POLICY RESPONSES TO CLIMATE CHANGE IN SOUTHEAST ASIA

Ferenc L. Toth
International Institute for Applied Systems Analysis, Laxenburg, Austria

RR-93-8
May 1993

Reprinted from *The Regions and Global Warming: Impacts and Response Strategies*

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
Laxenburg, Austria

Research Reports, which record research conducted at IIASA, are independently reviewed before publication. Views or opinions expressed herein do not necessarily represent those of the Institute, its National Member Organizations, or other organizations supporting the work.

Reprinted with permission from *The Regions and Global Warming: Impacts and Response Strategies*, 1992, J. Schmandt and J. Clarkson, eds., Oxford University Press, New York, NY, USA.

Printed by Novographic, Vienna, Austria.

Foreword

Energy-related emissions of greenhouse gases (GHGs), and especially of carbon dioxide (CO_2), are an important cause of increasing concerns about global warming and environmental change. In general, these concerns reflect a growing search for longer-term environmental security and sustainability of human development, within the energy community, in policy circles, and among the public at large. Mitigation and adaptation strategies in response to global environmental change need to be formulated at both global and regional levels. IIASA's Environmentally Compatible Energy Strategies (ECS) Project has been concerned with several aspects of these strategies. Research activities focus on the mitigation of energy-related sources of GHG emissions and on the assessment of impacts of and adaptation to global warming.

The costs of mitigation measures and their contributions to arrest global warming are addressed in most research studies that deal with energy and global change. Conversely, there is great uncertainty about the impacts of anthropogenic causes of global warming, possible adaptation measures, and their associated costs. There are indeed very few studies on the comparative assessment of mitigation and adaptation costs or on the potential benefits of policy responses intended to arrest global warming or enable adaptation to it.

Results summarized in this paper are related to the work on the assessment of impacts of and response strategies to global warming within the ECS Project. One important conclusion of the IIASA workshop on "Costs, Impacts, and Possible Benefits of CO_2 Mitigation" held in September 1992 was that a lot more studies will have to be conducted at the national and regional scales on the biophysical, social, and economic impacts of climate change. These studies are necessary to produce more reliable damage assessments and thus to quantify the benefits of various greenhouse gas mitigation measures.

This paper summarizes the findings of the study conducted in Southeast Asia that was organized and financially supported by the United Nations Environment Programme. It made use of various IIASA research results, such as various methods of climate impact assessment, and the policy exercise approach to synthesize results and assist policy formulation. The results of the study provide a valuable contribution to the increasing knowledge about the regional impacts of and possible adaptation strategies to global climate change.

NEBOJŠA NAKIĆENOVIĆ
Leader
Environmentally Compatible Energy Strategies Project

Preface

As evidence has accumulated over the past few years to support the theory that increasing concentrations of greenhouse gases in the atmosphere would lead to climate change, a large number of scientific and policy-oriented studies were initiated to explore the potential impacts of that change, as well as possible human responses to it. In the final account, all response strategies can be classified into two groups: prevention and adaptation. If the atmosphere is considered as a global common property resource, successful strategies to decrease future emissions of greenhouse gases will emerge from fierce international negotiations, hard bargaining, increased and/or redirected economic aid, technology transfer, and other side payments among groups of countries at different levels of economic development, with varying degrees of risk due to climate change, and with profoundly different assets and capabilities for adapting to it. Adaptation strategies, on the other hand, would be formulated and implemented at the local and regional levels and could be properly coordinated by national governments.

Given the present magnitude of uncertainties about future emissions and atmospheric concentrations of various greenhouse gases, about the sensitivity of global climate to them, and, especially, about the actual patterns of local and regional climate change, governments need to assess the potential range of socio-economic impacts in their jurisdictions in order to establish their positions at the formal international negotiations on abatement and to appropriately balance their own resources between adaptive and preventive measures.

This paper presents an overview of and summarizes the general conclusions from a UNEP project conducted in Southeast Asia to identify socio-economic impacts of and policy responses to climate change. A series of agricultural crops, river basins, and coastal areas were selected in order to study the biophysical impacts, which were then traced through to the most heavily affected economic activities and social groups. Policy exercises were conducted in Malaysia and Indonesia to present the results to senior policy makers responsible for strategic planning in relevant government agencies and to engage them in formulating possible response strategies.

The policy exercises linked the potential regional impacts of climate change to long-term and complex social and economic problems, to ongoing and planned large-scale development programs, and to long-term objectives for overall socio-economic development. These linkages provided a series of "no-regret" adaptation strategies that would provide generally agreed social, economic, and environmental benefits even if current predictions of climate change and regional impacts turned out to be highly overestimated.

Related publications

Toth, F.L., 1992, Policy Implications, pp. 109–121 in M.L. Parry, M. Blantran de Rozari, A.L. Chong, and S. Panich, eds., *The Potential Socio-Economic Effects of Climate Change in South-East Asia*, United Nations Environment Programme, Nairobi, Kenya.

Toth, F.L., 1992, Global Change and the Cross-Cultural Transfer of Policy Games, pp. 208–215 in D. Crookall and K. Arai, eds., *Global Interdependence*, Springer, Tokyo, Japan.

19. POLICY RESPONSES TO CLIMATE CHANGE IN SOUTHEAST ASIA

Ferenc L. Toth

The culmination of five years of intensive and widespread research efforts on climate change, the Villach Conference (WMO, 1986) called for studies to look at regional impacts of climate change in more detail and to analyze possible policy responses based on regional impact assessments. One response by the UNEP was the project on "Socioeconomic impacts and policy responses resulting from climate change: A study in Southeast Asia" (hereafter called the "Southeast Asia study" or simply "this study") involving three National Study Groups (NSGs) assembled under the leadership of a designated government agency in Indonesia, Malaysia, and Thailand; a core group of consultants headed by Prof. Martin Parry of the University of Birmingham (U.K.); and UNEP's Regional Office for Asia and the Pacific (ROAP) in a coordinating role. The project was concluded at the end of 1990 and the results published by UNEP in 1991.

This chapter draws on results of the project, but cannot be considered even an incomplete summary of the findings. In fact, the analysis presented here is one level of generalization higher, as the author seeks to present what are believed more general conclusions that can be derived from the project in the overall context of the greenhouse policy debate. Still, the focus is regional and the support material was generated in the Southeast Asia study.

Organization of the Chapter

Our analysis begins with a short overview of the most relevant economic and environmental concerns in the region so as to set the stage for the discussion of policy issues in the second half of the chapter. The section titled "Sensitive Areas" explains the social and economic importance of the areas selected for the impact assessments. It is followed by a short description of how regional scenarios of climate change were developed for the study. The next three sections provide an overview of the assessment techniques that were used to prepare the first- and higher-order impact assessments and to generate the policy responses. These sections also present a few examples of the potential impacts and policy responses. The final section is a succinct summary of some of the "general lessons" concluded from the study.

Socioeconomic Profile of the Study Region

The three countries participating in the study (Indonesia, Malaysia, and Thailand) belong to one of the most dynamic regions of the world. While the world in general could only achieve an average annual economic growth rate of 3 percent in the 1980s, the Asia-Pacific region grew 7 percent, more than three times as fast as the 2 percent average of the developing world as a whole. (Selected basic indicators are summarized in Table 19.1.)

This impressive economic performance was not without a price. Many countries in the region, including those participating in this study, achieved a considerable share of their economic growth by supplying an increasing quantity of raw materials to industries in the developed world and, thus, depleting their natural resources. The other major source of growth—industrial development—has also left its mark on the environment in these countries, as is evident from the air and water pollution, and the exhaustion of both renewable and nonrenewable natural resources. The result is that the region has become a significant contributor to global environmental change, including climate change.

TABLE 19.1. *General Indicators of the Three Countries in the UNEP Study*

	Indonesia	Malaysia	Thailand
Area, 1,000 km^2	1,905	330	514
Population, million (mid 1987)	171.4	16.5	53.6
Population density (per/km^2) (mid 1987)	90	50	104
Average annual growth rate, % (1980-87)	2.1	2.7	2.0
Projected avg. annual growth rate, % (1987-2000)	1.7	2.2	1.5
GNP per capita (U.S.$,1987)	450	1810	850
GDP growth rate (1980-87)	3.6	4.5	5.6

Source: World Bank (1989).

According to recent estimates, the CO_2 emissions from industrial sources in both South Asia and Southeast Asia amounted to 166 million metric tons, that is 3 percent of the world total in 1985 (WRI, 1988). Table 19.2 presents CO_2 emission data from industrial and commercial energy sources in the three study countries. The actual figures are much higher due to high ratios of non commercial energy use in the region. Greenhouse gas emissions from paddy fields and deforestation are also significant contributions to the global emission figures.

While the dynamics of growth are similar in the three countries, they represent markedly different stages of economic development. According to the World Bank classification, Indonesia (GNP per capita in 1987, $450) belongs to the group of low-income economies, while Thailand ($850) and Malaysia ($1,810) are in the lower-middle-income group, in the bottom half and close to the top, respectively. Despite a variety of problems in both the domestic and the world economy, each country has shown an impressive performance through the 1980s. Moreover, each country is fighting a different set of social, economic, and environmental problems with varying degrees of success. The differences in current levels of development and the diversity of other current problems create very different social and political climates that have to be taken into account when addressing issues characterized by lengthy time scales and significant uncertainty.

Sensitive Areas

Numerous studies have been conducted worldwide over the past few years to assess the impacts of climate change on various ecological, natural resource systems, and social systems (Kates *et al.*, 1985; Parry *et al.*, 1988). The geographical scales of these studies range from small regions of a few thousand hectares of agricultural land, important

TABLE 19.2. *Carbon Dioxide Emissions From Fossil Fuel Consumption and Cement Production*

	Indonesia		Malaysia		Thailand	
	Total	Per capita	Total	Per capita	Total	Per capita
1970	8.072	0.067	3.876	0.357	4.190	0.115
1980	20.810	0.137	6.699	0.487	10.921	0.235
1986	28.127	0.165	9.205	0.578	13.522	0.259

Source: Marland *et al.* (1989).
Note: Total in million metric tons of carbon, per capita in metric tons.

river basins, or short stretches of coast (see the case studies in Glantz, 1988) through larger regions up to global-scale studies (Prentice *et al.*, 1989). Based on a preliminary assessment of possible climatic vulnerabilities in Southeast Asia, this study focused on three major impact areas: agriculture, river basins, and coastal areas.

Virtually any form of agriculture is sensitive to longer-term changes and shorter term fluctuations in climate attributes. The most important climate component and the tolerable magnitude of change varies from crop to crop and also depends on the genetic characteristics of the varieties. Agriculture has traditionally been an important sector of the Malaysian, Indonesian, and Thai economies. The most important policy-related concerns over the impacts of climate change on agricultural development can be presented as three major issues:

1. National food self-sufficiency is a strategic political issue considered to be part of the overall national security. In Malaysia the 1988 level of self-sufficiency in rice production was 72 percent, exceeding the Fifth Malaysia Plan expectation of 55 percent to 60 percent (EPU, 1989, p. 137). Currently this is considered to be the desired minimum level of domestic rice production that should be maintained over the longer term. Indonesia has reached self-sufficiency in rice relatively recently; therefore, the current five-year plan points out: "Efforts to increase food crop production, covering rice and non-rice, are to be carried out to consolidate the country's food self-sufficiency achievements" (BAPPENAS, 1989, p. 44).
2. Contribution of agriculture to GNP and exports is an important economic concern in each of the three countries. The contribution of agriculture to GNP in 1986-1988 averaged 22 percent in Malaysia, 26 percent in Indonesia, and 16 percent in Thailand.
3. Employment and earnings provided by agriculture continue to be of strong social concern in these countries. Although the contribution of agriculture to GNP is only about 22 percent in Malaysia, the sector provides employment for one third of the labor force. These ratios are similar in the other two countries. As the process of industrialization is expected to continue in the region over the coming decades, the share of agriculture in GNP and employment will gradually decline. However, the decline in agriculture related employment has been much slower than the decrease in the sector's contribution to GNP and exports. Therefore, the long-term prospects in agriculture as a source of income for a significant fraction of the population requires special attention.

The NSGs selected a set of crops to analyze the impacts of climate change on agriculture. Rice is the only crop that was selected by each group. It is the major staple food in the region; hence, it is a strategic crop in achieving or preserving national food self-sufficiency targets over the long term. At the pre-interviews in preparation for the policy analysis component of the study, senior officials of the Economic Planning Unit (EPU) and the Department of Agriculture in Malaysia, and of equivalent government agencies in the other two countries, expressed strong concerns over the potential impacts of climate change on paddy production and on the economic conditions of the affected social groups.

Climate-induced changes in precipitation regimes and evapotranspiration rates are expected to create stresses in the management of water resources. Early studies on possible impacts of climate change have identified the importance of water resources and management as a key impact and response area (Revelle and Waggoner, 1983). Many parts of the study region are characterized by changes in dry and wet seasons. Therefore, a thorough assessment of the impacts of floods, droughts, water quantity and water availability constituted an important part of the project.

Coastal areas in the participating countries are usually important. The most fertile agricultural lands are located in the coastal regions, together with aquaculture and coastal fisheries. Coastal areas support high densities of population and have a long history as centers of infrastructure, settlements, defense, transportation, and other considerations. The rapid increase in beachfront tourism has added further to their economic importance. The length of coastline as a single indicator shows the potential threats from sea-level rise in these countries: Indonesia, 54,716 km; Malaysia, 4,675 km; Thailand, 3,219 km (WRI, 1988, p. 327).

Scenarios of Climate Change

The starting point for studying impacts of climate change is one or more forecasts of the most important climate attributes, typically as the result of a scenario in which the CO_2 concentration doubles. The most advanced climate simulation models, the three-dimensional General Circulation Models (GCMs), are generally agreed to perform relatively well at predicting changes in global mean values of climate parameters at annual or seasonal levels. Detailed (weekly or daily) predictions of climate change at the regional level are much more difficult, and their reliability is admittedly much lower. In addition, forecasting changes in the local climate in Southeast Asia is complicated by a series of human activities (deforestation, changes in land use) that interact with the global climate system and also significantly affect the local climate.

Given all these problems related to forecasting regional climate under double CO_2 conditions, the only sensible strategy in a policy oriented research would be to use a series of scenarios of climate change, assess their impacts, formulate possible policy responses, then compare and analyze them with a view to which strategies are expected to work under a range of plausible scenarios. Detailed scenarios of climate change for the region were prepared by Amos Eddy (Panturat and Eddy, 1989; Eddy *et al.*, 1989).

The input data sets used in this project included three monthly GCM output (GISS, GFDL, OSU); the United Nations Development Programme (UNDP) ASEAN monthly meteorological archives of the three countries (UNDP, 1982); and the daily values of maximum and minimum temperatures, as well as 24-hour precipitation data, from the meteorological station network in each of the three countries. The daily climate scenarios for a 25-year period were produced for the individual project sites as follows (Eddy *et al.*, 1989). The monthly GCM model output data were used in the form of ratios, and they were interpolated to the station location from the four surrounding GCM grid point values using bilinear interpolation. The resulting 12 monthly long-term mean ratios for temperature and for precipitation were interpolated to produce 366 daily ratios. In the final step, the 25-year historical record of daily data was modified using the 366 daily ratios, the GISS daily, GFDL daily, and OSU daily climate scenarios under double CO_2 conditions. Additional scenarios have also been developed to reflect the special climatic characteristics of the region (the El Nino Southern Oscillation) or special concerns proposed for analysis (increasing variability of precipitation as a result of climate change).

These scenarios were supposed to be used as inputs to plant process models for selected crops in each country. One clear deficiency of the national studies was that only one scenario was actually used to simulate crop yield responses. This fact has imposed severe limitations on the assessment of higher-order impacts as well as on the policy implications (see section titled "Policy Responses").

Most analyses carried out by the NSGs were based on the GISS GCM results. The Malay and Thai experts have actually developed daily scenarios for the double CO_2 conditions based on the procedures described above for use with the crop process simulation models. Monthly scenarios were used for crop studies in Indonesia and the river basin studies in Malaysia and Indonesia.

First-Order Impacts

Detailed results of the biophysical impact assessments conducted in the three nations are documented in the project report published by the UNEP. This section presents a few selected examples of first order impacts of climate change to support the discussions of socioeconomic impacts and policy responses.

Rice production

The CERES RICE model, Version 2.00 (Godwin and Singh, 1989), was used by expert teams in Malaysia and Thailand to study the impacts of climate change on rice production (the Indonesian team used different approaches, as outlined below). The model provides a daily time-step simulation of crop growth and development based on four classes of input data: climate, soil, plant genetics and cultural practices. Daily climate data for double CO_2 conditions were generated from the GISS model output according to the procedure described in the previous section. Data on soils, plant genetics, and cultural practices were obtained directly from regional and local agricultural agencies.

In Malaysia, the area selected for the study was the Muda region, the country's rice bowl, on the coastal plains of peninsular Malaysia, in the states of Kedah and Perlis. The area has a long tradition of rice cultivation and a large-scale irrigation project has been implemented in several phases since 1965 to provide irrigation, drainage, and other facilities for double-cropping of rice. The annual production is about 700,000 tons of rice from two harvests a year. That is more than 60 percent of the national total.

Detailed results of the modelling effort are presented in a report prepared by members of the NSG (Salim *et al.*, 1989). The rice model was calibrated for the region by 16 model runs using historical climate data and different combinations of main or off-season crops, transplanted or direct seeding methods, irrigation or rainfed options, and fertilized or unfertilized cultivations. The next eight runs simulated the impacts of double CO_2 conditions on the crop using a GISS-based climate data set for the combinations listed above. The maturity period was shorter by up to 10 days for the main season crop. As a result, the average reduction in grain yield was estimated to decline by 12 percent to 22 percent for both transplanted and direct seeded rice. The overall average reduction in grain yields was about 19 percent, while the variance of crop yields under double CO_2 conditions was higher for the main season crop than for the off-season crop. The Malay analysts reported problems related to handling the impacts of plant water availability in the RICE model, but they estimated that irrigation demand would be 15 percent to 20 percent higher under the GISS scenario.

In Thailand, two studies were conducted to estimate the impacts of climate change on rice production. The first study was carried out by members of the core team of consultants, together with local collaborators, and focused on upland rice in northern Thailand (Eddy *et al.*, 1989, Panturat and Eddy, 1989).[1] The second study was conducted by the Thai NSG and selected a typical lowland rice region in central Thailand (Thai NSG, 1990).

The study area for upland rice was the province of Chiang Mai, northern Thailand. The analytical procedure was the same as the one described above for the Muda region, but the model was the upland version of the CERES RICE model (Version 1.10, Ritchie 1988). The model was calibrated for the base climate series of 25 years of daily data for two soil types, and combinations of fertilized versus nonfertilized, irrigated versus nonirrigated crops. The results show that yields would decline under all management variations by 4 percent to 14 percent, but in most cases this would be offset by the direct fertilization effect of higher atmospheric CO_2 availability to the plants (Eddy *et al.*, 1989, p. 61). The exact impacts of higher CO_2 availability are, however, subject of a major debate, so the modelling results should be treated with care.

Results of the same group from their experiments with the lowland rice model (CERES RICE V 2.00) show a 15 percent to 20 percent decrease in lowland rice yields for both rainfed and irrigated crops, while the irrigation demand is 15 percent to 20 percent higher under the GISS double CO_2 climate. Their results also confirm that "the practice of transplanting from seed beds produced a higher average yield than does the direct seeding practice for both rainfed and irrigated strategies under both climate scenarios" (Eddy *et al.*, 1989, p. 64).

The above results seem to contradict those produced by the Thai NSG in their study of impacts of climate change on rice yields in Ayutthaya province, central Thailand (Thai NSG, 1990). This group also used the lowland version of the CERES RICE model and a daily scenario of climate change based on the GISS model. The analyses included two soils series, five rice varieties, transplanting versus direct seeding, and fertilized versus nonfertilized practices. The group's conclusion is that "if CO_2 was to be doubled in the next 30 to 40 years, rice culture in Ayutthaya Province, in general, would benefit from such a change, except for some

[1] See Chapter 11 by S. Panturat and A. Eddy.

varieties. The average 25-year yields increase up to 8 percent. The benefits, in most cases, would be very marginal, however. The average per year change is insignificant" (Thai NSG, 1990, pp. 11-12). This conclusion holds for both the main season and off-season crops. The latter is grown only in the lowland irrigated areas and full irrigation is assumed.

Sharp contradictions are common in the climate change and climate impact literature, but the Thai lowland case is a unique example. We have at least one plausible explanation, however. Authors of the NSG report readily admit flaws in their analyses: The absolute values of yield from past climate and the GISS scenarios are not consistent with general observation because the modelled yields of transplanted rice are much higher than the observed yields, whereas they are much lower for direct seeded rice than the observed values. "Such a high fluctuation and inconsistency is mostly due to the model itself. Normally, any model to be used in a particular area should be validated by field data and observation. This has not been done for the Thai case" (Thai NSG, 1990, p. 10).

Because of the difficulties in creating the climate scenarios at the level of detail required by the CERES model and the problems of obtaining other necessary data, the Indonesian group used an empirical/statistical approach and an ecophysiological process model to assess impacts of climate change on rice yields. Based on results from an earlier study in Indonesia, the report concludes that rice yields in the January-June season will decrease by an average of 2.5 percent, but this will be offset by the average increase of 5.4 percent for the July-December crop (Blantran de Rozari *et al.*, 1990, p. 33). The results suggest that the direct impact of climate change on rice yields will be fairly limited. As we demonstrate later, there are major threats to agricultural production in Indonesia coming from other sources.

Impact assessments of climate change on yields of other crops and plantations were conducted in each country. These studies relied on a variety of assessment techniques from simple empirical-statistical approaches to complex process models. The crops included maize (Malaysia and Indonesia), soybean (Indonesia), and rubber and palm oil (Malaysia). These efforts, however, did not provide the level of detail and sophistication presented in the rice studies above.

River Basins

Possible impacts of climate change on the water resource regimes are of major concern in Southeast Asia, especially in regions with a marked difference between wet and dry seasons. One general conclusion from the GCM results is that under double CO_2 conditions the wet seasons would bring more precipitation, while the dry season would aggravate existing water stresses through several months. This will bring additional challenges for the government agencies and institutions responsible for water management.

The Malaysian NSG selected the Kelantan River Basin in the northeastern part of peninsular Malaysia to analyze the impacts of climate change on water resources. The annual rainfall in the Kelantan region is high (2,200 to 3,000 mm), up to 50 percent falling in the monsoon months of October to December. The result is severe floods in the wet season. "In a major flood such as that experienced in 1967, 300,000 hectares (or some 20 percent of the total state area) were inundated, 540,000 residents were affected, of which 125,000 had to be evacuated, 30 lives were lost, and flood damage to public property was estimated to be over M$30 million" (Lim and Salmah, 1989, p. 4). The shortage of water in the dry season affects agriculture, hydropower generation, and industrial and residential water supplies.

The Malaysian experts used the Storage Function Model to assess the impact of climate change on flooding, and the Thornthwaite and Mather Water Balance Model to calculate the changing balance of inflows and outflows. Both models were properly calibrated for present climate using historical data, then the climate parameters were modified based on the GISS GCM results.

The first-order impact assessment found an increase in both flood peaks and duration in the Kelantan River Basin. While the increase in flood duration is not significant, the increase in peak discharges would be approximately 9 percent, resulting in a larger overbank spill and more widespread flooding. In terms of flood recurrence, this means that a

30-year return period flood under double CO_2 conditions would have similar impacts as a 50-year return period flood under present climate. The water resource study, on the other hand, concluded that water deficits in the dry season would increase by 30 percent to 35 percent. This would seriously exacerbate the present water supply conditions because the amount of water available, especially for irrigation, is already at a critical level.

The Indonesian NSG also used the Thornthwaite and Mather model to assess impacts of climate change on water resources in three river basins: Upper Citarum in West Java, Upper Brantas in East Java, and the Upper Saddan River Basin in Southwest Sulawesi. The focus of their study was the impact of increasing monthly average rainfall (by 7 percent to 33 percent in the Citarum, 5 percent to 50 percent in the Brantas, and 8 percent to 59 percent in the Saddan Basin) and increasing temperature (1 percent throughout the regions) on seasonal soil water deficits and surpluses in these areas. The results show that soil water deficits will decrease in all three basins (and completely disappear in the Saddan Basin), with dramatic increases in soil water surplus in all regions. Unfortunately, the NSG did not investigate the impacts of the increasing runoff on flooding.

Coastal Areas

The impacts of climate-change-induced sea-level rise (SLR) in coastal areas of Southeast Asia would involve complex processes associated with shoreline retreat, permanent or temporary inundation, coastal erosion, increased flooding, and increased saline intrusion inland. Forecasts of the rate and magnitude of SLR are subject to considerable debate in the scientific community, but the potential threats were deemed serious enough to call for an assessment of possible impacts in this study.

The Malaysian NSG selected the area covered by the West Johor Agricultural Development Project in the southern part of peninsular Malaysia to study the impacts of SLR (Zamali and Lee, 1989). The area includes some 150,000 ha of agricultural land behind an almost continuous stretch of mangrove-fringed muddy shoreline. The group identified increasing coastal erosion as the most severe impact of rising sea level that will further aggravate the already ongoing processes of coastal erosion. Increased tidal flooding resulting from higher sea level may inundate about 16 percent (20,000 ha) of agricultural land in the project area and approximately 1,000 km^2 of fertile agricultural land along the west coast of peninsular Malaysia. Associated increases in backwater flooding are expected to prolong flood duration in the upland areas, resulting in lower crop yields. Theoretically, the mangrove forests could migrate landward, driven by a gradual increase in sea level. But the hinterland areas are already developed, leaving the mangroves threatened by extensive drowning. Increasing saline intrusion will threaten water abstraction facilities. Depending on the topographical, geological, hydrological, and other properties at specific locations, these four processes (erosion, flooding, mangrove loss, and saline intrusion) will produce a variety of complex dynamic processes with far-reaching impacts on other ecological systems and socioeconomic activities in the region.

The Indonesian NSG selected the lower Citarum Basin (Bekasi, Krawang and Subang districts in West Java) as their study site for SLR (Blantran de Rozari *et al.*, 1990). Unlike the Malaysian NSG, this group attempted only to identify the area in the low-lying coastal plain that would be inundated by elevated sea. The coastal area in the three districts is characterized by a 2.5-km to 4-km wide belt of brackish-water fish ponds, while the area behind that belt is mainly wet rice fields. The current practice of aquaculture in the region is to construct fish or prawn ponds 0.5 m above the level of lowest tide. This means that as a result of a 0.6-m SLR, all the ponds will be inundated at normal tides, and the paddy fields and other agricultural areas behind it will also be seriously affected.

Higher Order Impacts

The previous section presented a few examples that were generated by the NSGs and the core team to assess first-order impacts of climate change on selected, valued, environmental components and resource systems. The direct impacts on biophysical processes (temperature, precipitation, runoff, flood return periods, saline intrusion in coastal areas and many others) are of little interest to policymakers who are concerned with shorter- or longer-term development of the economic sectors or specific regions for which they are responsible. Even the more sensitive issues like decreasing yields or inundated coastal areas are of limited policy relevance, unless we demonstrate the effects of first-order impacts on the most directly affected economic activities and social groups. Thus, analyses of economic and social consequences of first-order impacts are essential for preparing a complete assessment of risks and threats caused by climate change, as well as for providing the necessary inputs to the policy response component of the study.

Despite the large number of studies conducted to assess regional impacts of climate change, no generally accepted methodological blueprint exists for preparing the assessments of economic and social impacts. The NSGs followed the author's proposal to use a bottom-up approach. Based on the biophysical impacts generated in the first phase of the project and an inventory of economic activities in the study region, subsets of heavily affected and/or economically important activities were selected. The next step was analysis of the biophysical impacts on economic performance, identification of the most vulnerable social groups affected by these changes, and identification of potential economic and social conflicts arising from the changing natural resource and economic conditions.

Rice Production

The economic impact assessment started with an analysis of current distribution of farms by size and tenure group; the economic performance (e.g., net cash returns) of farms; the technological options available and economically feasible to different types of farms; and the most characteristic trends, longer-term changes in these attributes. The next step was the assessment of economic performance of various types and sizes of farms under the changing input/output conditions due to double CO_2 climate. Which farms would survive under double CO_2 climate? What are their options to adapt to the changing conditions? Which current trends in land ownership and tenure point toward conditions better adapted to double CO_2 climate? How would the biophysical and the resulting microeconomic changes affect the national food self-sufficiency and food security objectives?

The Malaysian study (Salim *et al.*, 1989) identified two major first-order impacts in the Muda region. First, the average reduction in grain yield was estimated to be between 12 percent and 22 percent for both transplanted and direct-seeded rice. The overall average reduction in grain yield is expected to be around 19 percent (decreasing output). Second, average irrigation demand is estimated to increase by 15 percent, with transplanted rice showing a smaller increase in irrigation demand than direct seeded rice (increasing input).

The impact of 12 percent to 22 percent reduction in yield will seriously affect the total net income of paddy farmers. With a lower total production, the amount of rice they can sell will decline and this will decrease the amount of cash subsidy they get from the government when they sell their produce. The situation will be exacerbated by the increasing demand for irrigation. It will not only increase production costs, but can limit the double-cropping of rice to a much smaller area due to the constraints in the amount of water available for irrigation in the dry season. At the national scale the result is that the present target of 60 percent rice self-sufficiency set by the Malaysian government will not only be threatened by decreasing yields, but also by decreasing area of double-cropping in the most fertile region of the country.

Earlier in this chapter it was pointed out that the overall economic importance of paddy is relatively small in terms of its contribution to agriculture value added, but that it is a major staple food, and therefore a strategic crop with respect to national food self-sufficiency. Yet, there seem to be problems with the paddy production. It has shown significant fluctuations over the past five years and declined by almost 10 percent between 1985 and 1990 (from 1,826 thousand tons to 1,665 thousand tons). The decline in the cultivated area was less dramatic, only 3.4 percent in the same period (from 661,400 to 638,700 ha), but the implications are likely to be more dramatic than suggested by these figures.

One long-term trend in land ownership in general, and paddy production in particular, is the joint ownership, subdivision, and fragmentation of peasant landholdings (Sundaram, 1988). Surveys conducted in the study region in 1976 and 1980 show that the average farm size decreased from 5.6 relongs to 4.22 relongs (Soon, 1983). This is far below the officially determined optimum two-cultivator peasant family farm size. The trend of land fragmentation is likely to continue because of the practice of Islamic and *adat* inheritance systems. The most typical solution to increased farm size is tenancy. While these arrangements clearly produce solutions to the farm size problem for some farmers, the number of people earning their living off the paddy is decreasing. Parallel to this process is the trend of land accumulated by a relatively small, well-to-do group. Concentration of land ownership and the spread of tenancy clearly point toward a capitalist type of agricultural management with larger land areas operated as a single unit employing wage laborers.

Climate change will affect these processes in several ways. First, the projected increase in input requirements and decrease in output will have the worst impact on the small farmers whose agricultural income has been insufficient, even under present conditions. In addition, deteriorating economics of paddy farming is likely to pull better-off farmers, operating somewhat larger farms, back under the poverty line. Paddy farmers constitute the largest group in terms of poverty incidence in Malaysia. In 1987 50.2 percent of paddy farmers were under the poverty line in peninsular Malaysia, 79.4 percent in Sabah, and 56.2 percent in Sarawak (EPU, 1989, pp. 52-53). Thus, impacts of climate change are likely to speed up the already ongoing processes of land fragmentation to below the economically feasible size, with a resulting land abandonment and land concentration.

The process involves both challenges and opportunities for the development of macro-scale social and economic policies in general, and agricultural policies in particular. To begin with the latter, both land concentration and increasing farm size, together with the shift from landlord-tenant to landlord-wage laborer relationship, are likely to increase the efficiency of paddy production. This has been an important objective in the previous Malaysia plan and is expected to be even more important for the Second Outline Perspective Plan (SOPP) as the nation moves from an extensive to an intensive development path. On the negative side, still related to the agricultural policy, what are the options for those who become landless? With increasing farm sizes, mechanization will accelerate, displacing wage laborers. The demand for wage laborers will increase far slower than the rate of increase in (land-)free agricultural labor. In addition, to operate the technology requires skilled workers, not very typical of the social strata becoming landless.

In the context of broader social and economic policy issues, we might consider another possibility for the landless: moving to urban areas, where the fast rate of growth in the industrial and service sectors will need a new labor force. One problem here is whether the rate of savings, capital formation, and investments will be able to keep up with the speed of transition in the rural areas. The other is how fast these people can be trained so that they can qualify to fill those new openings. The government can control the speed of these processes on both the "push" and the "pull" side. Providing increased support to the agricultural population to live off their agricultural income would slow down land abandonment and migration. Enhancing capital formation and investments and providing training and education programs for the newcomers to urban areas would make this transition smoother.

Kelantan River Basin in Malaysia

This study represents one rare example of climate impact assessments where possible impacts of climate change were combined with future trends in socioeconomic development projected for the same time horizon as the full impacts of double CO_2. The starting point was the present socioeconomic profile of the region, to which the NSG developed forecasts of changes in land use up to 2010, and water demand by sectors up to 2030 were added.

At present, the economy in the State of Kelantan in Malaysia is dominated by agriculture (70 percent of the population, 50 percent of the labor), accounting for 30 percent of the state's GDP. The most important crops are presented in Table 19.3.

TABLE 19.3. *Agriculture in the Kelantan Basin of Malaysia*

Crops	Area (ha)	Production (tons)
Paddy	70,000	200,000
Tobacco	10,000	8,000
Rubber	130,000	45,000
Oil palm	60,000	84,000

Source: Sea and Salmah, 1990, pp. 1-2

Rice production in the state accounts for 13.5 percent of the total national production figures, while tobacco production accounts for more than 80 percent of the total. In addition, there are expanding manufacturing and already substantial commerce and service sectors in the region.

The most severe damages caused by floods in 1967, 1983 and 1986 were estimated and then combined with the projected future expansions in the impact areas (affected population, agriculture, houses and buildings, infrastructure) by the year 2030, together with a 9 percent increase in flood peaks due to CO_2-induced climate change. The results show that there will be a 5 percent to 8 percent increase in the probable inundation area and a 10 percent to 12 percent increase in total flood damage.

Similar projections were made to identify the future demand for water by various sectors in the region (Table 19.4), by combining the increasing water demand figures with the estimated 30 percent to 35 percent water deficit in the Kelantan Basin resulting from climate change. The current priority order in fulfilling water demand is domestic, industrial, river maintenance, and irrigation. What this suggests is that the first three sectors are not likely to be affected by water shortages in the dry season, but that there will be major consequences for agriculture. "It has been estimated that the total irrigable area for paddy in the year 2030 would be 50,000 ha, requiring an annual peak demand of 84.6 m^3/sec of water. The deficit would, therefore, result in the abandonment of 65 to 70 percent of the off-season crop. The consequent loss of between 32,500 to 35,000 ha of paddy crop would affect the livelihood of tens of thousands of people and losses of millions of ringgit" (Sea and Salmah, 1990, p. 7).

Policy Responses

The main objective of the policy analysis phase of the project was to develop and evaluate strategic policy responses with a view to how societies in Southeast Asia might respond to the potential impacts of climate change identified in the previous phases so as to protect their environmental and natural resource base, their economic vitality and their

TABLE 19.4. *Projected Gross Water Demand for Kelantan River Basin* (m^3/sec)

Year	Domestic and industrial	Irrigation	River maintenance	Total
1985	0.5	35.0	70.0	105.5
1990	2.1	72.7	70.0	144.8
2000	4.3	84.6	70.0	158.9
2010	6.5	84.6	70.0	161.1
2030	9.2	84.6	70.0	163.8

Source: Sea and Salmah, 1990, p. 24

prosperity. The goal was to identify possible short-term adaptive moves and longer-term strategic responses, together with the potential gains and losses involved in those alternative policy responses. The central problem for the policy component of the study can be reformulated as generating national and local responses to impacts of a global change. The problem involves:

- *various spatial scales*: from individual farms to river basins to watersheds to regions and provinces to the national level;
- *various temporal scales*: changes in farming practices, selection of crops grown (1 to 2 years); crop varieties (breeding), changes in land use patterns, land conversion (few years); plantations (e.g., rubber), national agricultural policies (1 to 2 decades); canals, reservoirs, dams; coastal structures (several decades);
- *various economic sectors*: agriculture, fisheries, water management, tourism, energy;
- *various jurisdictional levels*: county, state/province, nation;
- *uncertainties and surprises*: even the best GCMs we are currently using are admittedly imperfect tools to predict climate change; but even if they were perfect, their input data and scenarios are highly uncertain (global energy use, deforestation, the role of wetlands and terrestrial vegetation); the crop models used by the NSGs are state-of-the-art but rely on imperfect data and outputs from the GCMs; a considerable amount of uncertainty exists regarding the relationships between climate change and sea-level rise;
- *management/policy orientation*: global climate change seems to be inevitable; therefore, an appropriate response is inevitable; appropriate response means developing policies that are robust with respect to potential surprises; because some actions involve long lead times, it is better to prepare now and act soon.

The Approach

Over the past 30 years various attempts have been made to develop approaches related to synthesizing scientific information from different disciplines relevant to a practical management problem and communicating it to the policymakers in an appropriate form. Two major approaches that have been widely used can be considered as extremes: computer models and expert committees (blue ribbon panels). Both approaches have their own merits and shortcomings, but there is still considerable room for improvements. To overcome some of the shortcomings and to complement existing methods, the policy exercise approach was developed at IIASA (Toth, 1986, 1989) and it was used in the Southeast Asia study to generate and analyze policy responses.

A policy exercise is a flexible structured process designed as an interface between academics and policymakers. Its function is to synthesize and assess knowledge accumulated in several relevant fields of science for policy purposes in light of complex management problems. It is carried out in one or more periods of joint work involving scientists, policymakers, and support staff. A period consists of three phases (preparations, workshop, evaluation) and can be repeated several times. At the heart of the process are scenario writing of "future histories" and scenario analysis via the interactive formulation and testing of alternative policies that respond to challenges in the scenarios. These scenario-based activities take place in an institutional setting, reflecting the institutional features of the problem at hand. There are two basic types of participants: policymakers as members of one or more policy team(s), and experts serving on the control team. Their activities at the policy exercise workshop are coordinated and moderated by a facilitator. If there is more than one policy team their relationships can be cooperative or competitive based on the nature of the problem with which they are dealing.

The policy exercises (PEs) in Malaysia and Indonesia were carried out in three phases. The preparations phase took almost two years and included data collection, modelling, completing the first order impact assessments, analyzing the socioeconomic impacts, several meetings of the NSGs, and conducting preinterviews with many to-be policy participants so as to ensure proper targeting of the exercise.

The workshops of the PEs were intensive, two-day meetings in Genting Highlands (Malaysia) and in Jakarta (Indonesia).

Because of the special characteristics of the project and the unusual circumstances of preparations, the original PE protocol was only loosely followed. In Indonesia, the input material for the workshop was sent out to participants prior to the workshop; in Malaysia it was not. Still, both workshops started with a session of introductory summaries presented by members of the NSGs and extended discussions of the reports per se. Because we had only one scenario of climate change and impact assessments with which to work, we made consecutive iterations on the same scenario by modifying the focus and key questions for the discussions and by regrouping participants accordingly.

The final phase of the policy exercise involves a careful analysis of the workshop results, preparing various forms of documentation from the exercise, and an overall evaluation. Products of a policy exercise include:

- a summary report dubbed as a cabinet briefing document (CBD), consisting of a short and succinct presentation of the problem, analysis, and major results;
- detailed policy assessments especially relevant to technological initiatives required to mitigate potentially adverse local and regional impacts of climate change, institutional changes (e.g., land ownership, water rights, legal considerations, government agencies) required to cope with the problems identified by the analysis; and
- research and monitoring necessary to acquire improved knowledge and to identify the most vulnerable economic sectors and geographical areas.

Context

In preparing for the policy exercises, the author conducted a series of preinterviews with the senior policymakers responsible for strategic policy formulation at ministries, and with directorate generals whose area or sector of responsibility is expected to be most heavily affected by the impacts of climate change. One important conclusion from these interviews was that it would be inappropriate to invite these individuals to consider and develop serious policy responses to highly uncertain events expected to occur in the distant future. Policymakers in these countries discount long-term risks and, therefore, there is a pressing need to improve our techniques and approaches so as to put long-term, uncertain, but high-risk issues into a policy-relevant context.

One possible strategy to overcome these difficulties will be an improved understanding of the transient processes involved in climate change. These improvements are expected to come from the new generation of high resolution GCMs that are also expected to decrease the level of uncertainties related to current predictions of regional climate change. More reliable impact assessments are more likely to capture the attention of policymakers, and, thus, their level of involvement and contribution to the analyses of climate policy issues can be considerably enhanced.

For the purposes of this project, the author proposed a different approach to make the impact assessments more relevant to senior policymakers. This proved to be highly successful even though the level of implementation varied across the three participating countries. The strategy was to link impacts of climate change to four major sets of issues in current policy-making.

1. *Link impacts of climate change to current problems and strategies to solve them.* The objective was to identify long-term, large-scale, and complex social and economic problems (equivalent in scales to those of climate change) and evaluate whether the proposed solutions and strategies remain valid under plausible impacts of climate change and explore how they could be enhanced according to the newly emerging threats and opportunities triggered by climate change. The objective of the exercise was clearly not to fine-tune these strategies to assumed double CO_2 conditions, but rather to evaluate whether they were robust with respect to different patterns of climate change and variability.

The previous section presented two examples of this approach. The area of abandoned paddy fields in the Muda region, Malaysia, was already increasing in the past because the reduced farm sizes did not permit economically feasible farming. Appropriate government strategies will be required to solve the problems of land fragmentation and land market rigidity resulting from traditional inheritance practices. But will the proposed strategies provide a long-term solution if we consider the gradually emerging impacts of climate change? Floods in the Kelantan River Basin, Malaysia, had repeatedly caused major damage to agricultural areas, property, and infrastructure in the past. Large-scale flood control and water management schemes are now in the planning phase to solve or mitigate these problems. Would these massive investments provide a long-term solutions if dam sizes, gates, and other engineering works are based on precipitation and run-off data derived from historical climate records?

2. *Link impacts of climate change to ongoing or planned long-term government programs to clarify whether the objectives remain valid if climate is changing and whether the strategies are robust to those changes.* What are the perceived modifications to these programs to deal with the new threats and opportunities emerging from impacts of climate change?

The Indonesian government has been carrying out an ambitious long-term program to reduce the population pressure in the most densely populated regions of Java, Bali, and Lombok. The transmigration program moves millions of people each year to newly opened areas in Sumatra, Sulawesi, Kalimantan, and other islands where they are provided with 2 ha of land, a house, farming equipment, and other assets to start a new life. The current five-year plan, Repelita V, is projecting the resettlement of 550,000 families between 1989 and 1994. This involves 1.1 million ha of land development. The question again arises: Are the resettled families expected to conduct economically feasible farming operations under double CO_2 climate, water, and sea level conditions?

3. *Link impacts of climate change to the long-term objectives for overall socioeconomic development to identify components and areas that might be threatened by those impacts.*

Poverty eradication is an important long-term objective in all three countries. The incidence of poverty is most severe among the rural population, and the resource base they rely on will be subject to impacts of climate change.

Increasing agricultural efficiency is one overall objective set by the government for the Malaysian agriculture and paddy production. Another important objective is to eradicate poverty, with a special emphasis on rural poverty. The New Economic Policy brought major achievements in poverty eradication, not without costs though. The Revised Fifth Plan allocated over M$13.6 billion to poverty eradication and 55.7 percent of this budget went to programs directly related to agriculture. Moreover, M$2,179 million was spent on new land development, and almost M$1.1 billion on the Integrated Agricultural Development Project. Other major programs included drainage and irrigation (M$478 million), replanting (M$643 million), and rehabilitation (M$873 million).

Impacts of climate change are likely to affect most of these programs over the long term. The major question is whether the program objectives remain valid under the changing climatic situation. Will the newly developed land be suitable for agricultural production, and will the production be economically efficient in these areas as key climatic attributes are changing over the coming decades? Will the newly constructed drainage and irrigation schemes be appropriate to handle markedly different precipitation patterns? Are the newly established and rehabilitated plantations appropriate for the new climate or will they have to be replaced well before their economically feasible lifetimes? Our present knowledge on these issues is rather vague, but these questions brought the long-term risks into the time horizon of strategic planners in ministries and departments of agriculture, irrigation and drainage, forestry, primary industries, and others in all three countries.

4. *Identify potential new economic or social problems arising as a result of climate change.* Most climate impact studies focus on these issues: What are the newly emerging problems resulting from climate-induced changes in the biophysical system?

Issues in these four areas are closely interrelated and in some cases they overlap. Nevertheless, the approach seemed to provide a useful framework to focus policymakers' attention on the relationships among their strategic objectives, current endeavors and the slowly evolving but long-term threats of climate change. Policy participants were asked to formulate responses on behalf of their own organization in five major categories: economic, technological, institutional, research and monitoring. Participants provided their responses according to a structured form, including specification of the problem and the category of response; a short description of the proposed policy; what government agencies are involved and who makes the final decision; a broad outline of the implementation; the source and amount of resources to implement it; and the potential side-effects of the proposed policy.

Examples of Results from Malaysia and Indonesia

Participants at the Malaysian policy exercise (PE) proposed a series of adaptive measures to mitigate adverse impacts of climate change on rice production. The initial focus of the discussions was, not surprisingly, the possible "technical fixes" stimulated by the undisputable success of breeding new, high-yield varieties over the past two decades. Participants proposed that objectives for future research and breeding efforts should also include increased resilience of the new varieties to climatic stresses. Among the many unknowns, the potential impacts of changing climate on pests and diseases were highlighted. Research on these relationships should be started very soon in order to get the relevant data to the breeders who are currently working with historical climate data and present climate-pest-crop relationships. More reliable information on the nature and magnitude of the expected climatic stresses affecting the crop is also needed.

The second set of examples of possible *technological* responses is related to the water stress and irrigation problem. The current level of irrigation efficiency is estimated to be around 55 percent to 60 percent, and it could be significantly improved by new irrigation techniques such as water recycling. This would involve establishing a large number of mobile pumps at strategic points in the irrigation scheme and transferring unused water back to the storage facilities for redistribution across the channels. Further analysis is required to determine the potential improvements in irrigation efficiency, the costs of different implementation strategies, and the potentially deleterious sideeffects of the new irrigation practices.

A series of possible *economic* responses was also discussed. The most straightforward solution to compensate the paddy farmers for losses in their income would be to increase the net cash subsidy paid to them. However, the negative sideeffects of this arrangement should be further explored. These include an increasing drain on the government budget and the secondary impacts on the efficiency of rice production and higher food prices. An indirect form of subsidy to offset yield losses would be an increased supply of free or low-priced fertilizers to the farmers. In addition to the economic sideeffects above, however, this would create additional environmental stresses: soil contamination, nutrient leaching, and eutrophication of the irrigation canals.

A larger scale *strategic* response to the already existing problem of reduced farm sizes, economic and technological inefficiency of small farms, and the emerging impacts of climate stresses would be to open up new agricultural areas and resettle the population in other regions. When this alternative was discussed, policymakers were concerned about the costs of new land development and the social and political stresses associated with relocating large number of people. Based on previous experience, they also raised the possibility of changes in local climate as a result of land-use changes: "We opened up jungle areas for annual crops and generated a 1°C annual mean temperature increase in the region. If we had known that, we would have opened it up for agroforestry," said a senior official from the Department of Agriculture, Malaysia.

Land fragmentation, economically inefficient sizes of landholdings, and resulting high incidence of poverty characterize the rubber sector as well. The recently introduced new clones increase yields by up to 50 percent and this will offset potential losses due to expected climate stresses. The proposed institutional response strategy to increase the efficiency in the rubber sector (and other plantations, and, perhaps even paddy) would observe the Islamic inheritance traditions. Smallholders would retain ownership of their land but they would be encouraged to let large plantation companies manage their land in return for rent and to look for employment elsewhere.

Discussions on the water-management

problems in the Kelantan River Basin focused on technical solutions to the current as well as increased future risks of flooding and water shortage. It was concluded that urban river stretches of more than 1,000 people/km^2 should be protected from the 50-year-return-period floods, while the remaining areas should be protected from the 20-year floods. A large number of alternatives (combinations of river improvements and dam constructions) were evaluated to identify the best solutions for flood mitigation, hydropower generation, water supply, and river maintenance. Policymakers from the Department of Irrigation and Drainage and other government agencies felt confident about their models and identified the scenarios of climate change as the most important sources of uncertainty in the sector. Nonetheless, some results will have to be reevaluated in the light of SLR (backwater effects, flooded areas and saline intrusion in the estuary of the Kelantan River), changes in land use and demand for irrigation water induced by climate change.

Some of these concerns emerged from the "looking outward" session of the PEs when participants were asked to identify key linkages to other sectors: what they would need to know about climate induced changes in the other sectors to improve their own strategic responses. Examples of the most important cross-sectorial impacts included water supply for irrigation and soil erosion (between agriculture and river basins); drainage problems (between agriculture and coastal management); and problems affecting estuaries (between SLR and river management). Participants were rearranged into new groups to analyze these cross-sectorial impacts, and in many cases they found that indirect impacts of climate change via other sectors would cause more serious problems to them than the direct impacts on their own sector.

Just to mention two examples of these cross-sectorial impacts: In Indonesia, increasing erosion from upland agriculture due to increasing rainfall under the double CO_2 scenario will create more severe problems for flood mitigation and river-basin management in the form of increased sedimentation in streams and reservoirs than would the otherwise significant increase in the amount of precipitation. The solution would involve substantially improved erosion control programs in the upland areas not only to protect soil fertility but also to prevent devastating impacts on flood control, on the life span of the already existing dams, and on the hydropower plants. In Malaysia, drainage problems caused by only a few inches of SLR in the coastal areas will severely affect coco, oil palm, and other plantations in the most fertile agricultural areas. The resulting losses in yields and the shorter lifetime of plantations are expected to cause higher-magnitude losses than the temperature and precipitation changes. Research into new technologies of drainage and breeding salt resistance crops should be considered, together with relocating the most sensitive crops and developing new land use zoning in the affected areas.

Many other response strategies were discussed at the PE workshop, and they were all related to present strategies or longer-term objectives set for the agricultural sector, water management, and coastal regions in Malaysia. Despite all the uncertainties readily admitted and fully revealed in the impact assessment reports, policymakers seemed to take the potential threats seriously. The PE is not intended to produce official decisions or new strategies with full-scale analytical underpinnings. Rather, it is a preparatory activity for effective participation in official decision processes. In this respect, the Malaysian exercise achieved its objectives by creating awareness among senior policymakers in key government agencies by identifying the most important risks and by sorting out the usable knowledge and usable ignorance related to the adaptive policy responses to climate change.

General Lessons

It would be premature to draw far-reaching conclusions on how developing countries balance the social costs of adaptation and prevention in the context of climate policy. Yet, one is forced to organize the experience accumulated in this study into an oversimplified framework that might prove profoundly wrong as more studies of a similar nature are conducted in different parts of the developing world. Based on the indicators presented earlier in this chapter, Malaysia is the most developed among the three participating countries. The taste of increasing welfare and the promising outlook for fast development in the future seemed to create the highest risk perception and awareness of the possible threats that might undermine past achievements or jeopardize future development prospects. The expert team provided a thorough analysis of the potential impacts, and policymakers who participated in the PE had the necessary long-term vision to consider the remote, but high stake, threats seriously.

In Thailand the prevailing growth enthusiasm seems to outweigh longer-term risks associated with some patterns of economic development both at the local and global scales. The impact assessments did not reach a level enabling them to serve as inputs to PEs, and the NSG did not seem to be very concerned with involving policymakers.

Indonesia is the least developed among the three countries and struggles with the most severe environmental problems in the region. Despite, or perhaps because of that, they developed some preliminary impact assessments and presented the results at a PE to members of the National Committee concerned with impacts of climate change.

The varying degrees of success in transferring the assessment techniques (climate scenarios, crop and hydrological models, PEs) fit well into this framework. The Malaysian NSG successfully calibrated and used the CERES RICE model. The Thai group was not able to calibrate it, and the Indonesians did not even attempt to use it. The hydrological model proposed by the core team was not used at all by the NSGs. Instead, the Indonesian and the Malaysian teams used the much simpler Thornthwaite and Mather Water Balance Model. The lessons for future climate impact assessments in developing countries is that complex models with extensive input data requirements are not appropriate when local expertise and historical data are in short supply.

The awareness and perception of climate associated risks have been changing both in the scientific and policymaking communities over the two-year life span of the project. Probably the most dramatic development occurred in Thailand, where public and policy concern even over apparent and immediate environmental hazards was limited, at best. In the traditional speech on the eve his birthday, Thailand's king "showed special concern about the so-called Greenhouse Effect, cited figures for the amount of pollution being discharged into the atmosphere by the burning of wood and fossil fuels" (*Bangkok Post*, December 5, 1989). In his New Year speech, the Thai Prime Minister echoed these concerns, and when the preinterviews were conducted in January 1990, senior policymakers of several government agencies expressed their interest in the issue and the results of the study. The question why the Thai NSG was not able to capitalize on this momentum and involve more policy people in the exercise remains unresolved. Beyond this striking example, however, just a casual overview of the English language papers in the three countries shows an increasing coverage of environmental problems and also of global environmental issues like climate change.

The three nations seem to have markedly different institutional mechanisms to manage complex policy issues like those associated with climate impacts. Driven by the values of performance and efficiency, Malaysian government agencies readily setup interministerial or other interagency committees whenever the problem at hand extends beyond their own area of jurisdiction. The success of the Malaysian part of this project is partly attributable to the excellent collaboration among a wide variety of government agencies and academic institutions. Institutional rigidities appear to be a problem in Indonesia. Based on the premises that information means power and institutions are reluctant to share power, limited flow of information among government agencies cause problems in managing complex issues. This is partly due to the present institutional setting in which ministries that wish to launch major development programs need to convince BAPPENAS to secure the necessary funds. Unlike the ministries, BAPPENAS does not have hierarchical networks going down to the district, subdistrict, and village levels. As a result, the ministries reveal only that part of the information necessary to make their proposals more attractive. Moreover, environment (Ministry of Population and Environment) and development (BAPPENAS) issues in policymaking are separated, even in their international contexts. This will have to change as new strategies of sustainable development get more emphasis in future development efforts.

The current practices of climate impact

assessment are not very helpful in attracting the attention of policymakers. The use of landmark CO_2 conditions as the starting point for the assessment work limits the analyses of full-scale impacts and practical implications. The evolving impacts of climate change would not be the only dynamic process affecting the natural resource systems, and it is easy to envision serious statistical studies conducted at the agricultural universities in Bogor (Indonesia) or Kuala Lumpur (Malaysia) 10 to 20 years from now analyzing the causes of changes in yields attributable to changes in soils, erosion, irrigation, and different climatic parameters. Dynamic patterns of climate change would be superimposed on other variables affecting the resource base (degradation, depletion), on redevelopment and rehabilitation efforts (drainage, land reclamation), and on factors in the social and economic systems (values, technologies, cultural practices). We know very little about these complex interactions, but we can certainly expect surprises due to the feedback relationships and unknown thresholds. Therefore, we need to put more emphasis on the dynamic nature of both climate impact studies and socioeconomic development, in order to understand their interactions and to formulate better strategies to manage their complex linkages.

Recent research efforts on impacts of climate change follow two major directions: one group of studies is concerned with sectorial implications (agriculture, water); the other group is looking at regional consequences. There are attempts to link results from sectorial studies conducted in different countries (impacts of changing agroclimatic conditions on agriculture) at the international level to assess global implications (on the world food system and international trade of agricultural products). Impact assessments conducted in Southeast Asia have identified cross-sectorial linkages of indirect impacts of climate change (water availability for irrigation, soil erosion on rivers and reservoirs) that might produce more severe consequences than the direct impacts on the sector. The resulting policy responses to the full-scale impacts might be profoundly different from those based on just the direct impacts. There is a need to link results from the two types of research because broad-scale studies often omit the rich diversity of potential adaptive measures at the local scale.

In retrospect, both moral and scientific concerns are related to the policy component of this project. The NSGs were not able to carry out full-scale analyses for at least three scenarios of climate change as originally planned. Despite all warnings and disclaimers, going into PEs with impact assessments based on just one scenario created the impression that the scenario is a forecast. This led to credibility problems at policy workshops both in Malaysia and Indonesia. Although it was repeatedly emphasized that the proffered material was merely a "not impossible" scenario, policymakers treated it as the prediction of impacts of climate change. The result was that instead of exploring and analyzing policy responses to plausible scenarios of impacts, we had long discussions on climate modelling, reliability of forecasts, the relationship between global and local climate change, and other issues irrelevant to the debate on response strategies. Familiarity of some participants with drafts of the IPCC report was not very helpful either. The report scaled down the magnitude of changes in most climate attributes, making the initial scenarios used in the study (and based on our 1988 knowledge) appear to be at the high end. This also diverted some of the debates at the exercises from the policy implications to credibility issues.

The policy exercises identified a series of adaptive measures to mitigate adverse impacts of climate change. Although participants were repeatedly encouraged to give serious consideration to economic and institutional responses beyond the most apparent technological fixes, the most specific and possibly most valuable outcomes were the guidance and recommendations from the policymakers to the analysts regarding future research to provide the kind of information they will need to formulate more specific responses. This confirmed earlier observations: "Until we know more about the magnitudes and rates of change of temperature and precipitation in specific regions . . . it will be hard to make a convincing case for more drastic measures of abatement or adaptation" (Revelle, 1989, p. 173). The second type of specific result that came out of the PEs outlined monitoring needs to identify the most vulnerable regions, sectors, and social groups. The proposed economic and institutional response strategies will require further work, but the policy exercises were successful in increasing the awareness of senior policymakers who represented the most relevant government agencies.

Given our present knowledge and the magnitude of uncertainties related to climate change, perhaps the most promising response strategy on the prevention side is the so-called tie-in strategy developed and presented in detail by Kellogg and Schware (1981) and more recently discussed by Schneider (1989). Pursuing this strategy would reduce greenhouse gas emissions from various anthropogenic sources and simultaneously would provide generally agreed social, economic, and environmental benefits, even if current predictions of climate change turned out to be highly overestimated. By linking the potential regional impacts to current problems, ongoing programs, and long-term objectives, the PEs in Malaysia and Indonesia have identified a series of tie-in strategies on the adaptation side. Tie-in adaptations would involve:

- a series of protective and rehabilitative measures in resource management;
- modified price, subsidy, export, and import strategies in economic policy;
- changes in the legal and government systems to enhance the institutional mechanisms; and
- numerous R&D options in agricultural, coastal-protection and water-management technologies.

The resulting improvements in reduced soil erosion, drainage, flood mitigation, and many other areas would prove greatly beneficial, even if local impacts of climate change were far less dramatic than indicated by some of the impact assessments generated in this study.

Acknowledgements

This chapter draws on results of a research project initiated and financially supported by UNEP with the participation of Indonesia, Malaysia, and Thailand. The opinions, observations, and conclusions presented here are those of the author and do not necessarily reflect the views of UNEP or of any governmental or nongovernmental agencies of the participating countries. Any errors or misinterpretations, though inadvertent, are the sole responsibility of the author.

References

Bangkok Post, 1989. Save Thailand from becoming a desert. *Bangkok Post* (December 5).

BAPPENAS (National Development Planning Agency), 1989. REPELITA V. Indonesia's Fifth Five-Year Development Plan 1989/90-1993/94. Percetakan Negara Republik Indonesia, Jakarta.

Blantran de Rozari, M., N. Koesoebiono, D. Sinukaban, *et al.*, 1990. Socioeconomic impacts of climate change (manuscript).

EPU (Economic Planning Unit), 1989. *Mid-term review of the Fifth Malaysia Plan 1986-1990.* National Printing Department, Kuala Lumpur.

Eddy, A., S. Panturat, S. Salim, *et al.*, 1989. Climate change impacts on food and water resources in S. E. Asia (manuscript).

Glantz, M.H., (Ed.), 1988. *Societal Responses to Regional Climatic Change. Forecasting by Analogy.* Westview Press, Boulder, Colo.

Godwin, D. and U. Singh, 1989. *CERES-RICE V2.00.* International Fertilizer Development Center, Muscle Shoals, Alabama.

Kates, R.W., J. Ausubel, and M. Berberian (Eds.), 1985. *Climate Impact Assessment: Studies of the Interaction of Climate and Society.* John Wiley, New York.

Kellogg, W.W., and R. Schware, 1981. *Climate Change and Society. Consequences of Increasing Atmospheric Carbon Dioxide.* Westview Press, Boulder, Colo.

Lim, T.K., and Md. S. Salmah, 1989. Impacts of climatic change on the water resources in the Kelantan River Basin (manuscript).

Marland, G., T.A. Boden, R.C. Griffin, *et al.*, 1989. *Estimates of CO_2 Emissions from Fossil Fuel Burning and Cement Manufacturing, Based on the United*

Nations Energy Statistics and the U.S. Bureau of Mines Cement Manufacturing Data. Oak Ridge National Laboratory, Oak Ridge, Tenn.

Panturat, S., and A. Eddy, 1989. Some impacts on rice yield of changes in the variance of regional precipitation (manuscript).

Parry, M.L., T.R. Carter, and N.T. Konijn (Eds.), 1988. *The Impact of Climate Variations on Agriculture, Vols. 1 and 2*. Kluwar Academic Publishers, Dordrecht, The Netherlands.

Prentice, I.C., R.S. Webb, T. Mikhail, *et al*., 1989. Developing a global vegetation dynamics model: Results of an IIASA summer workshop. Publication No. RR-89-7. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Revelle, R.R., 1989. Thoughts on abatement and adaptation. In: *Greenhouse Warming: Abatement and Adaptation*. N.J. Rosenberg, W.E. Easterling, P.R. Crosson, and J. Darmstadter (Eds.) Resources for the Future, Washington, D.C., pp.167-74.

Revelle, R.R., and Waggoner, P.E., 1983. Effects of a carbon dioxide-induced climatic change on water supplies in the western United States. In: *Carbon Dioxide Assessment Committee. Changing Climate*. National Academy Press, Washington, D.C., pp. 419-32.

Ritchie, J., 1988. User documentation of the CERES-RICE Simulation Model. Version 1.20. Upland Condition, 8/14/87 (draft).

Salim, S., E.F. Yong and P.K. Yeow, 1989. Effects of climatological changes on rice production in the Muda area (manuscript).

Sea, C.H., and Md. S. Salmah, 1990. Socioeconomic impact assessment on the water resources in the Kelantan River Basin resulting from climate change (manuscript).

Schneider, S.H., 1989. The greenhouse effect: Science and policy. *Science*, **243**:771-81.

Soon, W.H., 1983. Muda II evaluation survey: An impact evaluation study of the Muda II Irrigation Project. MADA Publication, February 1983.

Sundaram, J.K., 1988. *A Question of Class*. Monthly Review Press, New York.

Thai NSG (National Study Group), 1990. Effects of climate change on rice production in Ayuthaya province, Thailand (manuscript).

Toth, F.L., 1986. Practicing the future: Implementing the policy exercise concept. Publication No. WP- 86-23. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Toth, F.L., 1989. Policy exercises. Publication No. RR-89-2. International Institute for Applied Systems Analysis, Laxenburg, Austria.

UNDP, 1982. *The ASEAN Compendium of Climate Statistics*. Colorcom Grafik Sistem Sdn., Kuala Lumpur, Malaysia.

WMO (World Meteorological Organization), 1986. Report of the international conference on the assessment of the role of carbon dioxide and other greenhouse gases in climate variations and associated impacts. WMO, Geneva.

World Bank, 1989. *World Development Report 1989*. Oxford University Press, New York.

WRI (World Resources Institute), 1988. *World Resources 1988-89*. Basic Books, New York.

Zamali, M., and S.Ch. Lee, 1989. Impacts of sea level rise on the West Johor Agricultural Development Project Phase I (manuscript).