, Environment Section, Environment and Sustainable Development Division, United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP]); and from ADB, Tae Yong Jung, Herath Gunatilake (Senior Economist, ERD), and David McCauley (Principal Climate Change Specialist, Climate Change Program Coordination Unit, RSDD).

The ADB Study Team was assisted by a team of National Climate Experts and International Consultants. The National Climate Experts, who coordinated national consultations and prepared country reports, included Rizaldi Boer (Head of Climatology Laboratory, Bogor Agriculture University, Indonesia), Rosa Perez (Consultant/Researcher, Philippines), Ho Juay Choy (Professor, Department of Mechanical Engineering, National University of Singapore), Sitanon Jesdapipat (Associate, Climate Policy Initiative, Southeast Asia System for Analysis, Research and Training, Thailand), Nguyen Mong Cuong (Director, Research Center for Climate Change and Sustainable Development, Viet Nam), and Hoang Manh Hoa (Senior Expert, Climate Change Coordinator, International Cooperation Department, MONRE, Viet Nam).

The International Consultants, engaged to coordinate regional consultations, carry out modeling work, and prepare background reports, included Leandro Buendia (Lead Consultant), Keigo Akimoto (Senior Research Scientist, Research Institute of Innovative Technology for the Earth, Japan), Ancha Srinivasan (Principal Researcher and Manager, Climate Policy Project, Institute for Global Environmental Strategies), Agustin Arcenas (Assistant Professor, School of Economics, University of the Philippines), and Chris Hope (Faculty, University of Cambridge, UK).

From ADB, Ursula Schaefer-Preuss (Vice-President, Knowledge Management and Sustainable Development) and Xianbin Yao (Director General, RSDD) provided valuable guidance and support at various stages. Woonchong Um (Director, Energy, Transport and Water Division, RSDD) and Douglas Brooks (Principal Economist, ERD) reviewed the report and provided useful comments. Ann Quon (Office-in-Charge of Department of External Relations [DER]) and Jason Rush (Media Relations Specialist, DER) assisted in disseminating the results of the study through study launches and other media events. Many other staff, in and outside ERD, contributed to the study in one way or another.

John Weiss, Eric Van Zant, Michael Clancy, and Cherry Lynn T. Zafaralla edited the report, and Joe Mark Ganaban was the graphics designer and typesetter.

The ADB Study Team thanks all participants in the regional and national consultations for their valuable contributions to this study. Special thanks to UNESCAP for hosting Thailand's National Consultation and the Senior Policy Dialogue.

Finally, the views expressed in this report are those of the Study Team and do not necessarily reflect the views and policies of ADB, or its Board of Governors or the governments they represent, nor of the views of the participating country governments. ADB does not guarantee the accuracy of the data included in this publication and accepts no responsibility for any consequences of their use.

# Abbreviations, Acronyms and Symbols

ADB	Asian Development Bank
APCF	Asia Pacific Carbon Fund
ASEAN	Association of Southeast Asian Nations
BAU	business as usual
CCF	Climate Change Fund
CCS	carbon capture and storage
CDM	Clean Development Mechanism
CEFPF	Clean Energy Financing Partnership Facility
CER	certified emission reduction
CF	carbon finance
CPF	Collaborative Partnership on Forests
CTI	Climate Technology Initiative
DMCs	developing member countries
DNE21+	Dynamic New Earth21+
ENSO	El Niño Southern Oscillation
ETS	Emissions Trading Scheme
ETTV	envelope thermal transfer value
FAO	Food and Agriculture Organization
FCF	Future Carbon Fund
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GMS	Greater Mekong Subregion
HCMC	Ho Chi Minh City
HEV	hybrid-electric vehicles
IAM	integrated assessment model
ICEV	internal combustion engine vehicles
IPCC	Intergovernmental Panel on Climate Change
Lao PDR	Lao People's Democratic Republic
LDCF	Least Developed Countries Fund
LUCF	land use change and forestry
MAC	marginal abatement cost
MDG/s	millennium development goal/s
MONRE	Ministry of Natural Resources and the Environment (Viet Nam)
NCCC	National Climate Change Committee (Thailand)
OECD	Organization for Economic Co-operation and Development
OFDA	Office of US Foreign Disaster Assistance
ONEP	Office of Natural Resources and Environmental Policy and Planning (Thailand)
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PEF	Poverty and Environment Fund

REDD	reduced emissions from deforestation and degradation
RITE	Research Institute of Innovative Technology for the Earth
RRECCS	Regional Review of the Economics of Climate Change in Southeast Asia
SCCF	Special Climate Change Fund
SEA-START	Southeast Asia System for Analysis, Research and Training
SME	State Ministry of Environment (Indonesia)
SOI	Southern Oscillation Index
SRES	Special Report on Emissions Scenarios
START	System for Analysis, Research and Training
TGO	Thailand Greenhouse Gas Management Public Organization
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change

\$	US dollar
%	percent
°C	degree Celsius
cc	cubic centimeter
cm	centimeter
CH <sub>4</sub>	methane
CO	carbon monoxide
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> -eq	carbon dioxide equivalent
cu m	cubic meter
dS/m	deciSiemens per metre
GtCO <sub>2</sub>	gigaton of carbon dioxide
GtCO <sub>2</sub> -eq	gigaton of carbon dioxide equivalent
GWh	gigawatt hour
ha	hectares
kg	kilogram
kg/ha	kilogram per hectare
kg CO <sub>2</sub> /m <sup>2</sup>	kilogram of carbon dioxide per square meter
km	kilometer
km/h	kilometer per hour
ktoe	kiloton of oil equivalent
m	meter
mt CO <sub>2</sub>	metric ton of carbon dioxide
mt CO <sub>2</sub> -eq	metric ton of carbon dioxide equivalent
MtCO <sub>2</sub>	million ton of carbon dioxide
Mtoe	million ton of oil equivalent
MW	megawatt
N <sub>2</sub> O	nitrous oxide
NO <sub>x</sub>	oxide of nitrogen
ppm	parts per million
SF <sub>6</sub>	sulfur hexafluoride

sq km	square kilometer
SO <sub>x</sub>	oxide of sulfur
tC	ton of carbon
tC/ha	ton of carbon per hectare
tCO <sub>2</sub>	ton of carbon dioxide
tCO <sub>2</sub> -eq	ton of carbon dioxide equivalent
tCO <sub>2</sub> /ha	ton of carbon dioxide per hectare
TWh	terawatt hour
W/m <sub>2</sub>	watt per square metre



# Contents

Preface.....	iii
Foreword.....	v
Acknowledgments.....	ix
Abbreviations, Acronyms and Symbols.....	xi
Summary of Conclusions.....	1

## Part I Introduction

<b>Chapter 1 Background</b> .....	<b>3</b>
A. Climate Change—A Global Problem.....	3
B. Climate Change in Southeast Asia.....	4
C. About This Study.....	6
D. Organization of the Report.....	8
References.....	8
<b>Chapter 2 Regional Circumstances</b> .....	<b>7</b>
A. Introduction.....	8
B. Economic and Social Development.....	8
C. Land Use and Natural Resources.....	10
D. Summary.....	18
References.....	

## Part II Climate Change, Its Impact and Adaptation

<b>Chapter 3 Climate Change and Its Impact: A Review of Existing Studies</b> .....	<b>21</b>
A. Introduction.....	22
B. Observed and Projected Climate Change in Southeast Asia.....	22
C. Observed and Projected Climate Change Impact.....	33
Water Resources.....	33
Agriculture.....	37
Forestry.....	42
Coastal and Marine Resources.....	46
Human Health.....	51
D. Conclusions.....	54
References.....	55

<b>Chapter 4: Modeling Climate Change and Its Impact</b> .....	<b>61</b>
--	-----------

A. Introduction .....	63
B. Projected Global Climate Change .....	66
C. Projected Climate Change in Southeast Asia .....	68
D. Projected Climate Change Impact in Southeast Asia.....	71
Water Resources .....	71
Agriculture.....	72
Forestry (Ecosystems).....	76
Health.....	77
E. Conclusions .....	79
References.....	80

## **Chapter 5: Modeling the Economy-wide Impact of Climate Change** **81**

A. Introduction .....	83
B. Model and Scenario Assumptions.....	83
C. Modeling Results .....	85
D. Conclusions.....	89
References.....	89

## **Part III Climate Change Mitigation**

### **Chapter 6 Climate Change Adaptation Options and Practices** **89**

A. Introduction .....	91
B. Building Adaptive Capacity.....	92
C. Adaptation Options and Practices in the Water Resources Sector.....	95
D. Adaptation Options and Practices in the Agriculture Sector .....	101
E. Adaptation Options and Practices in the Forestry Sector.....	106
F. Adaptation Options and Practices in the Coastal and Marine Resources Sector.....	107
G. Adaptation Options and Practices in the Health Sector .....	115
H. Conclusions.....	118
References.....	119

### **Chapter 7 Climate Change Mitigation Options and Practices** **120**

A. Introduction .....	124
B. Southeast Asia's GHG Emissions .....	124
C. Mitigation Options and Practices.....	126
Land Use Change and Forestry .....	126
The Energy Sector .....	134
The Agriculture Sector.....	141
Agroforestry, Set-Aside, and Land Use Change .....	147
Grassland Management .....	147
Peatland Management and Restoration of Organic Soils.....	148
Restoration of Degraded Lands .....	148
Bioenergy .....	149
Livestock Management and Manure Management .....	149
D. Conclusions .....	150

References.....	152
-----------------	-----

## **Chapter 8 Energy Sector Mitigation Options** **151**

A. Introduction.....	156
B. Mitigation Options in the Energy Sector .....	158
C. Marginal Abatement Cost Curves.....	164
D. Conclusions.....	167
Appendix 1: Results by Country .....	168
Country-specific Projections under Different Scenarios .....	168
Indonesia .....	168
The Philippines .....	170
Thailand.....	172
Viet Nam.....	174
Appendix 2.....	176
Country-specific Marginal Abatement Cost Curves in 2020.....	176
Indonesia .....	176
The Philippines .....	176
Thailand.....	177
Viet Nam.....	178
References.....	179

## **Part IV Policy Responses**

### **Chapter 9 Climate Change Policy: A Review** **180**

A. Introduction.....	184
B. National Policy and Actions in Southeast Asia .....	184
C. Global and Regional Initiatives .....	194
D. Financing Climate Change Mitigation and Adaptation Activities.....	200
E. Conclusions.....	206
References.....	208

### **Chapter 10 Conclusions and Policy Recommendations** **208**

A. Climate Change and Its Impact in Southeast Asia .....	211
B. The Need for a Global Solution.....	212
C. What Should Southeast Asia Do? .....	213
(i) Adaptation toward enhanced climate resilience .....	214
(ii) Mitigation toward a low-carbon economy.....	216
(iii) Funding, Technology Transfer, and International/Regional Cooperation.....	219
(v) Strengthening Government Policy Coordination.....	221
(vi) Undertaking more research on climate change-related issues .....	222
(vii) Turning the economic crisis into an opportunity .....	222
References.....	223

# Tables, Figures, and Boxes

Table 2.1.	Selected Economic and Social Indicators.....	9
Table 2.2.	Environmental and Natural Resource Indicators in Southeast Asia .....	11
Table 2.3.	Livestock Production in Southeast Asia.....	12
Table 2.4.	Freshwater Resources in Southeast Asia .....	13
Table 2.5.	Primary Forest in Southeast Asia (1990–2005) .....	16
Table 2.6.	Forest Plantations in Southeast Asia (1990–2005) .....	16
Table 2.7.	Tourist Arrivals in Southeast Asia (2000–2005) .....	17
Table 3.1.	Observed Temperature Changes in Southeast Asia.....	23
Table 3.2.	Projected Change in Mean Surface Air Temperature for Southeast Asia under A1FI and B1 (with respect to baseline period of 1961–1990), °C .....	24
Table 3.3.	Observed Change in Precipitation in Southeast Asia.....	27
Table 3.4.	Projected Change in Precipitation for Southeast Asia under A1FI and B1 (with respect to baseline period 1961–1990), %.....	27
Table 3.5.	Observed Changes in Extreme Events and Severe Climate Anomalies in Southeast Asia .....	28
Table 3.6.	Observed Change in Sea Level in Southeast Asia.....	31
Table 3.7.	Projected Global Average Surface Warming and Sea Level Rise in 2100.....	32
Table 3.8.	Summary of Observed Impacts of Climate Change on Water Resources Sector in Southeast Asia.....	33
Table 3.9.	Summary of Observed Impacts of Climate Change on Agriculture Sector in Southeast Asia .....	38
Table 3.10.	Rice Yield Change in Viet Nam (comparison with base year, 1980–1990), % .....	41
Table 3.11.	Maize Yield Change in Viet Nam (comparison with base year, 1980–1990), % .....	41
Table 3.12.	Summary of Observed Impacts of Climate Change on Forestry Sector in Southeast Asia .....	42
Table 3.13.	Projected Change in the Area of Natural and Plantation Forests in Viet Nam.....	45
Table 3.14.	Summary of Observed Impacts of Climate Change on Coastal and Marine Resources Sector in Southeast Asia.....	46
Table 3.15.	Observed Impacts of Climate Change on Health Sector in Southeast Asia .....	51
Table 4.1.	World Population Growth and Economic Growth under B2 and A1FI.....	65
Table 4.2.	Population Growth and Economic Growth under B2 and A1FI.....	67
Table 4.3.	Population Aged 65 Years and above and Urban Population in the Four Countries .....	67
Table 4.4.	Definition of Biome Type .....	74
Table 5.1.	Key Assumptions Underlying A2 Scenario .....	84
Table 6.1.	Adaptation Options.....	92
Table 6.2.	Supply and Demand of Raw Water in Indonesia, by Island (2003) .....	94
Table 6.3.	Summary of Key Adaptation Options on Water Resources Sector.....	99
Table 6.4.	Adaptation Options in the Philippine Agricultural Sector.....	101
Table 6.5.	Summary of Index-based Insurance Schemes in Asia.....	103

Table 6.6.	Summary of Key Adaptation Options in Agriculture Sector .....	104
Table 6.7.	Summary of Key Adaptation Options in Forestry Sector.....	106
Table 6.8.	Measures to Enhance Adaptive Capacity of the Coastal Sector in the Philippines .....	112
Table 6.9.	Summary of Key Adaptation Options on Coastal and Marine Resources Sector.....	115
Table 6.10.	Summary of Key Adaptation Options in Health Sector .....	116
Table 7.1.	Greenhouse Gas Emissions (MtCO <sub>2</sub> -eq.) .....	122
Table 7.2.	Global GHG Emissions by Sector in 2000 (MtCO <sub>2</sub> -eq.).....	122
Table 7.3.	Trend of GHG Emissions in Southeast Asia (MtCO <sub>2</sub> -eq.).....	122
Table 7.4.	Mitigation Options for the LUCF Sector in Southeast Asia.....	124
Table 7.5.	Key Energy-efficient Mitigation Technologies and Practices .....	131
Table 7.6.	Key Mitigation Technologies and Practices on Renewable and Cleaner Energies.....	134
Table 7.7.	Targets for Renewable Energy and Alternative Fuels in Thailand .....	135
Table 7.8.	Key Mitigation Technologies and Practices for the Transport System and Road Traffic Management .....	136
Table 7.9.	Mitigation Options in Agriculture in Southeast Asia.....	139
Table 7.10.	Effects of Different Types of Nitrogen Fertilizer on N <sub>2</sub> O Emission in Rice Fields in Central Java, Indonesia (1997).....	142
Table 7.11.	Potential Options for the Reduction of CH <sub>4</sub> Emissions in Rice Fields .....	144
Table 8.1.	Key “win-win” Mitigation Potential in the Four Countries, 2020 .....	166
Table A.1.	Mitigation Potential in Energy Sector and Total Cost in 2020.....	179
Table 9.1.	Government Agencies and Climate Change Key Plans.....	184
Table 9.2.	Sectoral Policies, Programs, and Measures Relevant to Mitigation and Adaptation in Indonesia .....	186
Table 9.3.	National Policies in the Philippines Related to Adaptation.....	187
Table 9.4.	National Policies in the Philippines Related to Mitigation .....	188
Table 9.5.	National Climate Change Adaptation Plans and Implementation in Singapore .....	188
Table 9.6.	National Climate Change Adaptation Plans and implementation in Thailand .....	189
Table 9.7.	National Mitigation Plans and Implementation in Thailand .....	190
Table 9.8.	Priority Areas of Viet Nam’s Agenda 21 and Current State of Related Laws and Regulations.....	191
Table 9.9.	Comparison of Policies on Energy Efficiency.....	193
Table 9.10.	Comparison of Renewable Energy Policies.....	193
Table 9.11.	Comparison of Biofuel Policies .....	193
Table 9.12.	Multilateral Financial Schemes .....	201
Table 9.13.	Bilateral Financial Schemes .....	205
Table 9.14.	Other Financial Schemes—Private Sector.....	206

Figure 1.1. Atmosphere-Ocean General Circulation Model Projections of Surface Warming .....	4
Figure 2.1. Southeast Asian Countries .....	8
Figure 2.2. Poverty Estimates in Southeast Asia.....	10
Figure 2.3. Consumption Trend and Intensity of Fertilizer Use in Southeast Asia .....	12
Figure 2.4. Regional Exports of Forest Products (1990–2006) .....	14
Figure 2.5. Exported Wood-based Panels in Southeast Asia .....	14
Figure 2.6. Exported Pulp for Paper in Southeast Asia .....	15
Figure 3.1. Patterns of Linear Global Temperature Trends (1979–2005), °C per decade .....	22
Figure 3.2. Trend in Annual Precipitation in Southeast Asia (1901–2005).....	25
Figure 3.3. Extent of Damages due to Floods/Storms (1960–2008).....	28
Figure 3.4. Number of Climate-Related Hazards Occurrence by Type in Indonesia (1950–2005).....	29
Figure 3.5. Disasters in the Philippines (1905–2006) .....	30
Figure 3.6. Sea Level Rise in Indonesia and the Philippines .....	31
Figure 3.7. Changes in Volume of Water in Reservoirs in Java, Indonesia during La Niña and El Niño Years.....	34
Figure 3.8. Relationship between Crop Yield and Climate (1991–2003) .....	38
Figure 3.9. Forest Fire Destruction in the Philippines (1978–1999) .....	43
Figure 3.10. Coastal Erosion at East Coast Park, Singapore.....	48
Figure 3.11. Incidence of Dengue (histogram) and Affected Cities and Districts (line) in Indonesia .....	52
Figure 3.12. Potential Impacts of Climate Change on Key Sectors.....	54
Figure 4.1. Global Mean Temperature Increase Relative to the 1990 Level .....	66
Figure 4.2. Global Mean Precipitation Change (2100 Relative to 1990) .....	66
Figure 4.3. Global Mean Sea Level Rise Relative to 1990 Levels .....	66
Figure 4.4. Annual Average Temperature Increase Relative to 1990 in the Four Countries .....	68
Figure 4.5. Annual Average Precipitation Change Relative to 1990 in the Four Countries.....	69
Figure 4.6. Water Stress in River Basin Areas due to Global Warming under B2 (2050) .....	70
Figure 4.7. Rice Yield Potential in the Four Countries and World .....	72
Figure 4.8. Change in Production Potential in Southeast Asia Relative to 1990 Level (A1FI, with productivity improvement and adaptation measures, in tons per hectare per year) .....	73
Figure 4.9. Territorial Biome Distribution in Southeast Asia (1990–2100).....	75
Figure 4.10. Additional Deaths from Cardiovascular and Respiratory Diseases Due to Global Warming in the Four Countries .....	77
Figure 5.1. Global GHG Concentration under A2 Scenario .....	84
Figure 5.2. Global Mean Temperature Rise under A2 Scenario.....	84
Figure 5.3. Loss in GDP (market impact only) under A2 Scenario .....	85
Figure 5.4. Mean Impact under A2 Scenario.....	86
Figure 5.5. Mean Total Loss under Different Scenarios .....	86
Figure 5.6. Cost and Benefit of Adaptation .....	87
Figure 6.1. Damage Irrigation Facilities in Indonesia by Province (2003).....	95
Figure 6.2. Wells to Absorb Surplus Water from Irrigation and Rainfall at Grobogan.....	96
Figure 6.3. NWater: Reclamation of Water from Waste and Sewerage.....	97
Figure 6.4. Small Water Impounding System in the Philippines .....	98
Figure 6.5. Income Difference Between Farmers that Use and Do Not Use SOI Information .....	103
Figure 6.6. Wave Break to Protect Mangrove Seedling from Big Wave .....	108

Figure 6.7.	New Housing Design in Coastal Areas in Indonesia .....	111
Figure 7.1.	GHG Emissions in Southeast Asia.....	123
Figure 7.2.	Total Technical Mitigation Potential in Agriculture (all practices, all GHGs)for Each Region (2030) .....	144
Figure 8.1.	Nexus Between Energy Consumption, GDP, and CO <sub>2</sub> Emissions .....	156
Figure 8.2.	Energy-related CO <sub>2</sub> Emissions in the Four Countries .....	158
Figure 8.3.	Primary Energy Consumption in the Four Countries .....	159
Figure 8.4.	Primary Energy Consumption Adjustment in 2050, Relative to Reference Scenario in the Four Countries.....	160
Figure 8.5.	Change in Primary Energy Consumption per Unit of GDP, 2050 Relative to 2000 in the Four Countries.....	160
Figure 8.6.	Electricity Generation in the Four Countries.....	161
Figure 8.7.	Electricity Generation Adjustment in 2050 Relative to Reference Scenario in the Four Countries.....	161
Figure 8.8.	Change in Electricity Generation per Unit of GDP, 2050 Relative to 2000 in the Four Countries.....	162
Figure 8.9.	CO <sub>2</sub> Capture and Storage under S550 in the Four Countries .....	162
Figure 8.10.	CO <sub>2</sub> Capture and Storage under S450 in the Four Countries .....	163
Figure 8.11.	Projection of Kilometers by Car by 2050 in the Four Countries.....	164
Figure 8.12.	Marginal Abatement Cost Curve for the Four Countries (2020) .....	165
Figure A.1.	Indonesia – Primary Energy Consumption .....	168
Figure A.2.	Indonesia – Electricity Generation .....	168
Figure A.3.	Indonesia – CO <sub>2</sub> Emission and Storage .....	169
Figure A.4.	Philippines – Primary Energy Consumption .....	170
Figure A.5.	Philippines – Electricity Generation .....	171
Figure A.6.	Philippines – CO <sub>2</sub> Emission and Storage .....	171
Figure A.7.	Thailand – Primary Energy Consumption .....	174
Figure A.8.	Thailand – Electricity Generation .....	175
Figure A.9.	Thailand – CO <sub>2</sub> Emission and Storage .....	175
Figure A.10.	Viet Nam – Primary Energy Consumption.....	176
Figure A.11.	Viet Nam – Electricity Generation .....	177
Figure A.12.	Viet Nam – CO <sub>2</sub> Emission and Storage .....	178
Figure A.13.	Indonesia – Marginal Abatement Cost Curve (2020).....	179
Figure A.14.	Philippines – Marginal Abatement Cost Curve (2020).....	175
Figure A.15.	Thailand – Marginal Abatement Cost Curve (2020).....	177
Figure A.16.	Vietnam – Marginal Abatement Cost Curve (2020).....	178
Box 3.1.	The IPCC Special Report on Emissions Scenarios .....	23
Box 4.1.	The Uncertainties of Modeling Climate Change .....	63
Box 5.1.	PAGE2002 Model .....	83
Box 6.1.	Climate Change Adaptation Strategies on Water Resources in Ninh Thuan Province, Viet Nam .....	96
Box 6.2.	How Farmers Manage Climate Risks in the Lower Mekong Countries .....	101
Box 6.3.	Mangrove Reforestation in Southern Thailand.....	107
Box 6.4.	Albay in Action on Climate Change .....	108
Box 6.5.	Adaptation Strategies on Coastal Erosion and Flooding in Thailand: A Case Study of Bang Khun Thian District, Bangkok.....	110
Box 6.6.	Typhoon-Resistant Housing in the Philippines .....	112

Box 6.7.	Cost of Adaptation to Sea Level Rise in Ho Chi Minh City .....	113
Box 6.8.	Dengue Fever Prevention in Viet Nam: Using Mesocyclops to Combat the Larvae of <i>Aegis aegyptiaca</i> .....	116
Box 7.1.	Reducing Emissions from Deforestation and Degradation (REDD) in Developing Countries.....	125
Box 7.2.	Forest Management as Carbon Mitigation Option: The RUPES Kalahan, Philippines Case Study.....	129
Box 7.3.	Green Mark Ratings .....	133
Box 9.1.	Financing Requirement by the Four Countries to Achieve Target under a Hypothetical Global Deal .....	207
Box 10.1.	Policy Recommendations on Adaptation .....	215
Box 10.2.	Policy Recommendations on Mitigation.....	218
Box 10.3.	Funding, Technology Transfer, and International/Regional Cooperation.....	220
Box 10.4.	Strengthening Government Policy Coordination .....	221
Box Figure 5.1.	Chain of Impacts and Policy Analysis of PAGE2002 Model .....	83
Box Figure 7.2.1.	Study Area in Kalahan Forest Reserve, Philippines.....	132
Box Figure 7.2.2	Estimated Net Cumulative CO2 Removals by the Kalahan Reforestation Project .....	133
Box Figure 9.1.a.	GHG Emission Reduction by 2050 (50% Reduction from 1990 World Level) .....	207
Box Figure 9.1.b.	Emission Reductions for Non-Annex I Countries Under a Hypothetical Global Deal.....	208
Box Figure 9.1.c.	Funding Requirement by the Four Countries to Achieve its Target Share in a Hypothetical Global Deal .....	208



# Summary of Conclusions

## **Southeast Asia is highly vulnerable to climate change.**

Climate change is happening now in Southeast Asia, and the worst is yet to come. If not addressed adequately, it could seriously hinder the region's sustainable development and poverty eradication efforts—there is no time for delay.

The review identifies a number of factors that explain why the region is particularly vulnerable. Southeast Asia's 563 million people are concentrated along coastlines measuring 173,251 kilometers long, leaving it exposed to rising sea levels.

At the same time, the region's heavy reliance on agriculture for livelihoods—the sector accounted for 43% of total employment in 2004 and contributed about 11% of GDP in 2006—make it vulnerable to droughts, floods, and tropical cyclones associated with warming. Its high economic dependence on natural resources and forestry—as one of the world's biggest providers of forest products—also puts it at risk. An increase in extreme weather events and forest fires arising from climate change jeopardizes vital export industries.

Rapid economic growth and structural transformation in Southeast Asia helped lift millions out of extreme poverty in recent decades. But poverty incidence remains high—as of 2005, about 93 million (18.8%) Southeast Asians still lived below the \$1.25-a-day poverty line—and the poor are the most vulnerable to climate change.

The review has also assessed a wide range of evidence of climate change and its impact in Southeast Asia to date. It tells a clear story: mean temperature increased at 0.1–0.3 °C per decade between 1951 and 2000; rainfall trended downward during 1960–2000; and sea levels have risen 1–3 millimeters per year.

Heat waves, droughts, floods, and tropical cyclones have been more intense and frequent, causing extensive damage to property, assets, and human life. Recorded floods/storms have risen dramatically, particularly in the Philippines, rising from just under 20 during 1960–1969 to nearly 120 by 2000–2008.

This report has also reviewed the existing studies that attempt to predict climate change impact in the region, all suggesting that it will intensify, with dire consequences. Modeling work undertaken under this review covering Indonesia, Philippines, Thailand, and Viet Nam confirms many of these findings. Indeed, it suggests that the region is likely to suffer more from climate change than the world average, if no action is taken.

Annual mean temperature is projected to rise 4.8°C on average by 2100 from 1990. Mean sea level is projected to rise by 70 cm during the same period, following the global trend. Indonesia, Thailand, and Viet Nam are expected to experience increasingly drier weather conditions in the next 2–3 decades, although this trend is likely to reverse by the middle of this century.

Global warming is likely to cause rice yield potential to decline by up to 50% on average by 2100 compared to 1990 in the four countries; and a large part of the dominant forest/woodland could be replaced by tropical savanna and shrub with low or no carbon sequestration potential.

For the four countries covered in the modeling work, the potential economic cost of inaction is huge: if the world continues “business-as-usual” emissions trends—considering all market and non-market impacts and catastrophic risks of rising temperatures—the cost to these countries each year could equal a loss of 6.7% of their combined gross domestic product by 2100, more than twice the world average.

**Southeast Asia is among the regions with the greatest need for adaptation, which is critical to reducing the impact of changes already locked into the climate system.**

The review demonstrates that a wide range of adaptation measures are already being applied. But much more needs to be done. Adaptation requires building adaptive capacity and taking technical and non-technical measures in climate-sensitive sectors.

Further strengthening adaptive capacity in Southeast Asia requires mainstreaming climate change adaptation in development planning, that is, making it an integral part of sustainable development, poverty reduction and disaster risk management strategies. Some of the immediate priorities are:

- Stepping up efforts to raise public awareness of climate change and its impact;
- Undertaking more research to better understand climate change, its impact, and solutions, especially at local levels;
- Enhancing policy and planning coordination across ministries and different levels of government for climate change adaptation;
- Adopting a more holistic approach to building the adaptive capacity of vulnerable groups and localities and their resilience to shocks; and
- Developing and adopting more proactive, systematic, and integrated approaches to adaptation in key sectors that are cost-effective and that offer durable and long-term solutions.

The review notes that many sectors have adaptation needs, but water, agriculture, forestry, coastal and marine resources, and health require particular attention. While many countries have made significant efforts, the review identifies the following priorities for further action:

- *Water resources.* Scale up water conservation and management; and widen use of integrated water management, including flood control and prevention schemes, flood early warning system, irrigation improvement, and demand-side management.

- *Agriculture.* Strengthen local adaptive capacity through better climate information, research and development on heat-resistant crop varieties, early warning systems, and efficient irrigation systems; and explore innovative risk-sharing instruments such as index-based insurance schemes.
- *Forestry.* Enhance early warning systems and awareness-raising programs to prepare for more frequent forest fires; and implement aggressive public-private partnerships for reforestation and afforestation.
- *Coastal and marine resources.* Implement integrated coastal zone management plans, including mangrove conservation and planting.
- *Health.* Expand or establish early warning systems for disease outbreaks, health surveillance, awareness-raising campaigns, and infectious disease control programs.
- *Infrastructure.* Introduce “climate proofing” in transport-related investments and infrastructure, starting with public buildings.

### **Southeast Asia also has great mitigation potential.**

In 2000, the region contributed 12% of the world’s GHG emissions, amounting to 5,187 MtCO<sub>2</sub>-eq, up 27% from 1990. The land use change and forestry sector was the biggest source, contributing 75% of the region’s total, the energy sector 15%, and the agriculture sector 8%. There is considerable scope for mitigation measures that can contribute to a global solution to climate change and bring significant co-benefits to Southeast Asia.

As the largest contributor to emissions, the forestry sector is the most critical. Major mitigation measures include reducing emissions from deforestation and degradation (REDD), afforestation and reforestation, and improving forest management.

The region’s energy sector—as the fastest growing contributor to emissions—also holds vast, untapped potential for mitigation. Although Southeast Asian countries together contributed about 3.0% of global energy-related CO<sub>2</sub> emissions in 2000, this share is expected to rise significantly in the future given relatively higher economic and population growth compared to the rest of the world, if no action is taken.

“Win-win” options that would allow GHG emission reductions at a relatively low or even negative net cost could include, on the supply side, efficiency improvements in power generation, fuel switching from coal to natural gas, and use of renewable energy (including biomass, solar, wind, hydro and geothermal resources); and on the demand side, energy efficiency improvements and conservation in buildings (efficient lighting and electrical appliances, energy conservation, better insulation), industry sector (efficient equipment, heat/power recovery, recycling), and the transport sector (cleaner fuels, efficiency, hybrid/electric transport, rail/public transport).

In the case of the four countries’ covered in the modeling work, such “win-win” options could mitigate up to 40% of their combined energy-related CO<sub>2</sub> emissions per year by 2020. Another 40% could potentially be mitigated by using positive-cost options such as fuel switching from coal to gas and renewable energy in power generation, at a total cost below 1% of GDP.

In the agriculture sector, the region is estimated to have the highest technical potential to sequester carbon. Major mitigation options in agriculture include better land and farm management. These will help reduce non-CO<sub>2</sub> emissions, reverse emissions from land use change, and increase sequestration of carbon in the agro-ecosystem.

**Climate change mitigation is a global public good, and requires a global solution built on common but differentiated responsibility.**

Addressing climate change requires all nations, developed and developing, to work together toward a global solution.

However, there is significant variation among countries in capacity and affordability when undertaking adaptation and mitigation, and climate change and its impact to date are largely the result of past emissions from developed countries. These raise the important issue of equitable division of responsibilities.

An essential component of an effective global solution would, therefore, involve adequate transfers of financial resources and technological know-how from developed to developing countries. Yet, emerging estimates of the additional investment needed for mitigation and adaptation in developing countries suggest that hundreds of billions of dollars per year are needed for several decades to come, far greater than the resources currently committed globally. This is a cause for serious concern.

Global climate change cannot be tackled without the participation of developing countries. In the coming decades, their GHG emissions will grow faster than the developed countries, and the developing countries hold significant potential for cost-effective emissions reductions.

**As a highly vulnerable region with considerable need for adaptation and great potential for mitigation, Southeast Asia should play an important part in a global solution.**

The region has in recent years taken encouraging actions to adapt to climate change impact and to mitigate GHG emissions. Each country in Southeast Asia has developed its own national plan or strategy, established a ministry or agency as the focal point, and implemented many programs supporting adaptation and mitigation. Going forward, the review identifies a number of policy priorities.

*Adaptation.* The priority is to enhance climate change resilience by building adaptive capacity and taking technical and non-technical adaptation measures in climate-sensitive sectors. While at a fundamental level, a country's adaptive capacity depends on its level of development, more effort in raising public awareness, more research to fill knowledge gaps, better coordination across sectors and levels of government, and more financial resources will go a long way toward enhanced adaptive capacity. In the key climate-sensitive sectors, including water resources, agriculture, coastal and marine resources, and forestry, the priority is to scale up action by adopting a more proactive approach and integrating adaptation.

*Mitigation.* While adaptation is hugely important, the region should also make greater mitigation efforts. Low-carbon growth brings significant co-benefits, and the costs of inaction far outweigh the costs of action. Implementation of mitigation measures requires the development of comprehensive policy frameworks, development and availability of low-carbon technology, incentives for private sector action, elimination of market distortions, and significant flows of finance, among other things. Some specific policy recommendations are:

*Forestry sector.* There is a need for strengthening the region's technical and institutional capacities to undertake forest carbon inventories and implement appropriate policies and measures to benefit from future global REDD mechanisms. Countries should also step up efforts to avoid deforestation, to encourage reforestation and afforestation, and to enhance national and local governance systems for sustainable forest management, including monitoring and controlling illegal logging. Since forests are also home to many indigenous communities, policies must be designed to fully recognize and respect their rights and priorities, and ensure their participation in the design and implementation of REDD policies.

*Energy sector.* To promote the adoption of “win-win” mitigation options in Southeast Asia, a priority is to identify and relax the binding constraints on the adoption of these options. These could include information, knowledge, and technology gaps; market and price distortions; policy, regulatory, and behavioral barriers; lack of necessary finance for upfront investment; and other hidden transaction costs. A prominent market distortion in the energy sector in many Southeast Asian countries involves general subsidies for the use of fossil fuels. Governments should work to gradually eliminate such subsidies and provide targeted transfers only for the poor and vulnerable.

*Agriculture sector.* The priority is to reduce emissions through better land and farm management, supported by a combination of market-based programs (taxes on the use of nitrogen fertilizers, and reform of agricultural support policies), regulatory measures (such as limits on the use of nitrogen fertilizers and cross-compliance of agricultural support to environmental objectives), voluntary agreements (such as better farm management practices and labeling of green products), and international programs that support technology transfer in agriculture.

*Funding and technology transfer.* International funding and technology transfers are essential for the success of adaptation and mitigation efforts in Southeast Asia. The region should enhance institutional capacity to make better use of the existing and potential international funding resources. Existing funding sources, albeit inadequate in view of the vast task at hand, provide initial support and can be used as a catalyst for raising cofinancing. Southeast Asia has not yet made full use of these funding sources, and its representation in the global carbon market is still limited. Governments need to facilitate access to these current and potentially available sources through better information dissemination and technical assistance. There is a need to increase the region’s presence in making use of clean development mechanisms (CDM), REDD-related, and other financing mechanisms.

*Regional cooperation.* Because most countries in the region experience similar climate hazards, regional strategies are likely to be more cost-effective than national and subnational actions in dealing with many transboundary issues. These include integrated river basin and water resources management, forest fires, extreme weather events, threatened and shared coastal and marine ecosystems, climate change-induced migration and refugees, as well as regional outbreaks of heat-related diseases, such as dengue and malaria. Regional cooperation is also effective in pursuing some mitigation measures, for example: promoting power trade; using different peak times among neighboring countries to minimize the need for building new generation capacity in each country; developing renewable energy sources; promoting clean energy and technology transfer; and regional benchmarking of clean energy practices and performance. In the longer term, a regional voluntary emissions trading system could also be considered.

*Policy coordination.* Given that climate change is an issue that cuts across all parts of government, there is a need for involving not only environment ministries and related offices, but also economic and finance ministries, and for strong inter-governmental agency policy coordination. There is also a need for putting in place or enhancing central government–local authority coordination mechanisms (such as planning and funding) to encourage local and autonomous adaptation actions, and to strengthen local capacity in planning and implementing initiatives addressing climate change. For effective coordination, there is a strong case for the government agency responsible for formulating and implementing the development plan and strategy to take the lead. Addressing climate change requires leadership at the highest level of government.

*Research.* More research is required to better understand climate change challenges and cost-effective solutions at the local level and to fill knowledge gaps. Despite the emergence of more and more regional and country-specific studies on climate change in Southeast Asia in recent years, knowledge gaps remain huge.

**The current economic crisis provides an opportunity.**

The world is experiencing its worst economic turbulence since the Great Depression of the 1930s, a fact which could make the task of combating climate change more difficult. This is not necessarily the case.

Leaders of the G20 at the 2009 London Summit agreed to make the best possible use of investment funded by fiscal stimulus programs toward the goal of building a resilient, sustainable, and green recovery, and to make the transition toward clean, innovative, resource-efficient, low-carbon technologies and infrastructure.

In Southeast Asia, too, the present crisis offers an opportunity to start the transition toward a climate-resilient and low-carbon economy. Indonesia, Philippines, Singapore, and Thailand are using fiscal stimulus to support domestic demand through tax cuts, investment in infrastructure, and to increase spending on social programs. There may also be scope for building “green investment” programs into such stimulus packages that combine adaptation and mitigation measures with efforts to shore up the economy, create jobs, and reduce poverty.