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**The Economics of Climate Change
in Southeast Asia**

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Abstract

Southeast Asia is one of the world's most vulnerable regions to climate change due to its long coastlines, high concentration of population and economic activity in coastal areas, and heavy reliance on agriculture, natural resources and forestry. Climate change is already affecting the region, as shown by the increasing frequency and intensity of extreme weather events such as heat waves, droughts, floods and tropical cyclones in recent decades.

Based on the modelling work done for this study, under a high emissions scenario, the annual mean temperature in four countries – Indonesia, the Philippines, Thailand and Viet Nam – is projected to rise 4.8°C by 2100 from the 1990 level on average; the global mean sea level is projected to rise by 70 centimetres during the same period, with dire consequences for the region. Southeast Asia is likely to suffer more from climate change than the global average. The mean cost of climate change for the four countries – if the world continues with “business-as-usual” – could, by 2100, be equivalent to losing 6.7 per cent of combined gross domestic product (GDP) each year, more than twice the global average loss. Climate change could seriously hinder Southeast Asia's sustainable development and poverty reduction efforts. Combating climate change requires urgent action in both the areas of adaptation and mitigation – there is no time for delay.

Climate change mitigation is a global public good and requires a global solution that is built on a common but differentiated responsibility. As one of the regions highly vulnerable to climate change, Southeast Asia should play an important part in a global solution. While adaptation is the region's priority, Southeast Asia should also make greater effort at mitigation. This is because low-carbon growth brings significant co-benefits, and the costs of inaction far outweigh the costs of action. Implementation of adaptation and mitigation measures requires the development of a comprehensive policy framework, policy coordination among different ministries, incentives for private sector action, elimination of market distortions and ample financial resources, among others. While international funding and technology transfer are essential for the success of adaptation and mitigation in Southeast Asia, the region should enhance its capacities to make better use of existing and potential funding sources. Furthermore, regional cooperation offers an effective means of dealing with many crossboundary issues, such as water resources management, forest fire prevention, disaster risk management and the control of the outbreak of diseases, and allows for knowledge sharing. Adaptation and mitigation actions will create economic and business opportunities, and will provide new sources of growth. Southeast Asia should seize the opportunity now to start a transition towards a climate-resilient and low-carbon economy.

This Policy Series presents papers in a preliminary form and serves to stimulate comment and discussion. The views expressed are entirely the authors' own and not that of the RSIS Centre for Non-Traditional Security (NTS) Studies. The paper is the result of research conducted under the Asia Security Initiative programme on internal challenges supported by the MacArthur Foundation. Visit www.asicluster3.com to find out more about this initiative. More information on the work of the RSIS Centre for NTS Studies can be found at www.rsis.edu.sg/nts.

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Biographies

Juzhong Zhuang joined the Asian Development Bank (ADB) in 1997 and is currently Deputy Chief Economist of the ADB's Economics and Research Department. His recent research focuses on various development issues in Asia, including growth, poverty and inequality, structural transformation, the economics of climate change and the Chinese economy. He recently edited a number of books on Asian development, including *Diagnosing the Philippine Economy*; *Inclusive Growth toward a Harmonious Society in China*; and *Poverty, Inequality, and Inclusive Growth in Asia: Measurement, Policy Issues, and Country Studies*. From 1992 to 1997, he was a research officer with the Development Economics Research Programme at the London School of Economics, United Kingdom. He holds a PhD in Economics from the University of Manchester, United Kingdom.

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Jindra Nuella Samson is Economics Officer at the ADB. She joined the ADB in 2008 and is currently supporting the Economics and Research Department in climate change research and the implementation of regional technical assistance projects on the economics of climate change and low-carbon growth capacity building. Prior to joining ADB, she worked as an assistant scientist at the International Center for Tropical Agriculture (CIAT) where she conducted research in the fields of agriculture, rural development and participatory research. She graduated from the University of the Philippines with a Master's degree in Environmental Science and a Bachelor's degree in Economics.

I. Introduction

Southeast Asia is one of the most dynamic, fast-growing regions in the world. However, with its long coastlines, high concentration of population and economic activity in coastal areas, reliance on agriculture in providing livelihoods for a large segment of its population, especially those living in poverty, and high 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 fresh water and crop yields, 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.

Responding to climate change means taking both adaptation and mitigation actions. Southeast Asian countries must take measures to adapt to climate change, build resilience and minimise costs due to the unavoidable impacts from climate change caused by greenhouse gas (GHG) emissions. Adaptation is particularly important for poverty eradication in the region. The poor are most vulnerable to climate change impact because they have limited adaptive capacity due to low income and poor access to infrastructure, services and education. While adaptation is a priority for the region, Southeast Asia also has an important role to play in contributing to global GHG mitigation efforts by actively pursuing a low-carbon growth strategy. In 2000, Southeast Asia contributed 12 per cent of the world's GHG emissions, amounting to 5,187 million tons of carbon dioxide equivalent (MtCO₂-eq), an increase of 27 per cent from 1990. This is faster than the global average rate of increase.

The purpose of this paper (which draws on the recent work by the Asian Development Bank; see ADB 2009) is to provide a review of the economics of climate change in Southeast Asia. The paper is organised as follows. Section II looks at climate change and its impact in the context of Southeast Asia, focusing on what has been both observed and projected. Section III reviews adaptation measures that have been adopted by many Southeast Asian countries and identifies the areas where more efforts are needed, focusing on key climate-sensitive sectors including water resources, agriculture, forestry, coastal and marine resources, and health. Section IV examines Southeast Asia's challenges in and options for mitigating GHG emissions. This section will also discuss mitigation potentials of the energy sector in selected Southeast Asian countries, based on the marginal abatement cost (MAC) analysis. Finally, Section V highlights key policy messages.

II. Climate Change and Its Impacts in Southeast Asia

Southeast Asia is considered one of the world's most vulnerable regions to the impact of climate change. It is home to 563 million inhabitants, with population rising by almost 2 per cent annually compared with the 1.4 per cent global average (Table 1). It has long coastlines; high concentration of population and economic activity in coastal areas; heavy reliance on agriculture for livelihoods, especially for those at or below the poverty lines; and high dependence on natural resources and forestry in many countries. As one of the world's most dynamic regions, rapid economic growth in the past few decades has helped lift large numbers of people out of extreme poverty. But the incidence of income and non-income poverty is still high in many countries, and achieving the Millennium Development Goals (MDGs) remains a daunting task. Therefore climate change, if not addressed adequately,

could seriously hinder the region's sustainable development and poverty eradication efforts and, in turn, undermine human security.

Table 1. Selected Economic, Socio-demographic and Environmental Indicators

Indicators	Southeast Asia	Developing Asia ^b	World
Economic and social			
GDP growth, 1990–2007 (% , annual average)	5.5	7.0	2.9
GDP per capita, 2007 (at 2000 constant prices, \$)	4,020.3	3,802.5	5,964.3
Poverty incidence in 2005 (% , headcount ratio)			
Based on \$1.25-a-day	18.8	27.1	25.2
Based on \$2.00-a-day	44.6	54.0	69.4
Total population, 2007 (million)	563.1	3,519.7	6,612.0
Population growth, 1990–2007 (% , annual average)	1.9	1.5	1.4
Population density, 2007 (per square km)	781.5	901.6	51.0
Urban population growth, 2000–2005 (% , annual average)	3.5	2.6	2.1
Share of population within 100 km of coast, 2005 (%)	80.2	34.3	38.0
Employment in agriculture, 2004 (% of total employment)	43.3 ^a	36.8	-
Environment			
Total land area, 2007 (million hectare)	433.0	-	13,013.5
Forest area, 2005 (% of total land area)	46.9	-	30.4
Change in extent of forest area, 1990–2005 (% , annual average)	-1.3	-0.2	-
Length of coastlines ('000 km)	173.3	274.5	1,478.7
Access to improved water sources, 2006 (% of population)	85.2	80.4	86.2
Access to improved sanitation, 2006 (% of population)	71.4	65.3	60.0
Nitrogen use for agriculture, 2005 (ton per hectare)	0.05	-	0.02
Cereal production growth, 1990–2007 (% , annual growth)	2.7	1.9	1.3
Fishery and marine resource production growth, 1990–2007 (% , annual average)	4.7	5.1	2.4
Forest production growth, 1990–2007 (% , annual average)			
Industrial roundwood (cubic meter)	-1.3	-0.6	0.1
Paper and paperboard (ton)	11.7	8.8	2.8
Pulp and paper (ton)	15.2	4.5	0.8

- = data not available; \$ = in US dollars; % = percentage, km = kilometre

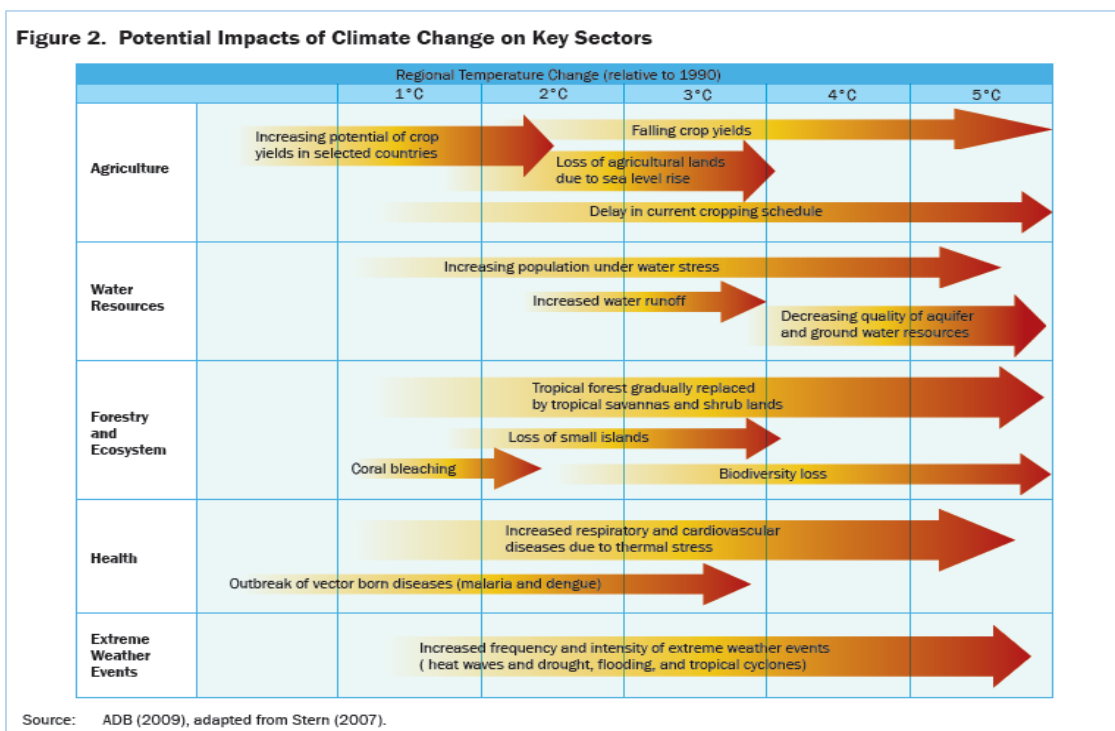
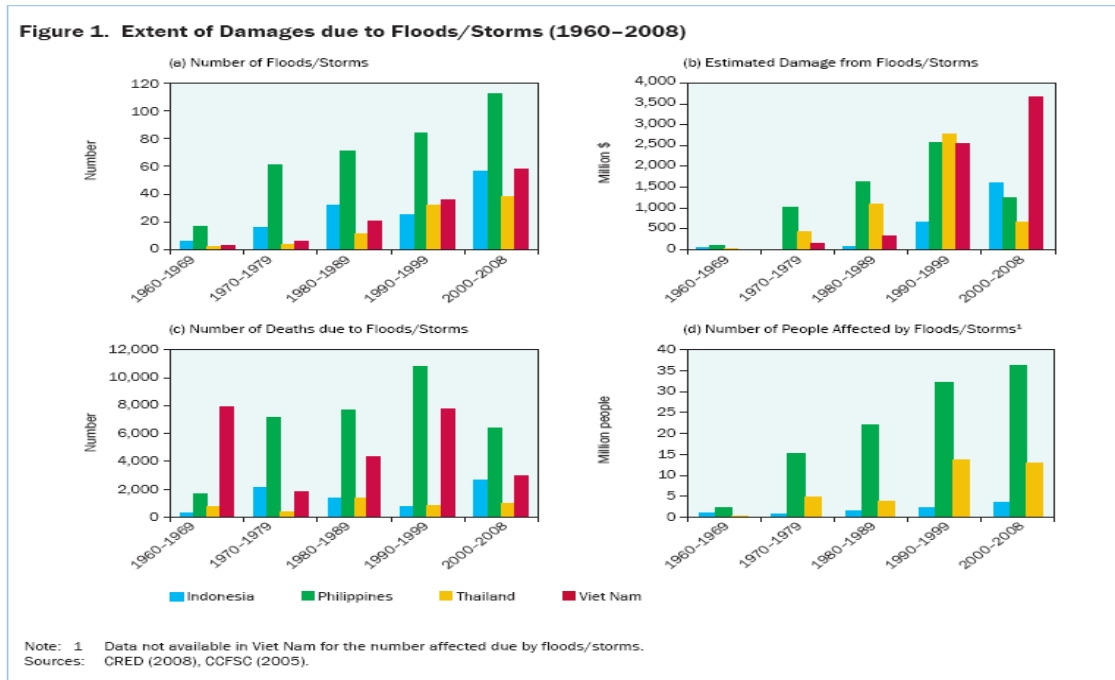
Notes: ^a This excludes Brunei Darussalam, Cambodia, Lao PDR and Myanmar.

^b Asian Development Bank's Developing Member Countries

Sources: World Bank's World Development Indicators online database; World Bank (2008); FAOSTAT (2008); FAO (2006); UNEP (2006).

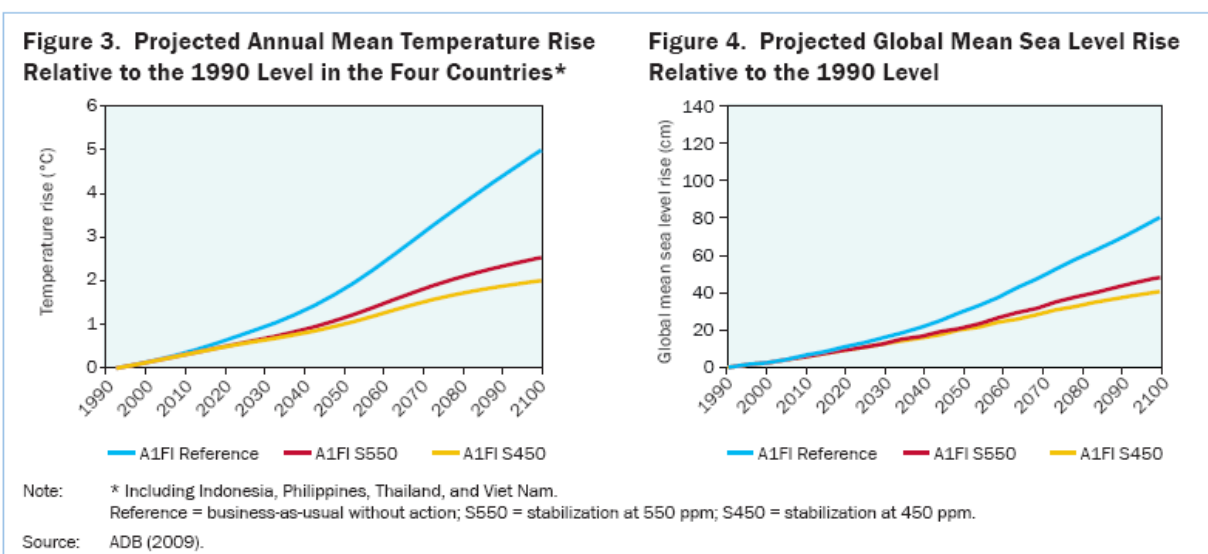
Climate change is already evident in the region. The frequency and intensity of extreme weather events have also increased in recent decades. This includes more heat waves, a significant increase in the number of heavy precipitation events and an increase in the number of tropical cyclones. These climatic changes have led to massive flooding, landslides and droughts in many parts of the region, causing extensive damage to property, assets and human life (Figure 1). Climate change is also exacerbating the problem of water

shortages in many parts of the region, constraining agricultural production and threatening food security, causing forest fires and degradation, damaging coastal and marine resources, and increasing the risk of outbreaks of infectious diseases. Figure 2 illustrates the potential impact of climate change on key sectors.



Climate change in Southeast Asia is projected to intensify in the coming decades, with an associated rise in the frequency and intensity of extreme weather events. Modelling work commissioned under a recent Asian Development Bank (ADB) study using a global integrated assessment model (IAM)¹ and focusing on four countries – Indonesia, the Philippines, Thailand, and Viet Nam – shows that, under a high emissions scenario:²

- The four countries' annual mean temperature is projected to rise by 4.8°C on average by 2100 from the 1990 level. The western part of Southeast Asia is predicted to become hotter than the eastern part. Global mitigation efforts to stabilise atmospheric concentration of GHGs at 550 parts-per-million (ppm) would reduce the four countries' annual mean temperature increase to 2.3°C, and at 450 ppm to 1.8°C by 2100 (Figure 3).
- Indonesia, Thailand and Viet Nam are projected to experience increasingly drier weather conditions in the next two to three decades, although this trend is projected to reverse by the middle of this century, with 2100 likely to exhibit higher precipitation than the 1990 level. The Philippines, however, is projected to experience an increase in precipitation for most of this century.
- The global mean sea level is projected to rise by 70 centimetres (cm) by the end of this century relative to the 1990 level (Figure 4). With global GHG stabilised at between 450 and 550 ppm, however, the global mean sea level is projected to rise by around 40 cm by the year 2100 relative to the 1990 level.

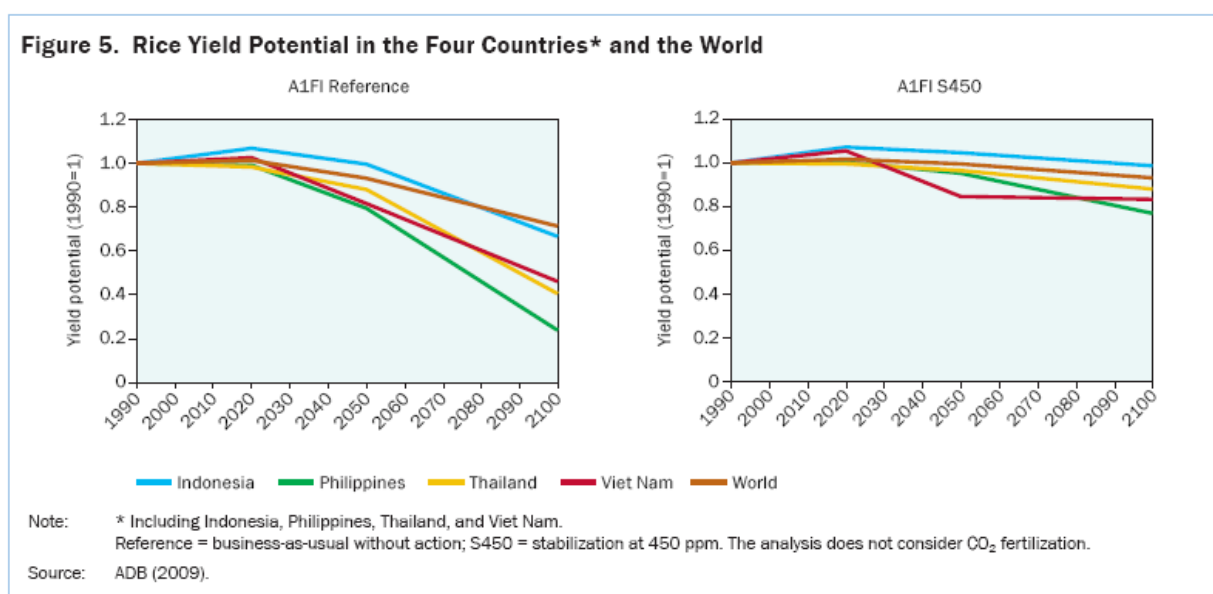


¹ This model was developed by the Research Institute of Innovative Technology for the Earth (RITE), Japan.

² The ADB study (see ADB 2009) acknowledges that estimating precisely how climate change would evolve is subject to considerable uncertainty, and cautions that results presented should be considered indications of direction and orders of magnitude rather than forecasts of the future.

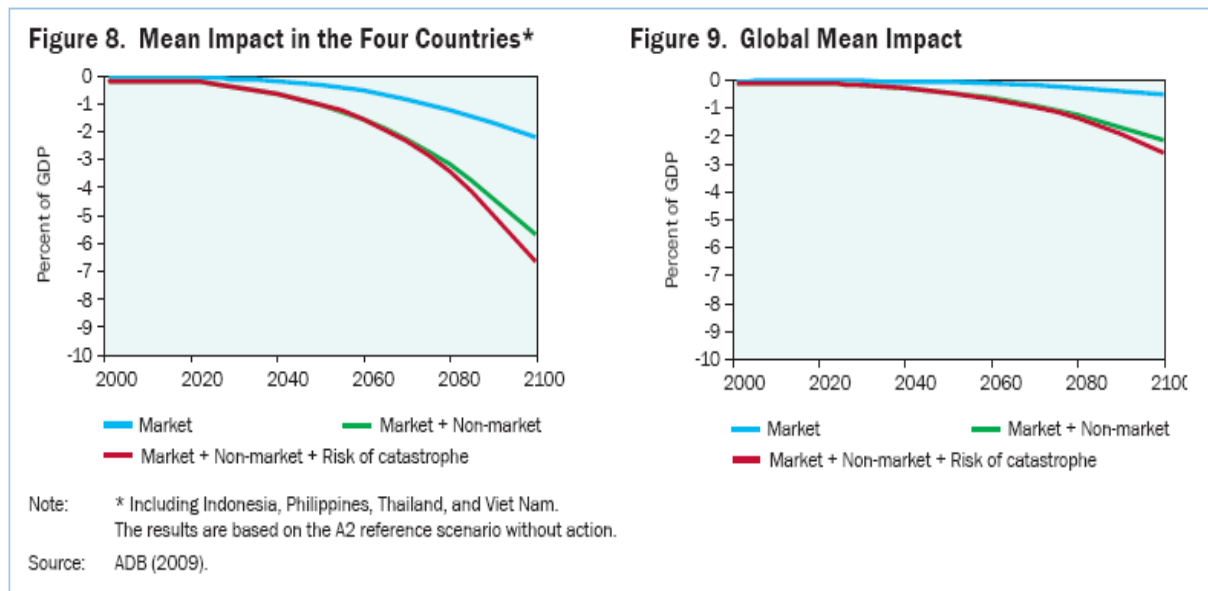
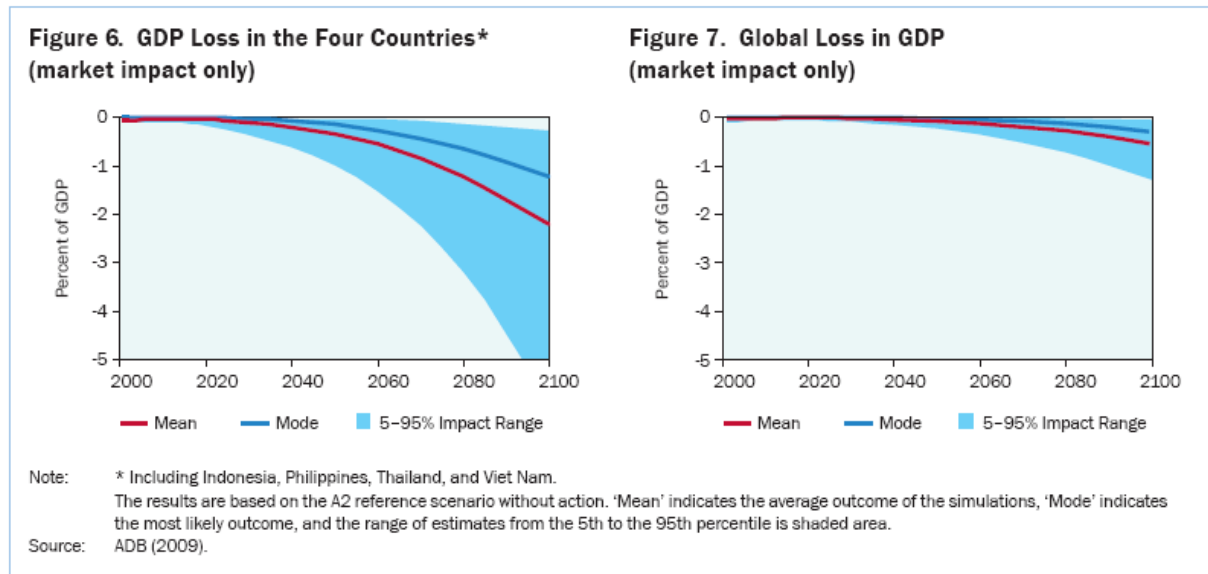
The modelling results also show that the predicted climate change is likely to have significant impact on economic and human activities in the four countries in the coming decades:

- *Water Resources.* Global warming is likely to worsen water stress in some parts of the region, particularly in Thailand and Viet Nam in the coming decades. About 3.9 million people in Thailand and 8.4 million in Viet Nam are projected to experience water stress by 2050.
- *Agriculture.* The four countries are projected to experience a potential fall in rice yield of about 50 per cent by 2100 relative to the 1990 level on average, assuming no adaptation and no technical improvement. The rice yield decline would range from 34 per cent in Indonesia to 75 per cent in the Philippines, and is projected to start in 2020 for most countries (Figure 5). However, stabilisation efforts could prevent this decline.
- *Forestry.* The change in biome distribution in terms of loss of high quality forests is projected to lead to significant biodiversity loss. A large part of the dominant tropical evergreen, semi-deciduous, and deciduous forest/woodland – all with high carbon sequestration potential – is projected to be replaced by tropical savanna and tropical xerophytic shrub lands that have low or no carbon sequestration potential.
- *Human health.* Climate change is also likely to lead to more deaths from cardiovascular and respiratory diseases due to thermal stress and from vector-borne infectious diseases (malaria and dengue) in the four countries in the coming decades.

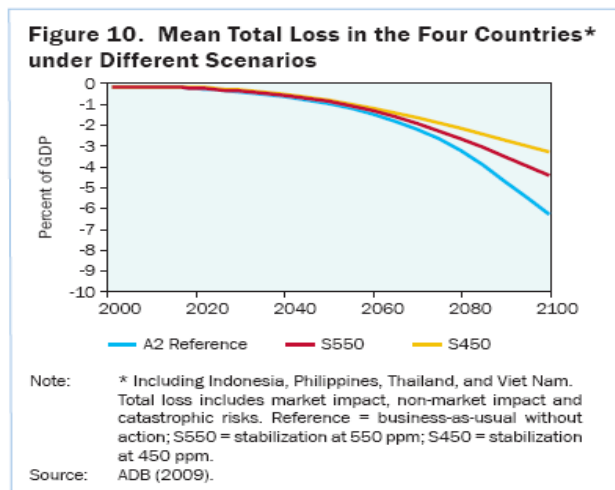


The ADB study also estimated the economy-wide cost of climate change for the four countries using the PAGE2002 Model described in Hope (2006). The results show that, for these countries as a whole, while the economy-wide cost of climate change without global mitigation efforts is relatively low in the medium term, it rises significantly thereafter. By the end of this century, the economy-wide cost each year on average could reach 2.2 per cent of

gross domestic product (GDP) if only market impact is considered; 5.7 per cent of GDP if non-market impact is included; and 6.7 per cent of GDP when catastrophic risks are also taken into account (Figures 6 and 8). These figures are much higher than the global averages (Figures 7 and 9). This is because the four countries have relatively long coastlines, high concentration of population in coastal areas, high dependence on the agriculture and natural resources sectors, relatively low adaptive capacity, and a mostly tropical climate, compared to the rest of the world. With GHG stabilisation at 450–550 ppm³ the economy-wide cost due to global warming would be significantly lower, suggesting that the cost of no action, and hence, the benefits of action could be very significant for the four countries (Figure 10).



³ This represents the range of the GHG concentration level consistent with the 2–3°C temperature increase from the pre-industrial level.



III. Climate Change Adaptation to Enhance Resilience

Adaptation involves adjustments in natural or human systems in response to actual or expected climate change impacts to reduce harm or exploit beneficial opportunities. Adaptation reduces vulnerability and increases the resilience of ecosystems, economies, communities and individuals. It helps to reduce the risks associated with climate change and is now widely recognised as an equally important and complementary response to GHG mitigation. It also offers an opportunity to adjust economic activity in vulnerable sectors and to support sustainable development and poverty reduction. Adaptation, therefore, should be a vital part of Southeast Asian countries' response to a problem that will disproportionately affect the poor.

Adaptation action is taken by individuals, households, communities, businesses and governments. Many actions are taken autonomously by private actors in reaction to actual or expected climate change without policy interventions and are known as "autonomous" adaptation. Other actions, "planned" or "policy-driven" adaptation, are taken as a result of deliberate policy decisions. Adaptation can also be "reactive" or "proactive", the former in response to actual climate change impact and the latter to anticipated climate change. Adaptation can be understood on two broad levels – building national and local adaptive capacity and delivering specific adaptation actions.

A. *Building adaptive capacity*

Building adaptive capacity involves creating conditions – regulatory, institutional, managerial and financial – needed to support adaptation actions. While building a country's adaptive capacity requires the effort of all segments of society, the government has a particularly important role in putting in place an effective policy and institutional framework, filling information and knowledge gaps, creating the right incentives and allocating adequate public resources for adaptation. Efforts made by Southeast Asian countries to enhance adaptive capacity have been encouraging, but much more is needed. Further strengthening of adaptive capacity in Southeast Asia requires mainstreaming climate change adaptation in development planning. Some of the immediate priorities for Southeast Asian countries in mainstreaming climate change adaptation identified by the ADB study are:

- Stepping up efforts in raising public awareness of climate change and its impact, with a view to building consensus for public action and engaging all stakeholders including households, businesses, government agencies, non-governmental organisations (NGOs), civil society and development partners in combating climate change.
- Undertaking more research to better understand: (i) climate change, its impact and adaptation needs at local levels; (ii) cost-effective technical and non-technical solutions that focus on the natural systems (water resources, agricultural production, forestry, coastal and marine resources and others); and (iii) sound adaptation practices and strategies beyond the natural systems (migration, social protection mechanisms, livelihoods of small-scale farmers and fishermen, and governance of adaptation at all levels).
- Stepping up efforts in information and knowledge dissemination.
- Putting in place or enhancing inter-ministerial coordination and planning mechanisms to promote multi-sector approaches to climate change adaptation, including linking climate change adaptation with disaster risk management. Given that climate change is an issue that cuts across all parts of the government – not only environment ministries and related offices, but also economic and finance ministries, and so on – it may be more effective if the coordination is led by the government agency responsible for formulating and implementing a country's development plan and strategy.
- Putting in place or enhancing central government-local authority coordination, planning, and funding mechanisms, to encourage local and autonomous adaptation actions, and to strengthen local capacity in planning and implementing adaptation initiatives.
- Adopting a more holistic approach to building the adaptive capacity of vulnerable groups and localities and their resilience to shocks, including developing their capacity to diversify local economies, livelihoods and coping strategies beyond tackling the natural systems.

At a more fundamental level, a country's adaptive capacity depends on its economic, social and human development, which are closely related to levels of income, inequality, poverty, literacy and regional disparity; capacity and governance of public institutions and public finance; availability or adequacy of public services including education, health, social protection and social safety nets; and capacity of economic diversification, especially at the local level. In all these aspects, there are wide variations across Southeast Asian countries and significant gaps between Southeast Asia as a whole and the developed world. Eliminating these gaps by keeping growth strong and making development sustainable and inclusive will go a long way toward improving Southeast Asia's adaptive capacity.

B. Sector-specific adaptation practices and options

Adaptation actions have been taken in a number of key sectors where climate change impact is most visible or damaging in Southeast Asia, including water resources, agriculture, forestry, coastal and marine resources, and health. These actions, however, are mostly reactive, rather than proactive; in many cases, their implementation is scattered rather than systematic, and isolated rather than integrated; and measures often offer short-term benefits, rather than long-term solutions. Southeast Asia needs a more proactive, systematic and integrated approach to adaptation in many key sectors that is cost-effective and offers durable and long-term solutions.

Adaptation inherently suffers from several market failures. The market failures arise because of uncertain information associated with large-scale and long-term investment such as climate proofing of buildings and defensive infrastructure; the positive spillover and the public goods nature of certain adaptive measures such as research and coastal protection; and the need for coordination among multiple stakeholders. As a result, private markets and autonomous actions alone will not lead to adequate adaptation. Many adaptation measures need to be driven by public policy and government interventions. Measures that have been practised in Southeast Asia and other areas for scaling up in the key sectors reviewed are described below.

- In the water resources sector, to improve the water shortage situation, Southeast Asian countries have used both supply- and demand-side measures, including rain harvesting technologies, improved irrigation facilities, training in the efficient use of water, reclamation of brown water and better water management practices. These practices should be scaled up, and experience and lessons should be better shared among communities within each locality, region, country and among countries in the region. Integrated water management, including flood control and prevention schemes, early warning systems, irrigation improvement and demand-side management should be applied more widely to capture multiple benefits.
- In the agriculture sector, the most commonly used adaptive measures in the region are adjustments to cropping calendars and patterns, changes in management and farming techniques, use of drought-resistant varieties, diversified farming, intercropping, and crop rotation among others. Farm-level adaptation practices are helpful in coping with climate variability, but there is a need for government to strengthen local adaptive capacity by providing public goods and services, such as better climate information and improved impact assessment, research and development on heat-resistant crop varieties, early warning systems, and water-efficient irrigation systems and other techniques. Innovative risk-sharing instruments for the agriculture sector such as index-based insurance schemes are being developed and tried in Southeast Asia, and the experience and expertise of the private sector should be brought in to complement public sector efforts.
- In the forestry sector, common adaptation practices include reforestation, afforestation, and improved forest management; the establishment of early warning networks; the use of appropriate silvicultural practices; awareness-raising on forest fire prevention; and monitoring of degraded forests. Early warning systems and awareness-raising programmes should be enhanced to assist vulnerable communities to better prepare for potentially more frequent forest fires as a result of

climate change. Furthermore, aggressive public-private partnerships for reforestation and afforestation should be pursued to offset forest and biodiversity losses due to the adverse effects of climate change and extreme climatic events.

- In the coastal and marine resources sector, common adaptation practices include: mangrove conservation and plantation; strengthening and reinforcing existing revetments, dikes and sea walls; relocation of aquaculture farms and coastal infrastructure; improved (and in some cases adaptive) design and standards for construction of houses and industrial areas; provision of information and awareness-raising programmes; monitoring of sea level rise; pumping to relieve flooding; and preparation of hazard and vulnerability maps. The implementation of these adaptation measures in the region is still scattered, and there is a need for integrated coastal zone management plans that take into account future climate risks and vulnerabilities. Mangrove and coral reef conservation and planting are highly effective at reducing the impact of tropical storms and cyclones; these practices have to be sustained. The co-benefits⁴ from these are substantial in terms of ecosystem services and human livelihoods.
- In the health sector, a number of reactive adaptation measures exist, including rebuilding and maintaining public health infrastructure, coordination with relevant organisations, and establishing green and clean areas. However, a more proactive approach, which includes measures such as the establishment of early warning systems for disease outbreaks, health surveillance, awareness-raising campaigns and infectious disease control programmes, has to be adopted or extended to better deal with the health impacts of climate change.

V. Climate Change Mitigation to Contribute to a Global Solution

While adaptation is Southeast Asia's priority, the region also has an important role to play in contributing to global GHG mitigation efforts by actively pursuing a low-carbon growth strategy. In 2000, it contributed 12 per cent of the world's GHG emissions, amounting to 5,187 MtCO₂-eq (Table 2), an increase of 27 per cent from 1990. This is faster than the global average rate of increase. The land use change and forestry (LUCF) sector was the biggest source of GHG emissions from the region in 2000, contributing 75 per cent of the total. The other two key sources are the energy sector at 15 per cent and the agriculture sector at 8 per cent. In 1990–2000, among the three sources, emissions from the energy sector increased at the fastest pace. Indonesia is the largest source of GHG emissions in Southeast Asia, mainly due to LUCF emissions (Figure 11).

⁴ Co-benefits refer to the by-products of policies or measures that are implemented. For example, a mangrove restoration and rehabilitation project to address climate change impacts in coastal areas also provides other benefits including carbon sequestration, ecosystem services, recreation values, etc. Another example is GHG mitigation measures in the energy sector that typically result in reduced air pollution and a more secure energy system.

Table 2. Global GHG Emissions by Sector in 2000 (MtCO₂-eq)

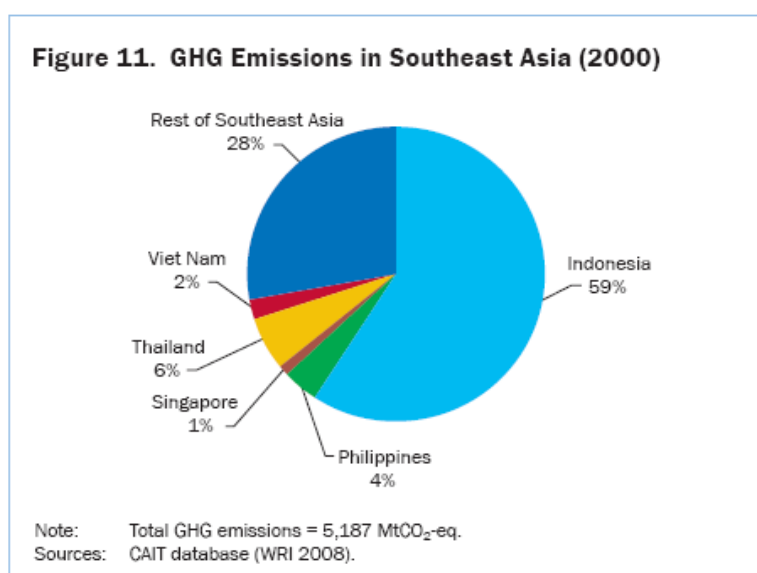
	Southeast Asia	Non-Annex 1 Countries ^a	Annex 1 Countries ^b	World
Energy	791.8	9,503.9	14,728.2	26,980.4
Industrial process	50.8	722.9	628.6	1,369.4
Agriculture	407.0	3,484.2	1,445.8	5,729.3
Land use change and forestry	3,861.0	7,887.0	-274.0	7,618.6
Waste	76.6	695.4	473.4	1,360.5
Total emissions	5,187.2	22,293.4	17,001.9	43,058.2
Per capita emissions	9.3	4.4	12.5	6.1

Notes:

^a Non-Annex 1 parties are mostly developing countries. Certain groups of developing countries are recognised by the convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures.

^b Annex 1 parties include the industrialised countries that were members of the Organisation for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition (the EIT parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

Source: CAIT database (WRI 2008).

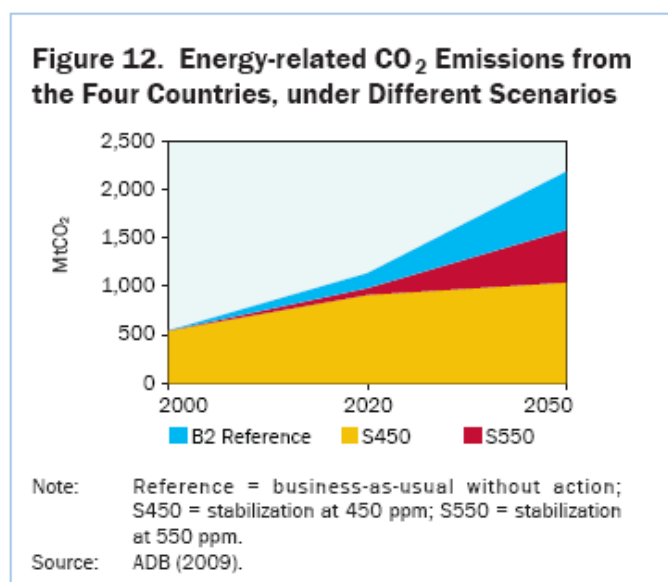


Southeast Asia's forestry sector holds the key to successful emissions reduction in the region. Major mitigation measures for the forestry sector include reducing emissions from deforestation and forest degradation (REDD); promoting afforestation and reforestation; improving forest management to increase stand- and landscape-level carbon density; and increasing off-site carbon stocks in wood products and enhancing product and fuel substitution. In the case of mitigation through afforestation and reforestation, a review of existing studies by the Intergovernmental Panel on Climate Change (IPCC, 2007) indicates that, at a carbon price up to US\$20 per ton carbon dioxide (tCO₂), Southeast Asia is likely to have the potential to mitigate about 300 million tons of carbon dioxide (MtCO₂) per year by 2040. Increasing the carbon price up to US\$100 per tCO₂ would increase the potential to

875 MtCO₂ per year. Efforts by Southeast Asian countries at implementing these measures have, in recent years, been encouraging but they need to do more.

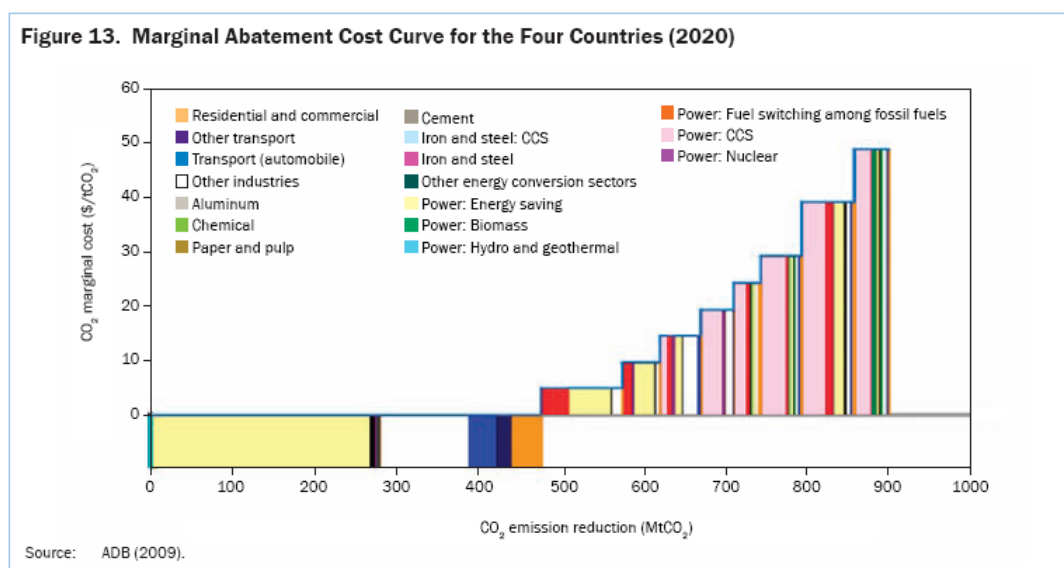
Although Southeast Asian countries together contributed about 3 per cent of global energy-related CO₂ emissions in 2000 (from the CAIT database in WRI 2008), this share is expected to rise in the future, with their relatively higher pace of economic and population growth compared to the rest of the world. The implementation of mitigation measures in the energy sector in these countries could therefore also contribute to global CO₂ stabilisation efforts in the coming decades. Many options also bring significant co-benefits, as explained earlier.

Energy modelling commissioned under the ADB (2009) study finds that under a medium emissions scenario (represented as the B2 reference scenario in the model), without mitigation actions, the four countries – Indonesia, Philippines, Thailand and Viet Nam – are likely to rely heavily on oil and coal as primary energy sources, with coal for power generation. This is due to their relatively low costs when environmental externalities are not considered. CO₂ emissions under this scenario are projected to increase by four times, or 3 per cent per year, in the period 2000–2050 (Figure 12).



With participation in global stabilisation efforts at 450–550 ppm, the four countries as a whole are projected to shift from coal and oil toward natural gas and renewable energy sources; to shift from coal-based power generation to cleaner fuels such as natural gas and renewable energy sources; and to shift from the currently dominant gasoline powered vehicles to cleaner fuels and innovative low-carbon vehicles such as different types of hybrid-electric vehicles. The modelling work also finds that there would be significant potential for energy-related CO₂ reduction in the four countries in the coming decades. The total emissions reduction potential at a carbon price of up to US\$50 is projected to be 903 MtCO₂, equivalent to 79 per cent of these countries' total energy-related CO₂ emissions in 2020 under a medium emissions scenario. More than half of this, about 475 MtCO₂, could be

achieved by win-win mitigation options that reduce CO₂ and at the same time bring in net cost savings (Figure 13).⁵



The win-win options are largely energy efficiency improvement measures, including energy savings in the existing coal and gas power plants for the power generation sector; diffusion of high-efficiency technologies for the energy-intensive industries; use of improved fuel-efficient, internal combustion engine vehicles and bio-ethanol for the transport sector; and adoption of various high-efficiency electrical appliances for the residential sector. It is estimated that another half of the mitigation potential could be achieved at a positive abatement cost up to US\$50 per tCO₂, and realisation of this potential would require an investment of up to US\$9.5 billion – about 0.9 per cent of the four countries’ GDP in 2020.

Also, Southeast Asia has the highest technical potential in the world to sequester carbon in agriculture. Smith et al. (2007) reported that the potential for emissions reductions from using all technically feasible practices and covering all GHGs (carbon dioxide, methane, nitrous oxide, carbon monoxide, and others) ranges from 550 to 1,300 MtCO₂-eq per year for Southeast Asia by 2030, the highest among all the regions in the world. Major mitigation options in agriculture are improved crop and grazing land management; restoration of organic soils (including peatland) that have been drained for crop production, and restoration of degraded lands; livestock management; manure and bio-solid management; and bio-energy use (IPCC 2007). Mitigation in agriculture has significant co-benefits, including better local environmental quality and improved food security, which are important factors in enhancing social resilience to the impacts of climate change.

⁵ The analysis considers only financial costs and does not take into account transaction costs and adoption barriers, such as incomplete information, high up-front investment cost, people’s behaviour, social/cultural norms, etc. These barriers are important reasons why many of the win-win options are not being adopted.

V. Policy Implications

Southeast Asia is projected to suffer more from the impact of climate change in the years to come, with the impact likely to be worse than the global average. If not adequately addressed, climate change could seriously hinder the region's sustainable development and poverty eradication efforts. Climate change is the most significant market failure the world has ever witnessed. Like any market failure, it can only be resolved through the intervention of public policy. However, government interventions alone are not enough. Successfully tackling climate change problems requires the participation and action of all stakeholders, including households, firms, individuals, NGOs and civil society. Further, as a global public good, addressing climate change requires all nations in the world, developed and developing, to work together on a global solution.

Large income gaps in different parts of the world imply that there are significant variations among countries in capacity and affordability when undertaking adaptation and mitigation. Further, the observed climate change and its impact are largely a result of past emissions from developed countries. These considerations raise the important issue of equitable division of responsibilities. Developing countries need to be aware that without adequate global effort in reducing GHG emissions, their prospects of income growth and poverty reduction would be under serious threat. Developed countries should also recognise the legitimate need of developing countries to narrow the income gap between them and the developed world, and appreciate their desire to ensure that addressing the climate change challenge does not come at the cost of slower development.

An essential component of an effective global solution would, therefore, involve adequate transfer of financial resources and technological know-how from developed to developing countries. Estimates of financing needs for climate change mitigation and adaptation vary widely, reflecting the uncertainties associated with potential climate change scenarios and their likely impact. However, emerging estimates of the additional investment needed for mitigation and adaptation in developing countries indicate a financial gap of hundreds of billions of dollars per year for several decades to come. This is far greater than the resources that have been committed or established as part of international financing mechanisms such as the World Bank's Climate Investment Fund, the Global Environment Facility (GEF), the Clean Development Mechanism (CDM) established under the Kyoto Protocol, and various regional and bilateral mechanisms. This is a cause for serious concern.

The past few years have witnessed the emergence of a consensus on the urgency of addressing climate change. The 15th Conference of the Parties (COP15) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Copenhagen in December 2009 was the culmination of two years of intense negotiations that had been launched with the Bali Action Plan adopted at COP13 in December 2007. At COP15, the parties "took note" of the Copenhagen Accord, a set of political decisions that brought forward the core elements of the Bali Action Plan and embraced a goal to limit temperature rise below 2°C. The Accord addressed mitigation (including REDD-plus⁶), adaptation, technology development and transfer, capacity building and financial assistance. Perhaps the most important decision is related to financing in support of developing countries'

⁶ "REDD-plus" refers to reducing emissions from deforestation and forest degradation, as well as forest conservation, the sustainable management of forests and the enhancement of forest carbon stocks.

actions. This included a collective commitment by developed countries for US\$30 billion in additional resources during 2010–2012; the goal of mobilising US\$100 billion per year in public and private finance by 2020; and the establishment of a Copenhagen Green Climate Fund. Although the Accord is not a legally binding instrument, it paves the way for closing the financial gap and a fuller agreement in Mexico in late 2010.

What should Southeast Asia do? The actions taken by Southeast Asia in recent years to adapt to climate change impact and to mitigate GHG emissions have been encouraging. Each country in Southeast Asia has developed its own national plan or strategy for climate change, established a ministry or agency as the focal point to deal with climate change and its impact, and implemented many programmes supporting adaptation and mitigation activities. The following are the priorities for climate change adaptation and mitigation actions in the years to come.

(i) Adaptation toward enhanced climate resilience

Southeast Asia should continue efforts to enhance climate change resilience by building adaptive capacity and taking technical and non-technical adaptation measures in climate-sensitive sectors. Strengthening adaptive capacity also requires mainstreaming climate change adaptation in development planning. This means that adaptation should be considered as an integral part of sustainable development and poverty reduction strategies. In this context, the ADB (2009) study identified some immediate priorities: (a) stepping up efforts to raise public awareness of climate change and its impact; (b) undertaking more research to better understand climate change, its impact and solutions, especially at local levels, and stepping up efforts in information and knowledge dissemination; (c) enhancing policy and planning coordination across ministries and different levels of government for climate change adaptation, including linking climate change adaptation with disaster risk management; (d) adopting a more holistic approach to building the adaptive capacity of vulnerable groups and localities and their resilience to shocks, including developing their capability to diversify local economies, livelihoods and coping strategies beyond tackling the natural systems; and (e) 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.

Many sectors have adaptation needs but water, agriculture, forestry, coastal and marine resources, and health require particular attention. Adaptation action has been taken in a number of key sectors where climate change impacts are most visible or damaging in Southeast Asia. But adaptation inherently suffers from several market failures. These arise because of uncertain information associated with large-scale and long-term investment such as climate proofing of buildings and defensive infrastructure; the positive spillover and the public goods nature of certain adaptation measures such as research and coastal protection; and the need for coordination among multiple stakeholders. As a result, private markets and autonomous actions alone will not lead to an adequate level of adaptation. Many measures need to be driven by public policy and government interventions.

(ii) Mitigation toward a low-carbon economy

The forestry sector, as Southeast Asia's largest contributor to GHG emissions, is critical to the successful reduction of such emissions. Major mitigation measures for the forestry sector include maintaining or increasing forest areas through REDD; afforestation and reforestation; and improving forest management. Reducing and/or preventing deforestation is the mitigating option with the largest and most immediate carbon stock impact. Since REDD also provides significant sustainable development co-benefits, Southeast Asian countries should address the causes of deforestation relevant to their own national circumstances. The creation of global financial mechanisms that are effective, predictable, sustainable, performance-based and supported by diversified resources – including market and non-market mechanisms – is an urgent priority for REDD. In order to benefit from a future global REDD mechanism, the region's technical and institutional capacities to undertake forest carbon inventories and implement appropriate forest policies and measures should be strengthened.

Southeast Asian countries should also step up efforts in reforestation and afforestation, and enhance national and local governance systems for sustainable forest management. The latter requires policy reforms appropriate to national and local circumstances, such as monitoring and controlling illegal logging, increased government rent capture for forest concessions, lengthened concession cycles and tenure security, and enhanced competition for access to concessions. Since forests are also home to many indigenous communities, policies must be designed to fully recognise and respect their rights and priorities, and ensure their participation in the design and implementation of REDD policies.

Mitigation in the energy sector should start with win-win options with which GHG emission reductions can be achieved at a relatively low cost or even a negative net cost. There are many win-win mitigation options available in Southeast Asia, with cost savings from mitigation exceeding expenses. Energy efficiency improvement measures fall in this category. A policy priority is to identify the binding constraints on the adoption of these options. Such binding constraints could include information, knowledge and technology gaps; market and price distortions; policy, regulatory and behavioural barriers; lack of necessary finance for upfront investment; and other hidden transaction costs. A thorough review of these possible constraints is needed in order to eliminate them. A prominent market distortion in the energy sector in many Southeast Asian countries involves general subsidies for the use of fossil fuels. Governments should gradually reduce general fuel subsidies and target the programmes only to the poor and vulnerable.

Given its rapid economic and population growth, Southeast Asia's energy demand is likely to continue to expand, and new sources of energy supply will have to be developed in the longer term. With the support of existing international funding and technology transfer and cooperation mechanisms, and those to be agreed on in the near future, Southeast Asian countries should step up their efforts at developing and switching to clean, renewable and low-carbon energy sources as well as clean and sustainable transport. Southeast Asia should join the global effort in moving toward a low-carbon economy.

Southeast Asia is estimated to have the highest technical potential to sequester carbon in agriculture in the world. Measures for reducing GHG emissions from the agriculture sector could be explored through a combination of market-based programmes, regulatory measures, voluntary agreements and international programmes. Examples of market-based

programmes are taxes on the use of nitrogen fertilisers and reform of agricultural support policies. Regulatory measures could include limits on the use of nitrogen fertilisers and cross-compliance of agricultural support to environmental objectives. Voluntary agreements on better farm management practices could be promoted, alongside labelling of green products. International programmes could support technology transfer in agriculture.

(iii) Funding, technology transfer and international/regional cooperation

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 create enabling environments in order to make better use of 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 co-financing. Southeast Asia has not yet made full use of these funding sources, and the region's share 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 use of CDM, REDD-related, and other financing mechanisms.

Technology needs vary greatly within and across Southeast Asian countries. The international climate regime will need to do more to facilitate the transfer of technologies that have been identified, while key performance indicators for transfer of low-carbon technologies should be developed. A regional framework should also be established to support south-south technical cooperation and information sharing among neighbouring countries in Southeast Asia, as it is likely easier to apply mitigation and adaptation measures adopted by neighbouring countries that successfully utilise locally available materials and traditional environmental management skills. Opportunities for technological leapfrogging, especially in the energy, infrastructure and waste management sectors, should be effectively explored.

In the longer term there is also a need to explore innovative forms of financing, such as risk-sharing instruments like catastrophe bonds, weather derivatives and micro-insurance index-based schemes through partnerships involving the private sector. A regional financial facility for supporting adaptation initiatives along the same lines as the International Finance Facility for Immunisation (IFFIm) could be considered.⁷ Private investment in the form of venture capital and mutual funds focusing on low-carbon and energy efficiency technologies could also play a role in funding adaptation and mitigation.

Many climate change issues can be better addressed through regional cooperation. Such cooperation could effectively address some climate change mitigation challenges by, for example, promoting power trade using different peak times among neighbouring countries to minimise the need to build new generation capacity in each country; developing renewable energy sources; as well as promoting clean energy and technology transfer, and regional benchmarking of clean energy practices and performance. Regional cooperation also has an important role to play in promoting good policies and practices, sharing information and knowledge on issues such as disaster management, and promoting and undertaking climate-related research and development in the region. It can also contribute significantly to

⁷ For more on the IFFIm as an example of financial facilities, see <http://www.iff-immunisation.org/>.

the development of regional climate scenarios and models to monitor and evaluate the impact of climate change.

(iv) Strengthening government policy coordination

Given that the climate change issue cuts across all parts of the government, there is a need for strong inter-ministerial policy coordination. Such coordination is critical for the effective implementation of any adaptation and mitigation policy. For example, if an environment ministry plans to raise the tax on petrol as part of an overall climate change strategy, this proposal should have full government backing and not be blocked by a ministry which, for example, is concerned about the objections of automobile producers. In the case of adaptation, there is a strong case for linking initiatives with disaster risk management. There is also a need to put in place or enhance central government-local authority coordination, planning and funding mechanisms to encourage local and autonomous adaptation actions, and to strengthen local capacity in planning and implementing adaptation initiatives. For effective coordination, there is a strong case for the government agency responsible for formulating and implementing a country's development plan and strategy to take the lead.

(v) Undertaking more research on climate change-related issues

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. There is an urgent need to undertake more research in the region to better understand the following: (a) climate change and its impact, risks and vulnerability, adaptation needs and mitigation potential at local levels; (ii) cost-effective technical and non-technical adaptive solutions in key climate-sensitive sectors including water resources, agriculture production, forestry, and coastal and marine resources, such as optimal cultivation and cropping patterns, heat-resistant crop variety, sound practices in forestry management and early warning systems for extreme weather events; (c) sound adaptation practices and strategies for dealing with issues beyond the natural systems, such as migration, social protection mechanisms, livelihoods of small-scale farmers and fishermen, and the governance of adaptation at all levels; and (d) cost-effective mitigation measures, in particular, those win-win options, and policy, institutional, behavioural and technological constraints to their adoption.

In conclusion, ADB (2009) confirms that Southeast Asia is already suffering from the impacts of the changing climate. If not adequately addressed, future climate change could seriously hinder the region's sustainable development and poverty eradication efforts. Combating climate change requires a global solution built on a common but differentiated responsibility. Given the high stakes, Southeast Asia should play an important part in working towards such global action.

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