Thailand's Initial National Communication

under

the United Nations Framework Convention on Climate Change

Ministry of Science, Technology and Environment
THAILAND

Thailand's Initial National Communication
under the United Nations Framework Convention on Climate Change

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FOREWORD

This initial communication documents the 1994 inventory of greenhouse gases and the steps being taken by Thailand to address climate change. It also compiles other important information such as vulnerability and adaptation, research and development, financial resources, technology transfer and public awareness. Thailand's Initial National Communication came into being through collective efforts of experts from numerous government and private institutions in the country.

Despite the difficulties caused by the recent financial and economic crises, Thailand has managed to make considerable progress in greenhouse gas abatement. Most of these efforts were well underway prior to the convention entering into force. The Royal Thai government has launched a series of programs to conserve energy, including demand-side management and energy auditing programs. Demand-side management, initiated in the course of implementing the Eighth National Economic and Social Development Plan (1997-2001), is expected to reduce energy consumption by 140 MW. Thailand has also actively promoted various afforestation and reforestation activities. Since 1992, The area under forest cover has been expanded by an estimated half a million hectares. Thailand will continue to implement energy conservation and other climate change related measures in the future.

The support provided by the Global Environment Facility through the United Nations Development Programme in the preparation of this first national communication is highly commended. With this support Thailand has been able to review our work and prepare to meet future challenges. The experiences gained from preparing this first communication document suggest the need for further development of technical, institutional and human resources to improve our work, particularly in the areas of vulnerability and adaptation. Because of the importance of coastal resources and agriculture to the country, Thailand is highly vulnerable to climate change, particularly as sea levels rise and extreme weather conditions are generated. Based on the principle of common but differentiated responsibilities, Thailand is fully committed to cooperating with international community and regional partners to minimize the impacts of climate change while conforming to its obligations under the United Nations Framework Convention on Climate Change.

(Arthit Ourairat, Ph.D.)

Minister of Science, Technology and Environment

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LIST OF UNITS & ABBREVIATIONS

Prefixes and multiplication factors

Symbol	Prefix		Abbreviation	Multiplication Factor
P	peta		10^{15}	1 000 000 000 000 000
T	tera		10^{12}	1 000 000 000 000
G	giga	(billion)	10^{9}	1 000 000 000
M	mega	(million)	10^{6}	1 000 000
k	kilo	(thousand)	10^{3}	1 000
h	hecto		10^{2}	100
da	deca		10^{1}	10
d	deci		10^{-1}	0.1
c	centi		10^{-2}	0.01
m	milli		10^{-3}	0.001
μ	micro		10^{-6}	0.000 001

Note

1 Tonne	= 10^{6} g	
1 k Tonne	= 1 Gg	
1 M Tonne	= 1 Tg	= 10^{3} Gg

Abbreviations for chemical compounds

Chemical Formula	Definition
C	Carbon
CH_4	Methane
N_2O	Nitrous Oxide
CO_2	Carbon Dioxide
CO	Carbon Monoxide
NO_x	Nitrogen Oxides
NMVOC	Non-Methane Volatile Organic Carbon
VOC	Volatile Organic Carbon

Standard Equivalents

Unit	Conversion Factors
1 tonne of oil equivalent (toe)	10.093 gcal or 42.244 GJ
1 Hectare	6.25 rai
1 Hectare	10,000 square meters (m^2)
1 Km^2	100 ha
1 Rai	1,600 square meters (m^2)
1 US dollar	25 Baht (prior to devaluation in June 1997) 37 Baht (approximately in March 2000)

Unit and Abbreviations

Unit	Symbol
Cubic Metre	m^3 or cu m
Cubic Feet	cu ft
Degree	°
Degree Celsius	°C
Dry Matter	dm
Gigawatt hour	GWh
Gram	g
Hectare	ha
Kelvin	K
Lipda	’
Million Standard Cubic Feet	mscf
Million Tonne of Oil Equivalent	Mtoe
Square metre	m^2 or sq m
Tonne of Oil Equivalent	toe
Tonne	t
Watt	W
Watt hour	Wh
Year	Yr

Acronyms and Abbreviation

ADB	Asian Development Bank
ASEAN	Association of South East Asia Nations
AIJ	Activity Implemented Jointly
ALGAS	Asia Least-cost Greenhouse Gas Abatement Strategy
BOT	Bank of Thailand
CCEC	Climate Change Expert Committee
CDM	Clean Development Mechanism
CPI	Consumer Price Index
COPATH	Carbon, Pasture, Agriculture, Total, Harvesting
DEDP	Department of Energy Development and Promotion
DEQP	Department of Environmental Quality Promotion
DSM	Demand Side Management
DTEC	Department of Technical and Economic Cooperation
ECON	Energy Conservation
EGAT	Electricity Generating Authority of Thailand
EGCO	Electricity Generating Public Company Limited
ESCAP	Economic and Social Commission for Asia and the Pacific
ESCO	Energy Service Company Limited
EU	European Union
FIO	Forest Industry Organization
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GISS	Goddard Institute of Space Studies
GRP	Gross Regional Product
HSD	High Speed Diesel
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
KURDI	Kasetsart University Research and Development Institute
LBL	Lawrence Berkley Laboratory
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSD	Low Speed Diesel
MOSTE	Ministry of Science, Technology and Environment
NCCC	National Climate Change Committee
NECTEC	National Electronics and Computer Technology Center
NEPO	National Energy Policy Office
NESDB	National Economic and Social Development Board
NGOs	Non-Government Organizations
OAE	Office of Agricultural Economics
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OECF	Overseas Economic Cooperation Fund
OEPP	Office of Environmental Policy and Planning
RFD	Royal Forest Department
SIIT	Sirindhorn International Institute of Technology

Acronyms and Abbreviation

SPP	Small Power Producer
TDRI	Thailand Development Research Institute
TEI	Thailand Environment Institute
TFMP	Thai Forestry Master Plan
TPC	Thai Plywood Company
WHO	World Health Organization
UKMO	United Kingdom Meteorological Office
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

THAILAND's

INITIAL NATIONAL COMMUNICATION

UNDER THE UNFCCC

Executive Summary

Introduction

Thailand, along with over 150 other nations, signed the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, in June 1992. Thailand ratified the Convention in March 1995.

This initial national communication sets out Thailand's contribution to international efforts to address climate change issues, as a non-Annex I country. It provides an overview of national circumstances that influence Thailand's capacity to respond and describes its greenhouse gas inventory and mitigation options. This communication also discusses developments with regard to vulnerability and adaptation issues, policies and measures taken, and the areas where Thailand still lacks the capacity to address climate change problems.

National Circumstances

Thailand is located in the southeastern region of the Asian mainland. The total land area of the country is approximately 513 thousand square kilometers (320 million rai). Located in the monsoon region, the climate is dominated by three distinct seasons: hot, wet, and cool. Average annual precipitation is 1,630 mm, although rainfall exceeding 2,000 mm is common in the Southern peninsula of the country.

The country is divided into five regions: North, Northeast, Central, East and South. The North is generally mountainous, with altitudes rising over 200 meters above mean sea level. A large part of the Northeast is on a high plateau and dry. The land in the central region is flat and relatively fertile. The East is dominated by fertile land suitable for tree crops and a long coastal line. The Southern Peninsula constitutes most of the 2,500 km coastline of the country. The topographical nature, soil characteristics and climate conditions influence agricultural specialization and socio-economic development in each region.

Socio-economic Profile

Thailand's population was estimated at 62 million in 1999. The success of population planning over the last two decades has reduced the population growth rate to 1.1 percent per year. In 1996, the average population density of Thailand was 117 persons per square kilometer, with Bangkok having the highest density of more than 3,500 persons per square kilometer.

Thailand experienced rapid economic growth during the 1980s until the first half of the 1990s. The country's real GDP grew by about 5 percent in the early 1980s to a peak of 13 percent in 1988, and remained high at around 8 percent until the first half of the 1990s. Economic growth between 1988-1996 nearly doubled per capita income and improved household welfare dramatically. But while absolute incomes improved, income distribution between urban and rural areas, particularly between Bangkok and other regions, has worsened.

The Economic Crisis

The country was confronted with serious economic difficulties in the later half of the 1990s. After the de facto devaluation of the baht in June 1997, the economy experienced a negative growth rate of nearly 2 percent in 1997, and dropped by about 10 percent in 1998. Production, investment and domestic demand collapsed, while unemployment increased substantially. As the country approached the new millenium, signs of economic recovery were imminent. GDP was estimated to have grown by about 3 to 4 percent in 1999 and it is hoped that the recovery process will continue to the year 2000 and beyond.

Natural Resource Profile

Slightly more than 40 percent of the land in Thailand is used for agriculture; another 25 percent is forest. The remaining one-third is used for other non-agriculture purposes and includes a small portion of idle land. Of the agricultural land, slightly more than one-half is paddy land. Another one-fourth of agricultural land is used for field crops, and more than 14 percent is planted to fruit trees. Coastal aquaculture is an important fishery activity in Thailand, with shrimp farming dominating. The expansion of agricultural land and coastal aquaculture has reduced the areas of terrestrial and mangrove forests rapidly.

Water resources development in Thailand is facing a crisis. The potential to expand the supply of surface water is reaching its physical and ecological limits, while the demand for water is increasing continuously. The use of groundwater, especially in the Bangkok Metropolitan Area, has been excessive and has caused serious land subsidence. The implementation of effective demand management and integrated management of watersheds are imperative to efficient water resource utilization in the country.

Energy Profile

The demand for energy in Thailand has grown along with an expanding economy. During the period of rapid economic growth, energy consumption increased by 8-10 percent annually. But with the recent economic downturn, energy consumption also has dropped. More than 65 percent of Thailand's modern and renewable energy supply is imported. The economic crisis has not only created serious difficulties for energy-related industries, but it also has induced excess supplies of power in the short-term. This has caused Thailand to revise its energy plans, policies, programs and projects accordingly. Thailand has recently undertaken demand-side management measures and has begun the

privatization of the energy supply sector in order to improve performance and efficiency.

Inventory of Greenhouse Gases in 1994

Inventory of the greenhouse gases followed the 1996 IPCC Revised Guildlines. Local emission factors are applied where available. These local emission factors are drawn for limited research studies and subject to future improvement.

Carbon Dioxide

Using the 1996 Revised IPCC Guidelines, gross emissions of CO_2 were estimated at 241 Tg in 1994. Taking into account the amount of carbon sequestered through reforestation activities and the re-growth of natural vegetation on abandoned land, total net CO_2 emissions were estimated at 202 Tg. The energy supply sector accounted for more than half of gross CO_2 emissions in 1994 (Figure 1). Compared to 1990, CO_2 emissions from forestry and land use changes declined while those from the energy supply sector increased (Figure 2).

Methane

Total CH_4 emissions in Thailand were estimated at 3,171 Gg in 1994. About 91 percent of emissions were from agriculture. Of this, approximately 73 percent were from rice cultivation, especially the main-season crop, and 22 percent were from enteric fermentation. Land use change and forestry sector activities emitted about 60 Gg of CH_4, while solid waste disposal and wastewater treatment generated about 35 Gg in 1994 (Figure 3).

Nitrous Oxide

Thailand also produced approximately 56 Gg of N_2O in 1994, almost all of which came from agriculture. Agricultural soils emitted about 35 Gg, while manure management in the livestock sector emitted about 19 Gg. Other minor sources were the energy supply sector, land use change and forestry.

Other Gases

Other GHG emissions estimated for 1994 were NO_x, CO and NMVOC. The emissions were 287 Gg, 555 Gg and 2,513 Gg, respectively. The energy sector was the main source of NO_x emission (95 percent). The industrial process was almost the only source of NMVOC emissions (94 percent). Land use changes and forestry were the main CO emitters (94 percent).

In terms of GWP, in 1994, Thailand emitted approximately 286 Tg of CO_2 equivalent. The amount was marginal, compared to the world total. Of this total, CO_2 contributed about 71 percent while CH_4 and N_2O contributed about 23 and 6 percent respectively (Table 1).

Figure 1 Share of CO_2 Emissions by Sources, 1994

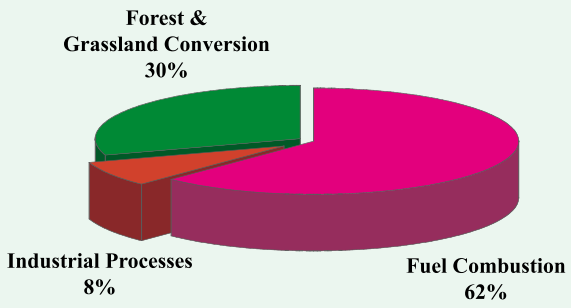


Figure 2 CO_2 Emissions by Sources, 1990, 1994

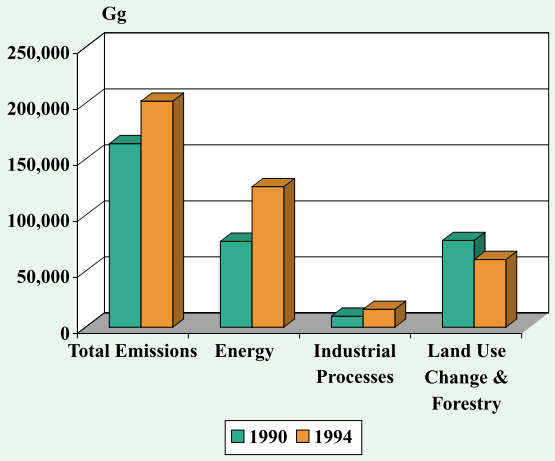


Figure 3 Share of CH_4 Emission by Sources

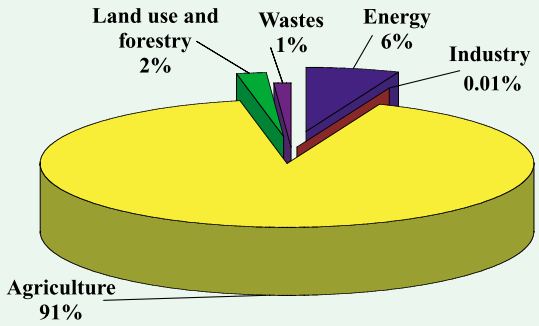


Table 1 Main Greenhouse Gas Emissions in Thailand, 1994 (Gg)

Greenhouse Gas	Emissions	GWP	CO_2 equivalent	percent to total
CO_2	202,458.05	1	202,458	70.69
CH_4	3,171.35	21	66,598	23.25
N_2O	55.86	310	17,317	6.06
Total			**286,373**	**100.00**

Greenhouse Gas Projections and Mitigation Options

GHG Projections

Energy Sector

Projections of GHG emissions were performed in selected sectors. Based on assumed GDP growth rates, final energy demand was projected to increase from 48.4 mtoe in 1995 to 68.7 mtoe by 2010, and further to 92.2 mtoe by 2020. These projections result in CO_2 emissions of 282 Tg in 2010, and 475 Tg in 2020.

Agriculture Sector

In agriculture, despite stabilization in the total area used for rice cultivation, CH_4 emissions were projected to increase from 2.1 Tg in 1994 to 2.20 Tg by 2010, and 2.24 Tg by 2020, due to an expansion in irrigated areas and more intensive fertilizer application. Different rates of expansion in the population of domestic animals were assumed in the livestock sector, resulting in a drop of CH_4 emissions from livestock from 748 Gg to 635 Gg by 2010, and then increase to 691 Gg by 2020. Emissions of N_2O from the sector were also projected at 19.1 Gg by 2010 and 21.8 Gg by 2020.

Forest Sector

Regarding the forest sector, predicting change in forest cover was difficult. However, based on the national policy on forest conservation and reforestation, it is expected that the carbon sequestration rate would increase, resulting in lower net emissions. If the trend for emissions between 1990 and 1994 is maintained, CO_2 emissions from land use changes and forestry could drop from 59 Tg in 1994 to about 51 Tg by 2010 and 46 Tg by 2020.

From the above projections, total CO_2 and CH_4 emissions from the main sectors in Thailand were projected to increase to 333 Tg and 2.8 Tg, respectively, by 2010 and to 511 Tg and 2.9 Tg, respectively, by 2020. The projected GHG emissions are highly dependent on the assumptions made. Changes in the pattern and growth rate of economic development and in the structure and efficiency of resource use will alter the projections. For example, forecasts of emissions from the energy supply sector above indicate increasing carbon intensity of energy use. Hence, a refinement of the assumptions would certainly improve the projections.

Mitigation Options

Studies on climate change in Thailand have identified several mitigation options to address GHG emissions. Interestingly, most of the options identified are similar to those available to other countries.

Energy Sector

The main options identified in the energy sector, for example, are energy efficiency through demand-side management and technology improvement as well as switching from high to low carbon content fuel sources. These options, if implemented, could reduce CO_2 emissions by as much as 330 Tg or more than 64 percent of the projected emissions by 2020. However, many of the options identified, are not economical for Thailand to implement at the present time, though least-cost analyses have shown that some options like demand-side management measures are generally economical to pursue. Thailand has been implementing several energy management programs which help mitigating CO_2 emissions. Among them are:

- Demand-side Management
- Energy Conservation Program
- Fuel switching
- IPP and SPP schemes
- Renewable energy

Forest Sector

The preserving of conservation forests to avoid emissions and the implementing of reforestation and afforestation activities to enhance carbon sinks are possible options in the forestry sector. Thailand's policy is to maintain at least 25 percent and 15 percent of the total land area as conservation forests and economic forests respectively. But, while most of the options in the forest sector are "no-regrets", many social factors must be taken into account before they can be effectively implemented. Community forests that involve mainly local inhabitants, for example, are being introduced to enhance effective forest management in Thailand.

Agriculture Sector

There are several technical options to reduce CH_4 emissions from agriculture. These include improved management of water, farm residues and chemical fertilizers, the selection of appropriate rice cultivars, and changes in cultivation techniques and practices. Because the agriculture sector in Thailand presently supports more than half of the households in the country, one must ensure that any measure introduced to control CH_4 emissions does not jeopardize their livelihood. In the livestock sector, the options to reduce CH_4 emissions include changing the feed mixture; using chemical treatments to improve digestibility; and expanding pasture and forage conservation. The efficient management of swine waste could also reduce emissions from fecal methane. However, a more detailed analysis, particularly of least-cost options, is needed.

Waste Sector

In the waste sector, at least three options were identified to mitigate potential emissions from domestic and industrial wastes, namely, recycling, reduction of wastes produced, and conversion of waste into energy. Measures to enhance recycling and reduce waste generation through the application of economic instruments have been proposed. Moreover, the technical options of using landfill gas to produce electricity or pipeline gas were found to be effective in reducing CH_4 emissions, but this measure requires large scale operations to be economically viable.

Vulnerability and Adaptation

Research and development related to vulnerability and adaptation to climate change in Thailand has just begun. Five sectors are being emphasized, namely: forestry, crops, water resources, coastal areas, and health.

Natural Forest

Based on climate scenarios from three GCMs (UK89, UKMO and GISS) that compare constant and doubling CO_2 cases, the results from the Holdridge Life Zone Classification model show that the composition of forests, by type, changed noticeably with a doubling of CO_2. The subtropical life zone areas are found to decline, while tropical life zone areas in the South increase. Subtropical dry forest areas could completely disappear and be replaced by tropical dry forests. A new type of forest, tropical very dry forest, could emerge in the North and the Northeast of the country.

Under this scenario, several adaptation options are proposed for implementation. Reforestation could be done with drought and heat tolerant tree species. Conservation areas for preservation could be prioritized to emphasize vulnerability. Gene banks and collection of various plant species could be accelerated to provide more diversity of choices. More importantly, capacity building to enable undertaking vulnerability and adaptation analyses in the forestry sector should be enhanced to improve research and development capability in this area.

Agriculture

Studies on the impacts of climate change on agriculture were conducted in two provinces for both rice and maize. Using the scenarios from four GCMs as the base, results of the analyses show that the potential impacts on rice yields are extensive and diverse between models as well as locations. Rice yields are found to drop by more than half in one case and increase by one-fourth in another. To a lesser extent, climate change could cause the yields of maize to drop from 5 to 44 percent.

These studies suggest that there are still many uncertainties in the climate scenarios from GCMs. Several constraints and limitations are identified. At a preliminary stage, however, adaptation to climate change could be approached by intensifying the conservation of drought-resistant varieties; by improving crop varieties to drought-tolerant types; by improving cropping practices to conserve water; and by promoting crop diversification. Several aspects of vulnerability and adaptation analysis in the agricultural sector also could be improved, including an improvement in the climate scenarios, development of more suitable crop models, and search for alternative analytical approaches. These should be done before a more meaningful adaptation analysis could be made.

Water Resources

Potential climate change impacts on water resources were analyzed by assessing the effects on the water storage capacity of a dam and on the Chao Phraya River basin. In one study, the results indicate that increased evapo-transpiration rates could cause water shortage in the watershed above the Sri Nakarin Dam in 10-15 years. Likewise, a more recent study shows that higher temperatures and lower rainfall due to climate change could reduce average annual runoff in the Chao Phraya basin in the central plain by more than 34 to 44 percent. The results, however, are based on only one station and one GCM. More research in this area is required to improve the understanding of potential impacts. The results also showed that adaptation options are limited to strengthening the existing water resource management system and to accelerating the implementation of new policies introduced recently, such as the proposed water act, effective demand-side management, and systems for integrated watershed management and community-based resource management.

Coastal Resources

Analyses of potential impacts on coastal areas due to a rise in the sea level indicate that such impacts vary widely depending on the topographical nature and land use patterns in the areas. As sandy coastal plains in

Thailand support a wide range of important economic activities, the potential impacts on these areas could be exceptionally high. The same is true for mangrove swamps and salt marshes. An assessment of the tidal range in the Gulf of Thailand indicates that a rise in the mean sea level by one meter could increase the tidal range by the same height. Tidal speed could also increase, causing more damage to shorelines. Several potential impacts are identified including impacts on inundation of coastal areas and the existing drainage and flood control facilities, increasing salinity intrusion. However, the vulnerability analysis conducted to date does not provide sufficient basis for drawing conclusions and policy recommendations with regard to adaptation options. More research in this area is required.

Health

On the potential impacts of climate change on health, the analysis emphasized the risk of a malaria outbreak. Based on projected increases in temperature for the period 1998-2050 under a climate change scenario, the number of cases of malaria infection rises substantially. The preliminary estimate of potential damage could be in hundreds of million dollars. Adaptation options could be drawn from historical experiences, although chemical control of the potential outbreak may not be appropriate due to disease resistance and ecological effects. More research and development of alternative approaches to control a possible malaria outbreak are required.

Future Research Issues

An important lesson derived from the vulnerability and adaptation analyses conducted in Thailand so far is the necessity to give more support to research and development on this subject. The specific areas of focus include:

- Improvement of climate modeling
- Development of impact modeling
- Expansion the analysis to other sectors
- Development of approaches to adaptation analysis
- Development of very long-term socio-economic scenarios

Policies and Measures

Sustainable Development Policy

The economic and social development of Thailand has been guided by successive 5-year National Economic and Social Development Plans. At present, the country is implementing the 8th Plan (1997-2001). Natural resources conservation and environmental protection have been emphasized since the 6th National Plan (1987-1991). The passing of the 1992 Environmental Quality Enhancement and Conservation Act has further improved protection for natural resources and the environment by requiring the government to prepare a 20-year Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality. The proposed policy provides for 5-year Environmental Quality Management Plans to be prepared and used to guide natural resource and environmental management side-by-side with the 5-year National Economic and Social Development Plans.

The most fundamental change in Thai society that could dramatically accelerate the sustainable development of the country was the adoption of the New Constitution in 1997. The new Constitution provides the basic principles for development of a better political system for Thai society. It gives local communities the right to manage natural resources, to access public information, and to participate in the overall development process for management of natural resources and the environment. Several other laws also contribute to natural resources and environmental conservation, such as the Energy Conservation and Promotion Act promulgated in 1992, the proposed new water act, and the Community Forestry Act. It is noteworthy that Thailand has incorporated the National Action Plan for Agenda 21 into its national development plan as well.

Climate Change Policy

While the 5-year National Economic and Social Development Plans and the 5-year Environmental Quality Management Plans have incorporated climate change issues into social and economic development strategies, the National Committee on Climate Change has played an important role in drawing up a national strategy to address climate change issues. An Expert Committee on Climate Change has been established to provide technical recommendations to the Committee.

To address climate change problems, Thailand has adopted a basic policy of "no-regrets" in the choice of options to mitigate greenhouse gases. International and regional cooperation under the Framework Convention on Climate Change is another fundamental policy of the country. In this regard, Thailand has hosted several AIJ projects and has participated actively in research and development on climate change issues with other countries.

Mitigation Measures

Energy Sector

At the implementation level, energy policies and measures such as demand-side management and energy conservation programs in the commercial and industrial sectors have succeeded in conserving energy as well as improving energy efficiency substantially. The 5-year DSM program was estimated to have avoided the emission of about 1.7 million tons of CO_2. Other measures such as excise tax incentives to promote the use of environmentally friendly machines, equipment and

raw materials and restructuring of electricity tariff to promote energy efficiency have also been implemented. Energy policies of Thailand which can enhance CO_2 mitigation, among others, are:

- The second phase of Demand-side Management
- Fuel switching
- Energy conservation program
- Demonstration program on solar energy
- Development of Energy Service Company
- Public Campaigns on energy conservation
- Improving public transportation system

Forest Sector

Over the past 5 years, various reforestation and afforestation programs have increased forest cover by several hundred thousand hectares. As shown in the 1994 GHG inventory, forest expansion has sequestered nearly 40 million tonnes of CO_2. The amount of CO_2 removed could be even more extensive, when the areas reforested in recent years are considered. Several new forestry policies and measures to complement existing forest conservation efforts are being formulated to avoid any increase in emissions.

Adaptation Measures

The lack of sufficient research and development inhibits the development of comprehensive policies and measures concerning adaptation. Potential adaptation options have been identified in very general terms, such as the development of genetic properties related to climate change, changes in agricultural practices, and aggressive water resources conservation. The main thrust with regard to vulnerability and adaptation is to enhance the research and development capacity of Thailand in these areas.

Public Awareness

Another important policy is the necessity of increasing public awareness of climate change issues. The public should be kept informed and updated regularly on scientific, technical, and policy developments related to climate change.

Financial Resources, Technology Transfer and Capacity Building

Technologies are important to sustain economic development. During the early stages of Thailand's development, substantial official development assistance (ODA) was received from various bilateral and multilateral sources. The assistance in the form of "soft and hard technologies", has declined gradually over the years. These technologies have now acquired primarily through the market system.

Technology Transfer

Thailand views transfer of climate change technology different from that of other types of technologies. Firstly, the transfer process must adhere to the Framework Convention on Climate Change. Secondly, efforts to balance efficiency and equity considerations must always be endeavored. Free market forces can be effective only to a certain extent, and public interventions in the market may be necessary to facilitate such transfer. The many barriers to effective technology transfer and adoption should be eliminated and favorable conditions must be enhanced.

Technology Needs

The potential recipients should identify and prioritize their technology needs, and the technology providers should give full support to their acquisition. On GHG inventory and mitigation technologies in particular, Thailand emphasizes technology transfer and capacity building on inventory methodologies and welcomes mitigation technologies that support its "no-regrets" options. The transfer of technologies should be considered within the Framework Convention on Climate Change.

Barriers to Technology Transfer

In regard to barriers to technology transfer, Thailand views external barriers, and not domestic barriers, as the main constraints to such transfer. External barriers are largely beyond the control of recipient countries like Thailand. There must be a transparent system to ensure that the transferred technology is appropriate, up-to-date and clean - and not driven purely by profit motives. The achievement of such objectives requires some form of public policy intervention, rather than submitting to market forces alone.

Capacity Building

Capacity building for local experts and researchers, especially in the study of vulnerability and adaptation options, is critically important to Thailand. The development of an interactive process between local researchers and regional and international experts will help accelerate the capacity building process. Such capacity building is necessary for Thailand to effectively address vulnerability and adaptation issues.

Opportunities

Key elements for enhancing technology transfer include the serious consideration of efficiency and equity issues; the development of local initiatives; the establishment of a technology information network; the creation of effective financial mechanisms; and, the strengthening of local capacity.

Public Education and Awareness

Thailand has promoted education and public awareness of climate change issues through various means. At the very basic level, a primer to increase understanding of climate change issues was translated into Thai and disseminated to public schools, libraries and government agencies. Posters, leaflets and other information materials have been distributed on special occasions or events. Workshops and seminars to present and discuss key issues have been organized. Public education and awareness, as well as public participation in environmental protection activities also have been promoted regularly.

Subjects pertaining to the conservation of natural resources and environmental protection, including climate change, have been incorporated into the educational curricula of schools from the primary level. The 1992 National Education Scheme and the 8th National Education Development Plan (1997-2001) give further impetus to the study of natural resources and the environment. The importance of wise use and conservation of natural resources has been one of the four fundamental principles that guide the National Education Scheme. Several projects have been implemented to promote energy conservation in schools, not only in terms of education but also in practice. Thailand also has encouraged the use of the Internet to promote information exchange among schools. There are now more than 1,300 schools registered with the online education site, Schoolnet, and the number is expanding.

Thailand has emphasized the participation of students and youth in resource conservation. The participation of students in public reforestation and afforestation programs throughout the country has been encouraging. Responsible authorities have provided basic training courses on biological, forestry and wildlife resources for conservation for the students and youth.

To promote public awareness of the environment, various government agencies stage campaigns through different media. A "bottom-up" approach to resource management has stimulated more local participation and awareness of environmental problems. Local public awareness programs have been developed and 30-40 million baht is allocated annually to such activities from the public budget.

Public awareness is strongly linked to public participation in activities that address environmental issues. Promoting the role of local communities, NGOs and the private sector in pursuit of sustainable development in Thailand has therefore contributed greatly to raising public awareness of environmental problems and issues such as climate change. Thailand is resolved to continue its active support and efforts to promote education and public awareness on climate change issues.

THAILAND's
INITIAL NATIONAL COMMUNICATION
UNDER THE UNFCCC

Chapter

1

Introduction

Thailand signed the United Nations Framework Convention on Climate Change on 12 June 1992, and ratified it in December 1994, becoming effective three months later, on 28 March 1995. As a party to the Convention, Thailand has actively participated in the Convention process. This initial communication is one of the obligations the Convention requires of developing countries like Thailand.

Preparation of this initial national communication was guided by the Guidelines for Initial Communication for Non-Annex I Parties. The estimation of national greenhouse gas inventory of Thailand for 1994 used the 1996 Revised Guidelines of IPCC as a reference. This initial national communication is the result of the collaborative efforts of all agencies concerned, using experiences gained from research and development on climate change issues accumulated over the past few years.

This communication begins with an executive summary, followed by a brief introductory chapter that discusses national circumstances and provides an overview of Thailand's sustainable development process. The chapter also gives a brief account of the recent financial and economic crises. Based on the results of greenhouse gas emission estimates in different sectors, Chapter 3 presents a summary of a national inventory of greenhouse gases for 1994. Chapter 4 discusses projections of greenhouse gases and mitigation options potentially applicable to Thailand. In Chapter 5, the results of research to evaluate vulnerability and adaptation in major sectors - forestry, agriculture, water resources, coastal areas, and health - are presented. Lessons learned are discussed and areas for future research and development are identified. National policies and measures to pursue sustainable development, and to address climate change are described in Chapter 6. The financial resources that Thailand must mobilize to address natural resource and environmental management issues, to adopt technology and develop know-how, and to build national capacity are discussed in Chapter 7. In this chapter, the requirements for technology transfer and capacity building are outlined and ways to enhance national capacity to address climate change are discussed. Chapter 8 provides information on public education and awareness programs for natural resource conservation and environmental protection. Finally, Chapter 9 concludes the national communication of Thailand.

THAILAND's
INITIAL NATIONAL COMMUNICATION
UNDER THE UNFCCC

Chapter

2

National Circumstances

- Topography and Climate
- Socio-Economic Profile
- Natural Resource Profile
- Energy Profile

2.1 TOPOGRAPHY AND CLIMATE

Thailand lies between latitudes 5º40' and 20º30' N and longitudes 97º20' and 105º45' E in the southeastern part of the Asian mainland. Myanmar is on the western and northern borders, Laos to the northeast, Cambodia to the east, and Malaysia to the south (see Figure 2.1). The total land area of the country is 513,115 square kilometers (320.7 million rai).

The climate in Thailand can be classified generally into three distinct seasons: hot, wet and cool seasons. The mean annual temperature is between 22-32ºC, with the peak normally occurring in April. The highest recorded temperature during the period 1961-1990 was 44.5ºC. Average annual precipitation is 1,692 mm, although rainfall exceeding 2,000 mm is common in the Southern Peninsula.

Thailand is divided into five regions: North, Northeast, Central, East and South. The North is mainly mountainous with average altitudes rising over 200 meters above mean sea level. The Northeast comprises the Korat Plateau, which lies 100-200 meters above sea level. The Central Plains are the alluvial basin of country's principal river, the Chao Phraya, which drains this most fertile area known as "the rice bowl of Asia". Most of the land area in this region lies below 50 meters elevation and is prone to flooding. The Southern Peninsula, which stretches downward to the Malaysian border, consists of a narrow strip of land where mountain ranges run north to south separating the eastern coast along the Gulf of Thailand and the western coast by the Andaman Sea. The East is dominated by fertile land suitable for tree crops and a long coastline. Thailand has a coastline of more than 2,500 km.

Coastal areas can be divided into the Gulf of Thailand coastline that adjoins the Pacific Ocean, and the Andaman Sea coastline of the Indian Ocean. The two coasts possess different characteristics. The Gulf of Thailand is relatively shallow, with an area of about 30,400 square kilometers, that can be divided into 3 sections - the inner, eastern, and western Gulf. The entire length of this coastline is approximately 1,875 kilometers and is administered under 15 provinces. The average depth of the area is 58 meters, with the deepest part at 84 meters. The Gulf of Thailand is under the influence of the northeastern and southwestern monsoons. The Andaman Sea covers an area of about 116,280 square kilometers and has a total coastline of 740 kilometers. The deepest part of the sea is 1,800 meters. It is an open sea and is under the same seasonal monsoon influence as the Gulf of Thailand.

Figure 2.1 Map of Thailand

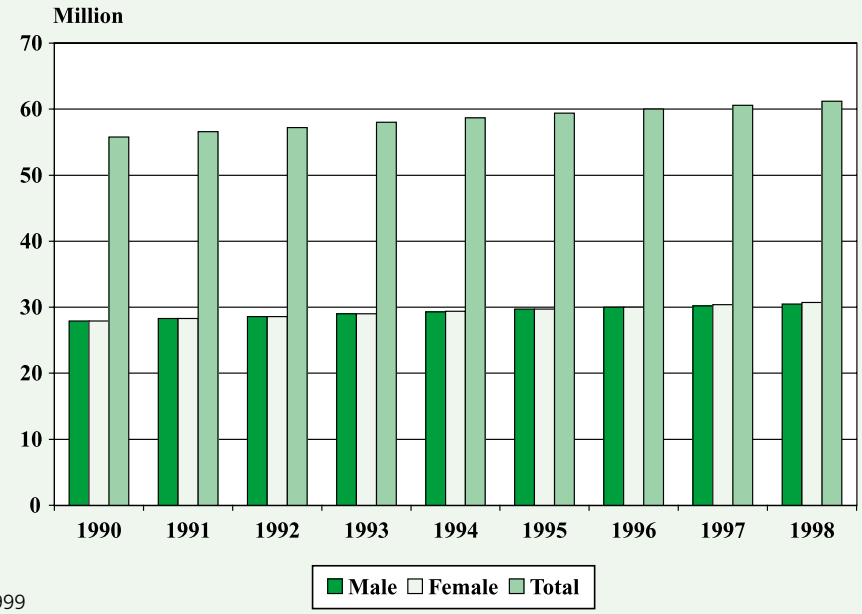
Thus situated, Thailand is quite vulnerable to extreme weather events such as tropical storms, flood and drought. Flood and drought, in particular, have become more common in recent years and are increasingly damaging. During the period 1951 to 1991, almost all of the 145 tropical cyclones fell into the category of "tropical depressions," the least severe storm classification. In some years, the storms were more devastating. Since 1991, at least two tropical storms have affected Thailand annually, resulting in considerable damage to human life and property. Areas affected by flooding appear to be on the increase. This vulnerability is seen as natural, yet most people in Thailand believe that the severity of damage could be reduced if local ecological systems are better conserved and managed. Such was the case of a massive landslide in Southern Thailand that induced the government to impose a logging ban since 1989.

2.2 SOCIO-ECONOMIC PROFILE

Thailand's population reached approximately 62 million in 1999. The population grew at an average of 1.5 percent per year during the period 1980-1997, but has substantially slowed down to about 1.1 percent in more recent years (see Figure 2.2). The average population density as of 1996 was 117 persons per sq km, with a large difference between Bangkok and other regions of the country (Table 2.1). The vicinity of Bangkok and the Eastern region also showed a relatively high population density compared to other regions.

The average life expectancy at birth of a Thai is about 72 years. The life expectancy for males increased from about 56 years in 1964-65 to 70 years in 1995-96,

Figure 2.2 Population of Thailand, 1990-1998



Source: NESDB, 1999

Table 2.1 Population Density in Thailand, by Region (as of December 1996)

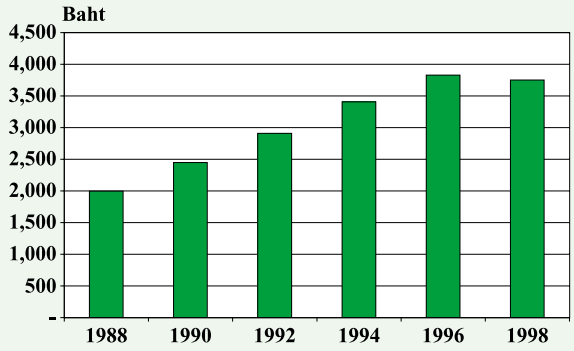
Region	Density (persons/sq km)
Bangkok Metropolitan Area	3,568.16
Provinces Adjacent to Bangkok	552.90
Central Sub-Region	82.06
West	109.52
East	909.52
Northeast	123.36
North	70.66
South	110.42
Whole Kingdom	117.16

Source: Office of Central Civil Registration, Ministry of Interior

while that for females increased from 62 years to 75 years during the same period. The death rate among infants also declined rapidly at an average rate of 10 percent per year during 1991-1996. The maternal mortality rate, meanwhile, was only 10.6 deaths per 100,000 pregnant women in 1997 (Kakwani and Potong, 1999).

Rapid economic development during the 1980s and the first half of the 1990s reduced the incidence of poverty significantly. The number of people living in poverty decreased substantially from nearly 18 million in 1988 to little less than 7 million in 1996. Based on a socioeconomic survey covering the period 1988 to 1996, per capita real income, a crude measure of standard of living, increased from less than 2,000 baht (US dollar 1.00 = 25.00 baht) per month to more than 3,830 baht in 1996 (Figure 2.3). Household welfare[1], which is indicated by the percentage of excess income households have over their respective poverty thresholds, grew from 212 in 1988, to 386 in 1996 (Kakwani, 1999).

Figure 2.3 Average Per Capita Real Income (baht per month)

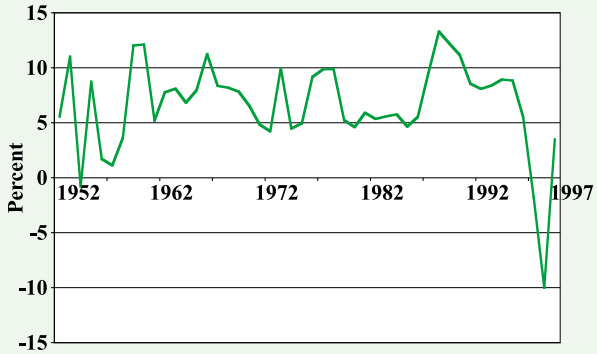


Source: NESDB

The Economy Prior to the Crisis

The five-year National Economic and Social Development Plans provide a blueprint for economic and social development of Thailand. At present, the country is halfway through its 8th National Plan (1997-2001). Figure 2.4 shows the long-term trend of economic growth of the country.

Figure 2.4 Economic Growth of Thailand 1952-1997



Since the adoption of its first National Economic and Social Development Plan nearly four decades ago, the economy of Thailand has gone through substantial structural change. The pattern of economic development in Thailand is common to many other countries in the world - from an agricultural-based economy to an agro-industrial and industrial-oriented economy. The 1960s and 1970s were a period of growth and diversification. With an average growth rate of nearly 8 percent per year, agricultural production expanded and diversified significantly, while the industrial sector was focused mainly on import substitution activities. The 1980s were a period of structural adjustment and industrial take-off. Guided by the 5th and 6th National Plans, the economic boom was largely export driven, especially during the latter half of the 1980s. Consequently, the country's economic structure changed, with the contribution of the agriculture sector falling from about 30 percent in the 1960s, to only slightly more than 10 percent of GDP in the 1980s. The industrial sector, on the other hand, accounted for about 30 percent of GDP in the 1980s.

The enormous inflow of direct foreign investment into Thailand and the favorable world economic situation helped Thailand register double-digit growth for a few years. This rapid growth, in turn, accelerated demand for infrastructure facilities and skilled labor, pushing wages up and creating an artificially high demand for infrastructure. Meanwhile, Thailand's competitive position in the international market began to deteriorate, particularly in labor-intensive and resource-based industries.

During the early 1990s, the economy grew by between 6-11 percent annually, boosted by continued expansion in the non-agriculture sector (Table 2.2). GNP per capita increased from about 39,000 baht in 1990 to more than 60,000 baht in 1994. Both exports and imports grew rapidly, and although the trade balance was chronically in deficit, the balance of payments remained positive due to massive inflows of both short and long-

[1] the ratio of per capita income of a household to the per capita poverty line of that household

Table 2.2 Key Economic Indicators, 1990-1994 (prior to the economic crisis)

	1990	1991	1992	1993	1994
Population (millions)	**55.84**	**56.57**	**57.29**	**58.01**	**58.73**
GDP					
GDP at constant 1988 prices (Percent change)	11.2	8.6	8.1	8.4	9.0
Agriculture	-4.7	7.3	4.8	-1.3	5.4
Non-agriculture	14.1	8.8	8.6	9.8	9.4
GDP at current prices (billion baht)	2,183.5	2,506.6	2,830.9	3,170.3	3,634.5
(Percent change)	(17.6)	(14.8)	(12.9)	(12.0)	(14.6)
GNP per capita (Baht)	38,613.0	43,655.0	48,311.0	53,593.0	60,953.0
CPI (percent change)	**6.0**	**5.7**	**4.1**	**3.3**	**5.0**
External Accounts (US dollar billion)					
Exports	22.9	28.3	32.2	36.6	44.7
(Percent change)	(15.1)	(23.8)	(13.8)	(13.4)	(22.5)
Imports	32.7	37.8	40.1	45.1	53.4
(Percent change)	(29.8)	(15.7)	(6.0)	(12.4)	(18.1)
Trade Balance	-9.8	-9.5	-7.9	-8.5	-8.7
Current Account Balance	-7.1	-7.4	-6.1	-6.1	-7.8
(Percent of GDP)	(-8.3)	(-7.5)	(-5.5)	(-4.9)	(-5.4)
Net capital movement	9.7	11.3	8.1	10.5	12.2
Private[1/]	11.0	10.3	8.0	10.3	12.0
Public	-1.2	1.0	0.1	0.2	0.2
Bank of Thailand	-	-	-	-	-
Balance of Payments	3.8	4.2	3.0	3.9	4.2
International Reserves (US dollar billion)	14.3	18.4	21.2	25.4	30.3
Exchange rate (Baht per US dollar)	**25.59**	**25.52**	**25.4**	**25.32**	**25.15**

[1/] Include commercial banks and BIBFs

Source: NESDB

term capital. International reserves stood at US dollar 30 billion in 1994. The foreign exchange rate was almost fixed at 25 Baht per US dollar 1.

Despite the rapid economic growth achieved at the end of the 7th National Plan, social, natural resource and environmental goals were not achieved. Increased social inequality threatened the economic and political stability of the nation, while natural resources and the environment deteriorated at alarming rates.

The experiences of the 7th National Plan provided fundamental lessons in drawing up the 8th National Plan. This new plan has been undertaken to improve the quality of life of all people in society. People became the center of development, and human resource development became the fundamental objective of the Plan.

The Economic Crisis

Since the second half of the 7th National Plan (1994), the Thai economy had shown signs of slowing down. Economic indicators suggested an overvalued currency and over-investment in unproductive sectors, as well as widespread speculation. The collapse of the financial sector sparked a series of economic problems and the Thai currency came under serious attack from financial speculators. Thai exports recorded their first negative growth in 1996 while import growth was negligible. The trade and current account deficits widened, and massive withdrawals of private short-term capital pushed the country's capital account balances in the red (Table 2.3).

In June 1997, the government decided to adopt a managed float exchange rate system, allowing the baht to depreciate from 25.50 baht per US dollar, to as high as 53.82 baht per US dollar in January 1998. At the same time, the operations of several banks and financial

institutions were suspended and eventually closed down due to huge accumulated losses from non-performing loans. Production, investment, and domestic demand collapsed, while unemployment increased as businesses and manufacturers ceased operations, cut production costs, or down-sized. In order to contain the crisis, Thailand turned to the International Monetary Fund for support and adopted austere fiscal and monetary policies.

Despite various monetary and fiscal measures taken, the economic crisis continued in 1997 and deepened in 1998. GDP growth dropped by 12 percent and 11 percent in the second and third quarters of 1998, respectively. On the whole, Thailand's economy showed a negative growth rate of about 10 percent in 1998.

The economic crisis is believed to have bottomed out during the second quarter of 1999. The foreign exchange rate has stabilized at around 37-39 baht per US dollar. Excessive liquidity in the market has pushed interest rates down to the lowest level in ten years, while inflation has remained under control (Table 2.3). The pace of economic recovery remains uncertain, however. This largely depends on the ability of the government to solve problems in the financial sector as well as on the country's ability to improve competitiveness and increase exports.

Table 2.3 Key Economic Indicators, 1995-1999 (during the crisis)

	1995	1996	1997	1998p	1999E
Population (millions)	**59.40**	**60.00**	**60.60**	**61.20**	**61.8**
GDP					
GDP at constant 1988 prices (Percent change)	8.9	5.9	-1.8	-10.0	3.0-4.0
Agriculture	2.9	3.6	-0.7	-0.7	3.0
Non-agriculture	9.7	6.2	-1.9	-11.1	3.0-4.0
GDP at current prices (billion Baht)	4,185.6	4,608.5	4,724.1	4,664.70	4,765.0
(Percent change)	(15.2)	(10.1)	(2.5)	(-1.3)	(2.2)
GNP per capita (Baht)	69,316.0	75,103.0	75,938.0	n.a.	n.a.
CPI (percent change)*	**5.8**	**5.9**	**5.6**	**8.1**	**0.3**
External Accounts (US dollar billion)*					
Exports	55.7	54.7	56.7	52.9	46.4
(Percent change)	(24.8)	(-1.9)	(3.8)	(-6.8)	(5.5)
Imports	70.4	70.8	61.3	40.6	38.4
(Percent change)	(31.9)	(0.6)	(-13.4)	(-33.8)	(12.9)
Trade Balance	-14.7	-16.1	-4.6	12.3	8.0
Current Account Balance	-13.2	-14.4	-3.1	14.3	9.8
(Percent of GDP)	(-7.8)	(-7.9)	(-2.0)	(12.3)	
Net capital movement**	21.9	19.5	-9.1	-9.5	-5.9
Private[1/]**	20.8	18.2	-8.1	-15.5	-11.7
Public**	1.1	1.3	1.6	2.0	1.8
Bank of Thailand**	-	-	-2.6	4.0	4.0
Balance of Payments	7.2	2.2	-10.6	1.7	2.4
International Reserves (US dollar billion)***	37.0	38.7	27.0	29.5	32.5
Exchange rate* (Baht per US dollar)	**24.92**	**25.34**	**31.37**	**41.37**	**37.71**

* Figures for 1999 are for Jan-Oct; ** figures for 1999 are for Jan.-Sept; *** as of November 1999

Note: p is preliminary; E is estimated

[1/] Include commercial banks and BIBFs.

Source: NESDB

2.3 NATURAL RESOURCE PROFILE

Land and Forests

The total land area of Thailand is about 513 thousand square kilometers (321 million rai). The country is divided into five regions. Of the total land area, the Northeast and the North each constitutes about one-third. The Central Plain and the South occupy about 13 percent and 14 percent of the total land area, respectively. The remaining 7 percent of the area is in the East. Of the total land area, more than 40 percent is used for agriculture, about 25 percent is forests, and about 16 percent is degraded land, that is not suitable for cultivation due to salinity, mountainous terrain, and soils that are shallow or have low fertility.

The expansion of agricultural lands has resulted mainly from the conversion of forest areas. Population growth has overtaken the rate of land expansion, resulting in a drop in average land holding per capita from 0.40 ha in 1983, to 0.35 ha in 1993.

More than half of all agricultural land is used to cultivate paddy rice, followed by field crops (24 percent) and fruit trees and tree crops (16 percent) (Table 2.4). A small portion of land is devoted to growing vegetables and flowers. Nearly 3 percent of the total agricultural land is idle (Table 2.5). Paddy and field crops are planted widely in all regions, except in the South where fruit trees and tree crops are cultivated widely.

Stretching from North to South and occupying large tracts of land, Thailand's forests are quite diverse, consisting of tropical evergreens, mixed deciduous and dipterocarps, as well as small stands of pine and mangrove. Tropical evergreens are the dominant species and are distributed extensively throughout the southern part of the country. Mixed deciduous and dry dipterocarp forests are found mostly in the North, West and Northeast.

Prior to 1960, forest land accounted for more than 50 percent of the country's total land area. The logging of forest resources through timber concessions gradually reduced forested areas. Harvesting and encroachment of forests by poor rural communities also contributed to the decline in forested land. In 1989, the government banned logging and aggressively promoted afforestation and reforestation.

Table 2.6 shows the change in forest cover over the past decade. Forest cover was reduced from 28 percent to 25 percent between 1988-1998. Most of the remaining forested areas are found in the North. There are some forests in the Central and Eastern regions, while the Northeast has the lowest forest cover in the country. Thus, despite the logging ban in 1989, deforestation still continues to the present.

Table 2.4 Land Use in Thailand, 1995 (ha)

Type of Land Use	Northeast	North	Central Plain and the East	South	Whole Kingdom
Total land	16,885,434	16,964,429	10,390,120	7,071,519	51,311,502
Forest land	2,126,467	7,388,592	2,387,984	1,245,463	13,148,506
Farm holding	9,257,468	4,674,679	4,358,031	2,906,394	21,196,571
Housing area	212,563	143,706	125,449	81,272	562,989
Paddy land	6,064,598	2,431,350	1,889,650	541,243	10,926,840
Field crop	2,059,018	1,634,792	1,413,101	14,878	5,121,790
Fruit trees	381,239	316,457	727,453	2,145,890	3,571,039
Vegetable land	38,986	51,437	48,543	14,304	153,269
Grass land	76,836	17,470	19,886	7,560	121,750
Idle land	350,153	41,898	60,556	62,826	515,434
Other land	74,075	37,569	73,393	38,422	223,459
Unclassified land	5,501,500	4,901,157	3,644,105	2,919,663	16,966,425

Source: Center for Agricultural Statistics, Office of Agricultural Economics

Table 2.5 Distribution of Land Use by Region in Thailand, 1995 (percent)

Type of Land Use	Northeast	North	Central Plain and the East	South	Whole Kingdom
Total land	100.00	100.00	100.00	100.00	100.00
Forest land	12.59	43.55	22.98	17.61	25.62
Farm holding	54.83	27.56	41.94	41.10	41.31
Housing area	1.26	0.85	1.21	1.15	1.10
Paddy land	35.92	14.33	18.19	7.65	21.30
Field crops	12.19	9.64	13.60	0.21	9.98
Fruit trees	2.26	1.87	7.00	30.35	6.96
Vegetable land	0.23	0.30	0.47	0.20	0.30
Grass land	0.46	0.10	0.19	0.11	0.24
Idle land	2.07	0.25	0.58	0.89	1.00
Other land	0.44	0.22	0.71	0.54	0.44
Unclassified land	32.58	28.89	35.07	41.29	33.07

Source: Adapted from Table 2.4

Table 2.6 Forest Cover in Thailand in Selected Years, 1988-1998

Region	Total Area (sq km)	Forest Cover (percent)					
		1988	1989	1991	1993	1995	1998
North	169,644.29	47.39	47.29	45.47	44.35	43.55	43.06
Northeast	168,854.34	14.03	13.97	12.91	12.72	12.59	12.43
Central	67,398.70	25.59	25.55	24.65	24.34	24.17	23.81
South	70,715.19	20.69	20.65	19.02	18.11	17.61	17.15
East	36,502.50	21.46	21.33	21.07	20.91	20.80	20.57
Whole Kingdom	513,115.02	28.03	27.95	26.64	26.03	25.62	25.28

1. The existing forest cover in this table refers to all forest types such as evergreen, pine, mangrove, mixed deciduous, dry dipterocarp, scrub, swamp, bamboo and forest plantations in national forest reserves, national parks, wildlife sanctuaries, forest work plans and forest concessions that can be detected by LANDSAT - TM images at the scale of 1: 250000, but not including rubber plantations and orchards.
2. The areas of the different regions of the country are based on the calculation of the Royal Thai Survey Department in 1978 and declared by Cabinet resolution on 12 July 1983. The areas of new provinces (Nongbua Lumphoo, Umnad Chareun and Sa Kaew) are based on the calculation of the Local Administration Department on 30 December 1993.
3. Forest cover data for 1989 were acquired from the interpretation of LANDSAT - 4 and 5, taken in 1989, with some ground checks in 1989 and 1990.
4. Forest cover data for 1991 were acquired from the interpretation of LANDSAT - 5 (TM), taken in 1991, with some ground checks in 1991 and 1992.
5. Forest cover data for 1993 were acquired from the interpretation of LANDSAT - 5 (TM), taken in 1993, with some ground checks in 1993.
6. Forest cover date for 1995 were acquired from the interpretation of LANDSAT - 5 (TM), taken in 1995.
7. LANDSAT - 5 (TM) Geocoded images at the scale of 1 : 50000 were used for interpretation of mangrove forest area in 1993. In order to get the same standard, LANDSAT - 5 (TM) Geocoded images at the same scale were used in 1995, and existing mangrove forest areas in Samut Prakan, Bangkok, Samut Sakhon and Samut Songkhram were detected.
8. Forest cover data for 1998 were acquired from the interpretation of LANDSAT - 5 (TM), taken between January and March 1998, but did not include ground checks.
9. The areas of existing and decreasing forest were based on the areas of each region and the country.
10. Field verification was conducted by using stratified random sampling system.

Source: Royal Forest Department

Coastal Resources

Thailand has a coastline that extends for more than 2,500 km. The coastal zone is divided into that bordering the Gulf of Thailand, adjoining the Pacific Ocean, and that adjacent to the Andaman Sea, which is part of the Indian Ocean.

The physical structure and natural endowment of Thai seas have generated a diversity of biological and non-biological resources. Thai seas contain more than 200 families of fishery resources. Of these, there are more than 1,000 species of fish and about 900 types of other marine resources. In addition, these areas are rich in non-biological resources such as oil, gas and other mineral resources as well as 18 recreational areas.

Coastal aquaculture is the most important fishery activity in Thailand, dominated by shrimp farming. Shrimp production constitutes about three-fourths of the total coastal aquaculture output. More than 30,000 households earn their livelihood from shrimp farming, which covers an area of more than 64,000 ha in three regions (Table 2.7). Since the early 1990s, Thailand has been one of the world's leading exporters of shrimp and shrimp products. In 1994, total production of shrimp and prawns was nearly 390 tonnes, valued at nearly 46 billion baht (Office of Agricultural Economics, 1998). In 1995, more than 72,000 ha of shrimp farms produced over 260,000 tonnes of shrimp and prawns, most of which were the jumbo tiger prawn (Table 2.8).

Mangrove forests, seagrass beds and coral reefs are natural resources vital for maintaining the ecological balance of Thai seas and coastal areas. Mangrove forests are important nursery grounds for a variety of fish. They are important sources of charcoal and firewood and protect coastal areas from seashore erosion.

Since 1961, significant areas of terrestrial and mangrove forests in Thailand have been destroyed (Table 2.9). The area decreased from 358 thousand ha to only slightly higher than 168 thousand ha in 1996 (Table 2.10). Mangrove forests in Thailand have been converted to other uses, including aquaculture, residential areas, industrial facilities, solid waste disposal sites, roads and public buildings. Most of the remaining mangrove forests in Thailand are found in the South of the country, especially along the Andaman Sea.

Table 2.7 Coastal Shrimp Farming by Region in Thailand, 1990-1995 (ha)

Region	1990	1991	1992	1993	1994	1995
Central	21,553.3	20,392.6	19,176.5	20,131.0	21,104.0	18,950.1
Eastern	15,925.3	21,358.2	21,312.6	21,115.4	20,995.5	23,947.2
South (Andaman Sea)	1,545.3	2,950.6	3,271.4	4,232.3	5,266.9	6,360.0
South (Gulf of Thailand)	25,582.1	30,630.7	29,051.5	26,408.0	25,880.5	25,679.5
Total	64,606.0	75,332.1	72,812.0	71,886.7	73,246.9	74,941.8

Source: Department of Fisheries

Table 2.8 Area and Production of Shrimp Culture in Thailand, 1985-1994

Year	Area (ha)	Production (tonnes)				
		Total	Banana	School	Jumbo tiger	Other
1985	40,769	15,841	10,397	3,635	106	1,703
1990	65,849	118,227	7,666	1,872	107,969	720
1991	75,332	162,070	5,812	970	155,069	219
1992	72,796	184,884	4,752	693	179,358	81
1993	71,887	225,514	3,285	1,257	219,900	1,073
1994	73,247	263,446	2,180	803	259,083	1,380

Source: Department of Fisheries

Table 2.9 Forests in Thailand, by Region (ha)*

Region	1961	1979	1989	1993	1996
Central	20,625	195,200	3,725	33,519	34,057
Eastern	178,500	275,900	129,430	81,548	79,113
South (Andaman Sea)	1,446,250	1,113,475	888,564	836,545	830,650
South (Gulf of Thailand)	565,000	211,100	106,775	102,654	103,571
Total	**2,210,375**	**1,795,675**	**1,128,494**	**1,054,266**	**1,047,390**

* the figures are based on the interpretation of aerial photos with different scales.
Source: Royal Forest Department

Table 2.10 Change in Area of Mangrove Forest in Thailand, 1993 and 1996 (ha)

Type of land use	1993	1996
Mangrove Forest	168,683	167,582
Shrimp farm	64,992	66,998
Community	4,961	8,800

Source: Royal Forest Department

Water Resources

The average annual rainfall in Thailand is 1,692 mm, with the highest rainfall recorded in the South (2,304 mm) and the lowest in the North (1,258 mm). During the past four decades, rainfall in Thailand has shown a slightly declining trend of 0.3 percent per year (OEPP, 1997). Rainfall in Thailand generates about 775 billion cu m of water annually. Of this, only about 30 percent is surface water or runoff (Table 2.11). In 1996, the average surface water per capita in Thailand was 3,877 cu m. This is projected to decline gradually to 3,589 cu m and 3,191 cu m in 2000 and 2010, respectively (OEPP, 1997).

In 1995, Thailand had 26 large dams and reservoirs with a total storage capacity of 66 billion cu m and effective storage capacity of about 43 billion cu m (OEPP, 1997). The most recent addition, Pasak Cholasit Dam, was inaugurated in November 1999. In addition, there are various medium and small-sized dams and reservoirs across the country. Most of the stored water is used for agriculture. More than 30 million rai of agricultural land benefits from various water resource development projects in the country. The potential to develop additional large dams and reservoirs in Thailand is now very limited due to physical limitations and growing concerns regarding their environmental impacts.

Groundwater is another important water resource in Thailand. Groundwater availability in Thailand varies from more than 100-300 cu m per hour in the Central region to less than 5 cu m per hour in some areas of the

Table 2.11 Amount of Rainfall and Runoff by Region in Thailand

Region	Average rainfall per year (mm)	Area (sq km)	Amount of rainfall per year (million cu m)	Runoff per year (million cu m)
North	1,258	169,644.3	213,412	64,024
Central	1,265	67,398.7	85,259	25,577
Northeast	1,407	168,854.3	237,578	71,274
East	2,092	36,502.5	76,363	22,909
South	2,304	70,715.2	162,927	48,878
Total	**1,630**	**513,115.0**	**775,539**	**232,662**

Source: Meteorological Department

Northeast. A rough estimate of the recharge rate of groundwater in the Chao Phraya basin, the largest river basin in Thailand, is about 5 percent of the amount of rainfall. The extensive use of groundwater by public water works, industries and communities, especially by Bangkok and the metropolitan region, has resulted in land subsidence. The most critical area has a land subsidence rate of more than 10 percent per year. At present, groundwater use in Bangkok and vicinity is strictly controlled. Several measures have been employed to reduce environmental problems due to groundwater extraction, including:

- Termination of groundwater extraction by public water works in critical zones;
- Regulation of groundwater extraction;
- Harmonization of groundwater and piped water charges;
- Strict implementation of land use planning; and,
- Control of land use in areas where groundwater is regulated.

While the measures have been effective in the controlled areas, problems due to excessive groundwater extraction have been increasing in others. This has led to expanded application of groundwater regulations by other provinces.

While the development of water supply sources almost has reached its limits, the demand for water is steadily increasing. Demand for water by urban communities and the industrial sector has grown rapidly over the last few decades. The conflict between agricultural and non-agricultural uses of water, especially in the dry season, has become increasingly critical and is expected to intensify in the next century. Thailand therefore has started to pursue several measures to increase water management efficiency. These include the introduction of integrated water resource development, improvement of water laws and regulations, crop diversification, and water minimization programs. The potential for applying appropriate economic instruments also is being explored.

2.4 ENERGY PROFILE

Energy is the most fundamental input to production and consumption activities, and the economic boom in Thailand has increased energy consumption substantially. During the period 1990-1997, primary energy demand grew by 8.9 percent annually. The demand for electricity, in particular, grew by 14.1 percent per year over the same period, representing an average additional capacity requirement of 1,100 megawatts (MW) per annum. Thailand's primary response during this period of high growth was to increase energy supply to meet increasing demand through expansion of electricity generation, transmission and distribution systems, oil refining and marketing facilities, as well as natural gas production and pipeline networks.

Thailand is not self-sufficient in energy (Table 2.12). Proven and probable reserves of oil and natural gas amount to some 165 million barrels and 20,000 billion cu ft, respectively. These are found mostly offshore in the Gulf of Thailand. Lignite reserves are estimated at around 2,300 million tonnes, more than half of which are located at Mae Moh in the northern part of the country. The potential for hydroelectric development in the country also is seriously constrained by environmental and social problems. Thailand thus is required to import primary energy such as oil, gas and coal, as well as electricity to meet energy requirements.

Table 2.12 Energy Supply (in ktoe) and Share of Net Import to Total Supply (percent), 1988-1997

Year	Modern Energy	Renewable	Total Supply	Net Imports to Total Supply
1988	21,816	12,776	34,592	55
1989	25,726	14,284	40,010	61
1990	30,340	14,782	45,122	62
1991	33,075	15,286	48,361	58
1992	36,254	16,281	52,535	61
1993	40,885	17,731	58,616	63
1994	45,691	19,378	65,069	62
1995	52,567	20,240	72,807	64
1996	58,704	21,387	80,091	71
1997	61,329	20,510	81,839	67

Source: NEPO

Biomass energy resources vary from 15.5 million cu m to 34.4 million cu m Major forms of biomass include fuelwood, bagasse and rice husk. Fuelwood is mainly used in rural households, while bagasse, oil-palm residue and rice husk are used to generate steam and power in sugar, oil-palm and rice mills.

The share of modern energy sources increased from 63 percent of total energy supply in 1988, to 75 percent in 1997, while the share of renewable energy, including biomass, decreased continuously during the same period (Table 2.12). During the past decade, final energy consumption in Thailand increased rapidly from 34,592 ktoe in 1988 to 53,070 ktoe in 1997, representing an average growth rate of 10 percent per year. (Figure 2.5).

The share of oil to primary energy consumption was about 55 percent in 1990 but has declined gradually due to substitution. The contribution of traditional rural energy sources such as fuelwood and charcoal also rapidly declined from about 40 percent of total energy consumed in the early 1980s to only 23 percent in 1997. Electricity's share, on the other hand, increased from about 8 percent to 11 percent. Thailand has succeeded in providing electricity to most of its inhabitants, even in remote areas.

To support the growing demand for electricity, Thailand's total installed capacity increased from less than 7,000 MW in 1988 to nearly 18,000 MW in 1997 (Table 2.13). The increase in generating capacity came mainly from steam plants, and was encouraged by the oil crisis. Natural gas and lignite were used to substitute for oil in new power plants. By the end of 1997, oil constituted only 24 percent of the total generation grid, while lignite and gas contributed 21 percent and 47 percent, respectively (Table 2.14).

The economic crisis in Thailand had a severe impact on the country's energy sector. For the first time in decades, the demand for energy recorded negative growth. The baht devaluation increased the local cost of energy, especially during a period of rising international oil prices.

The situation was amplified by the financial difficulties the country was facing. Deterioration in the financial markets not only disrupted normal operations in the energy sector but also hindered implementation of energy investment plans. Energy related entities with foreign loans suddenly faced higher debt repayments and the drying up of credits normally extended by financial institutions. Constraints in local financial markets also made it difficult for the government to raise long-term borrowing to finance infrastructure projects.

The economic crisis reduced Thailand's energy consumption substantially. In 1998, consumption of petroleum products fell from 1997 by about 10 percent (Table 2.15), that of lignite also dropped by 11 percent (Figure 2.6) while power demand declined by 3 percent (Figure 2.7).

The decline in electricity demand resulted in surplus power generating capacity and prompted the shelving of several new power projects. The annual reserve margin of Thailand's power system, for instance, which averaged 8.6 percent during the period 1990-97, is expected to rise to nearly 50 percent in 2000. The previously tight demand for natural gas, which required rapid conclusion of various gas supply agreements during the period 1992-96, also has developed into a surplus and has led to delay in launching various natural gas schemes.

The economic difficulties brought about by the financial crisis also affected viability of power investment projects. These were compounded by the inability of public utilities to make sufficient tariff adjustments to reflect increased costs, thus further weakening their financial positions. In Thailand, all IPP projects that had earlier signed power purchase agreements with EGAT found their projects longer viable.

Several policy measures have been taken to counter the impact of the economic crisis on the energy sector in Thailand. While the expansion of supply has been postponed, price adjustments have been allowed. The privatization and deregulation of the energy supply sector also have been accelerated and specific contracts have been renegotiated.

All negotiations for additional supplies that had not been committed before the crisis have been postponed indefinitely or substantially delayed. These include the LNG supply agreement with Oman, the natural gas supply agreement with Indonesia, the gas purchase from the Thailand-Malaysia Joint Development Area and 2,700 MW of power to be purchased from projects in Laos PDR. Projects that already have been committed also have been renegotiated, and the commercial operation dates for about 40 private power projects have been delayed by between 3 months and 4 years.

Investments by state-enterprises have either been delayed or cancelled. Electricity transmission and distribution projects have been delayed in line with lower demand, and EGAT has cancelled a number of new power generation projects, such as the 2,000 MW Tab Sakae power plant and thermal units 3-4 at Ratchaburi province. The natural gas pipeline network also has been scaled down.

The economic crisis increased the government's fiscal incentive to privatize. It also has generated increased pressure to deregulate and enhanced competition in providing consumers with lower prices and more efficient service. The depressed capital markets, however, also meant that privatization had to rely much more on strategic foreign investors than on public offerings. This has made resistance to privatization much stronger due to nationalist sentiment.

In 1998, Thailand publicly announced a target to deregulate the power supply industry and indicated a desire to separate electricity generation from transmission so that power pooling and retail competition could be introduced by 2003. Meanwhile, the government has continued to privatize EGAT's existing generating plants by selling its shareholding in EGCO to China Light and Power Company Limited in 1998, and by announcing a plan to privatize the 3,200 MW Ratchaburi power plant in 1999. Deregulation of the gas sector also was recently announced, which entails separation of the Petroleum Authority of Thailand's gas transmission operations from its gas trading activities, the introduction of third party access by 2000, and the opportunity for private investment in new natural gas transmission projects.

Figure 2.5 Final Energy Consumption, 1988-1997

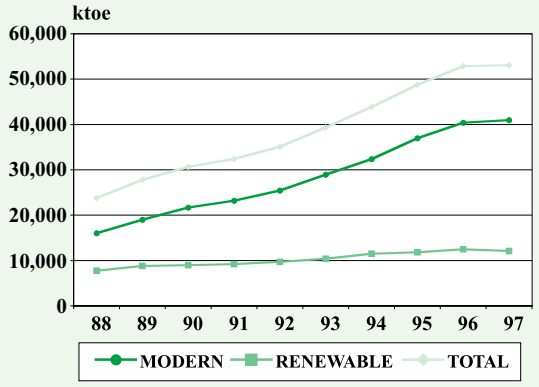


Table 2.13 Power Consumption and Installed Capacity, 1988-1997

Year	Consumption (GWh)	National grid installed capacity (MW)	Capacity Installed Privately for own use (MW)
1988	28,253	6,997	875
1989	32,834	7,366	948
1990	38,342	8,725	1,002
1991	43,398	9,707	1,064
1992	49,304	11,732	1,074
1993	56,279	12,734	1,127
1994	62,510	13,075	2,028
1995	71,225	14,912	2,632
1996	77,354	16,513	2,000
1997	82,429	17,805	2,554

Source: DEDP

Table 2.14 National Grid Generation by Energy Sources (GWh)

Year	Hydro	Fuel Oil	Diesel Oil	Coal & Lignite	Natural Gas	Others*	Total**
1988	3,779.0	3,142.2	23.8	6,799.5	18,719.9	-	32,464.4
1989	5,570.8	4,738.8	23.4	7,878.6	19,194.8	-	37,406.4
1990	4,975.5	10,012.6	365.4	11,052.8	17,767.6	1.1	44,175.0
1991	4,586.5	12,636.4	125.5	13,036.5	19,799.9	1.1	50,185.9
1992	4,238.5	14,928.9	171.7	14,815.0	22,943.0	1.3	57,098.4
1993	3,700.1	17,494.5	751.9	13,503.8	27,953.2	1.3	63,404.8
1994	4,513.7	19,644.4	1,476.9	14,130.9	31,409.7	1.1	71,176.7
1995	6,712.9	21,714.6	2,688.1	14,779.6	33,899.5	1.2	79,795.9
1996	7,340.7	20,976.5	4,627.2	17,507.2	36,748.9	1.5	87,202.0
1997	7,199.8	19,303.6	2,486.5	18,924.6	43,179.2	1.6	91,095.3

Note: * Geothermal, solar cell and wind turbine, etc.
** Excluding co-generation from SPP generated from renewable and conventional energy started in 1995.

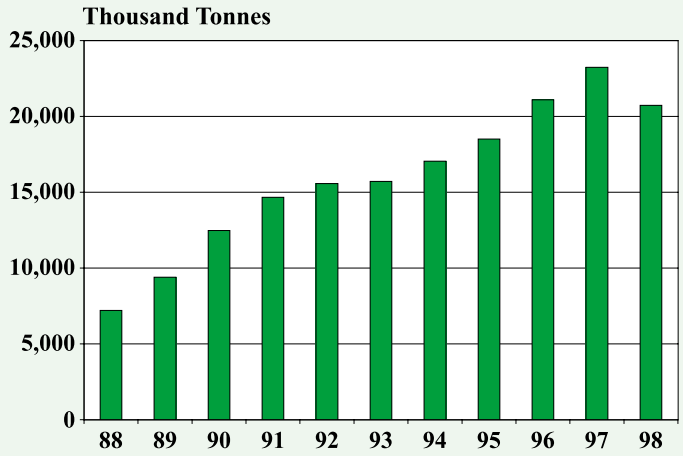
Source: DEDP

Table 2.15 Consumption of Petroleum Products (million liters)

Year	Gasoline	Regular	Premium	Kerosene	Diesel	HSD	LSD	Jet Fuel	Fuel oil	LPG	Total
1988	2,923	1,623	1,300	126	7,285	7,187	97	1,832	2,736	1,401	16,301
1989	3,322	1,796	1,526	119	8,650	8,520	130	2,112	3,634	1,572	19,409
1990	3,687	1,941	1,746	123	9,928	9,811	117	2,292	5,210	1,716	22,957
1991	3,890	2,005	1,885	111	9,951	9,811	140	2,468	6,114	1,845	24,379
1992	4,335	2,118	2,217	112	10,354	10,195	159	2,724	7,271	2,059	26,855
1993	4,912	2,164	2,748	108	12,033	11,834	200	2,899	8,027	2,224	30,202
1994	5,591	2,173	3,419	114	13,289	13,069	220	3,134	8,991	2,404	33,522
1995	6,293	2,206	4,087	101	15,619	15,424	195	3,295	9,722	2,644	37,675
1996	6,918	2,076	4,842	98	17,827	17,666	161	3,393	9,653	3,141	41,030
1997	7,356	1,973	5,383	86	17,535	17,388	147	3,543	9,094	3,249	40,863
1998	7,173	2,201	4,972	55	15,285	15,167	118	3,315	7,941	3,207	36,975

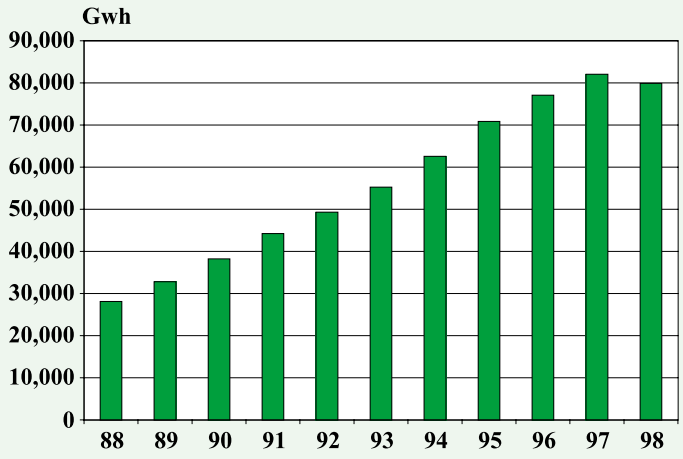
Note: HSD = High speed diesel; LSD = Low speed diesel and LPG = Liquefied petroleum gas
Source: DEDP

Figure 2.6 Lignite Consumption in Thailand, 1988-1998 (thousand tonnes)



Source: NEPO

Figure 2.7 Power Consumption in Thailand, 1988-1998 (thousand tonnes)



Source: NEPO

THAILAND's
INITIAL NATIONAL COMMUNICATION
UNDER THE UNFCCC

Chapter

3

Inventory of Greenhouse Gases Emissions in 1994

- Introduction
- Energy
- Industrial Processes
- Agriculture
- Forests and Land Use
- Wastes

3.1 INTRODUCTION

The 1994 national inventory of greenhous gasses (GHGs) represents the second official inventory of GHGs in Thailand. The first official inventory was undertaken for 1990 and was prepared in 1997. Prior to the 1990 inventory, however, the Thai government commissioned a study to assist in its preparation for the UN Conference on Environment and Development (UNCED) in June 1992. The study was conducted jointly by the Thailand Development Research Institute (TDRI) and the Thailand Environment Institute (TEI). Besides presenting a 1989 inventory of GHGs, the joint TDRI/TEI study evaluated some of the potential impacts of global warming on Thailand and identified various options to reduce greenhouse gas emissions.

Thailand's 1994 inventory of greenhouse gases is the result of recent studies conducted by various researchers throughout the country. In estimating the 1994 GHG inventory, the researchers used the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories (IPCC, 1997). To the extent possible, the researchers used local emission factors to substitute for those recommended by the IPCC, thus making the latest estimates more accurate and relevant to the country[1].

Still, many gaps in knowledge exist. These suggest that continued research be undertaken to generate scientific and technical information that is suitable to local conditions and circumstances. Basic research, field observations and testing are needed to improve the quality of the data, to reduce uncertainties, and to enhance understanding of the relationship of these emissions with productive activities in order to help determine the needs and limitations of reducing them.

Table 3.1 shows Thailand's national inventory of GHGs for 1994. Gross emissions of carbon dioxide (CO_2), the main greenhouse gas, amounted to about 241 Teragrams (Tg) in 1994. Due to carbon sequestration from reforestation activities and the re-growth of natural vegetation on abandoned lands, however, net CO_2 emissions were estimated at 202 Tg.

Unlike previous GHG inventories, the amount of CO_2 emissions from forestry and land use changes has declined compared with emissions from energy activities. Energy combustion and fugitive emissions have become the largest source of CO_2 emissions, accounting for about 52 percent of gross emissions of CO_2 in 1994. Several factors have contributed to the slowdown in emissions from forestry and land use changes. These include the imposition of the logging ban since 1989 and increased reforestation and commercial plantation activities. At the same time, reforestation and plantation activities have raised the amount of carbon removed from the atmosphere.

Total CH_4 emissions were estimated at 3,171 Gg in 1994. Most of the emission was from agriculture in which rice constituted about 73 percent, and by livestock constituted about 27 percent. The crucial issue on CH_4 emission is that the bulk of CH_4 emissions came from activities that are closely linked to the livelihood of many Thais. Any measures undertaken, therefore, could have serious implications for the local socio economic and cultural environment. In 1994, Thailand also emitted about 56 Gg of N_2O, 287 Gg of NO_x, 555 Gg of CO and 2,513 Gg of NMVOC (Table 3.1).

In addition to estimating the amounts of GHGs emitted, many researchers examined possible mitigation measures to reduce GHG emissions. Some were able to quantify the potential for GHG emissions reduction, while others were limited only to identifying mitigation options and did not estimate the amount that could be reduced through each measure. In several cases, the suggested mitigation measures were based on studies conducted elsewhere. Hence, their suitability, acceptability and effectiveness to local conditions have yet to be proven.

The potential mitigation options identified ranged from the generation of electricity from landfills to the chemical treatment of feeds for ruminants. Some were technology based, while others, like the shift from the transplanting of rice seedlings to the direct seeding method in rice cultivation, involved a change in cultural practices. Some estimates showed that GHG emissions could be reduced by as much as 70-80 percent. The potential for reduction was even much larger when the options were combined. In rice cultivation, for instance, improved water management and the use of pre-fermented organic matter instead of green manure could reduce total methane emissions by up to 30 percent.

Like most measures, the effectiveness of these mitigation options depends on the rate of acceptance and implementation, which may involve substantial capital and hidden implementation costs. The present inventory makes no evaluation of the cost-effectiveness of these options. Neither was an assessment made of other obstacles to implementation, which could seriously hamper the dissemination and effectiveness of the options.

Using the global warming potential (GWP) factors[2], the total emissions of the main GHGs of Thailand in 1994 in carbon dioxide equivalent was estimated at 286 Tg. Of this, CO_2 and CH_4 constituted 71 and 23 percent respectively (Table 3.2).

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[1] The local emission factors applied here are based on limited experiments and case studies and subject to refinement. More research and development of local emission factors are still needed.

[2] Different GHGs have different capacity in forcing or affecting the climate system. The GWP combines the capacity of a gas to absorb infrared radiation and its residence time in the atmosphere with a time frame analysis and then express the result relative to CO_2.

Table 3.1 Thailand's National Greenhouse Gas Inventory, 1994 (Gg)

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC
Total Emissions & Removals	**241,030.55**	**-39,101.60**	**3,171.35**	**55.86**	**286.65**	**555.11**	**2,513.30**
1. Energy	125,482.80	0.00	196.55	0.83	271.85	33.90	0.72
A. Fuel Combustion	125,482.80	0.00	2.85	0.83	271.85	33.90	0.72
Energy & Transformation Ind.	45,529.30		2.07	0.10	155.30	14.70	0.00
Industry, Mining & Construction	30,824.20		0.61	0.58	113.90	17.10	0.00
Transport	39,920.40		0.09	0.00	0.26	1.30	0.70
Commercial	890.50		0.02	0.08	0.87	0.20	0.00
Residential	3,469.40		0.06	0.06	1.37	0.50	0.00
Agriculture	4,849.00		0.00	0.01	0.15	0.10	0.02
B. Fugitive Emissions			193.7				
Solid Fuels			16.02				
Oil and Natural Gas			177.68				
2. Industrial Processes	15,970.40		0.31				2,512.58
3. Agriculture			2879.10	54.62			
A. Enteric Fermentation			629.53				
B. Manure Management			139.64	19.19			
C. Rice Cultivation			2,110.53				
D. Agricultural Soils				35.43			
E. Prescribed Burning of Savannas							
F. Field Burning of Agric. Residues							
G. Others							
4. Land Use Change & Forestry	99,577.35	-39,101.60	59.57	0.41	14.80	521.21	
A. Changes in Forest & Other							
Woody Biomass Stocks	40,180.51	-39,101.60					
B. Forest & Grassland Conversion	59,396.84		59.57	0.41	14.8	521.21	
C. Abandonment of Managed Land							
D. Others							
5. Wastes			35.22				
A. Solid Waste Disposal			19.57				
B. Wastewater Treatment			15.65				

Source: Center for Applied Economic Research, 2000a

Table 3.2 Total CO_2 equivalent emissions of Thailand, 1994

	Emission (Gg)	GWP	CO_2 equivalent	Percent of Total
CO_2	202,458.05	1	202,458	70.69
CH_4	3,171.35	21	66,598	23.25
N_2O	55.86	310	17,317	6.06
Total			**286,373**	**100.00**

3.2 ENERGY

Due to increasing use of commercial fuels and a decline in the rate of deforestation, the energy sector has become the largest source of CO_2 emissions in Thailand, accounting for more than half of total national CO_2 emissions in recent years. It is also the largest source of CO, NO_x and NMVOC, as well as the principal source of fugitive CH_4 emissions.

Previous GHG inventories considered only emissions from energy combustion activities. But starting with the 1990 GHG inventory, emissions from energy resource extraction, processing, transportation, storage and distribution were included.

Estimates of GHG emissions from this sector are probably the most accurate because the energy sector is studied extensively and is well integrated into the modern economy. The commercial nature of transactions in this sector also make various abatement options easier to assess and quantify, thus making decisions and actions relatively easier to implement.

CO_2 emissions depend mainly on the carbon content of fuels, rather than on technological processes or emission controls. The non-CO_2 emissions, meanwhile, require a detailed evaluation of the technologies used.

Over the last two decades, Thailand has succeeded in diversifying its sources of energy and reducing dependence on imported fuels. Domestic energy sources now provide more than one-third of the country's energy needs. Tangible success has been achieved particularly in the energy industries sector, where more than two-thirds of energy requirements for power generation are derived locally. By type of fuel, therefore, the largest source of CO_2 emissions in the energy supply sector is natural gas. But this hides the fact that emissions would be even larger were it not for the shift to this cleaner fuel.

A substantial amount of biomass (e.g., charcoal, wood, paddy husk and bagasse) is still consumed as fuel for households, commercial establishments and industry. Some 15 million tonnes of bagasse, 10 million tonnes of fuelwood, and 6 million tonnes of charcoal were estimated to have been used in 1994. To avoid double counting, however, the GHGs emitted from their use are accounted for in the agriculture and forest sectors.

Fuel Combustion

Total CO_2 emissions from the combustion of fuels amounted to 125,483 Gg in 1994 (see Table 3.3). As the largest consumer of fuel, the energy supply sector (mainly power plants) emitted the largest share of CO_2 (36 percent), followed by the transport sector (32 percent) and the industry and construction sector (25 percent). When combined, these three sectors emitted more than 90 percent of CO_2 emissions and at least 97 percent of the other trace gases except nitrous oxide. The CO_2 emissions from consumption of fossil fuels in Thailand, compared to the world total, was highly insignificant. In 1994, CO_2 emission from energy sources in Thailand was only about one-half percent of the world respective emission.

The contribution of each sector to total GHGs may be misleading, however, because an economic sector that consumes large amounts of secondary forms of energy such as electricity, do not reflect the amount of emissions from the fuel's transformation. These emissions are accounted for in the energy supply sector. Thus, although consuming a large part (25 percent) of total electricity produced in 1994, the commercial sector contributed the least (0.7 percent) to overall fossil fuel-derived CO_2 emissions.

Also, as pointed out earlier, the commercial, residential and industrial sectors consume huge amounts of biomass fuels. In order to avoid double counting, however, the GHGs emitted from their consumption are accounted for in the agriculture and forest sectors.

Table 3.3 GHG Emissions from Fuel Combustion in 1994 (Gg)

Sector	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Energy Supply	45,529.3	2.07	0.10	155.3	14.7	0.0
Industry and Construction	30,824.2	0.61	0.58	113.9	17.1	0.0
Transport	39,920.4	0.09	0.00	0.26	1.3	0.7
Commercial	890.5	0.02	0.08	0.87	0.2	0.0
Residential	3,469.4	0.06	0.06	1.37	0.5	0.0
Agriculture	4,849.0	0.00	0.01	0.15	0.1	0.02
TOTAL	**125,482.8**	**2.85**	**0.83**	**271.85**	**33.9**	**0.72**

Note: These exclude emissions from the combustion of biomass fuels, which are accounted for under the agriculture and forest sectors.

Source: Center for Applied Economic Research, 2000a

Fugitive Emissions

Thailand's move to become more self-reliant in energy has spurred domestic exploration and development activities. Consequently, there has been an increase in GHGs emitted from coal mining and oil and natural gas drilling as well as from various transmission, storage and distribution systems. CO_2 and gases that have low molecular weight such as CH_4 and volatile organic carbon (VOC) are released during mining, mineral extraction and other post-mining activities, but only CH_4 emissions are estimated in this report. Nonetheless, the estimates suffer from the lack of reliable emission factors that take into consideration the stratum and depth of deposits and the quality and characteristics of the fuels.

Methane emissions from coal mining as well as oil and gas production activities were estimated at around 194 Gg in 1994 (see Table 3.4). The bulk of fugitive CH_4 emissions (91 percent) came from natural gas production activities, which included extraction, processing, transport, distribution, venting and flaring. The production of 17 million tons of coal from surface mining leaked some 16 Gg of CH_4 into the atmosphere, while oil production, refining and storage activities produced 0.9 Gg of fugitive CH_4 emissions.

3.3 INDUSTRIAL PROCESSES

Various types of greenhouse gases are emitted from industrial production processes other than energy combustion activities. These processes involve the chemical or physical transformation of raw materials into intermediate or final products. Thus the amounts and types of GHGs emitted depend on the quantities of raw materials used as well as the nature and conversion efficiency of the manufacturing process.

Using the mass balance approach to estimating the emission factors for different types of manufacturing processes, GHG emissions were estimated for seven major industries, namely, cement, lime, glass, pulp and paper, iron and steel, petrochemicals, and food and beverage industries. In 1994, almost 16,000 Gg of CO_2, 0.3 Gg of CH_4, and 2,513 Gg of NMVOCs were emitted from the various manufacturing processes in these industries (see Table 3.5). The cement industry was the largest source (90 percent) of CO_2 emissions, followed by lime manufacturing (6 percent) and the food and beverage industry (3 percent).

Table 3.4 Methane Emissions from Fossil Fuel Production Activities in 1994 (Gg)

Activities	Methane Emissions
Coal	**16.02**
Mining	14.88
Post-mining	1.14
Oil	**0.92**
Production	0.14
Refining	0.66
Storage	0.12
Natural Gas	**176.76**
Production	26.19
Processing, Transport, and Distribution	76.39
Venting and Flaring	74.18
Total Emissions	**193.70**

Source: Center for Applied Economic Research, 2000a

Table 3.5 Greenhouse Gas Emissions from Major Industrial Processes, 1994 (Gg)

Industry	CO_2	CH_4	NMVOC
Cement	14,920.0		
Glass	63.6		2.2
Lime	918.0		
Pulp and Paper	49.3		
Iron and Steel	19.5		ns
Petrochemicals	-	0.3	4.7
Food and Beverage			2,505.7
Total	**15,970.4**	**0.3**	**2,512.6**

ns = not significant

Source: Center for Applied Economic Research, 2000a

3.4 AGRICULTURE

The agriculture sector plays an important role in the economy and society of Thailand. It is still widely regarded as the backbone of the economy. Despite the gradual reduction in its contribution to the country's total economic output, the agriculture sector continues to provide the basis for an agro-based manufacturing sector. It also remains an important source of labor, especially during the off season, and is the main source of livelihood for about 60 percent of the population.

A number of agricultural practices and activities, including traditional cultivation methods, are known to produce adverse environmental consequences. However, recent concerns about greenhouse gases have focused more attention on activities where changes in management or agricultural practices can help alleviate problems related not only to GHGs but also to the environment in rural areas.

Rice Cultivation

Despite being one of the major rice producing countries in the world, Thailand's contribution to global CH_4 emissions is relatively small. Methane emissions from paddy fields were estimated at 2,110 Gg in 1994 (see Table 3.6). About 86 percent of these was emitted from the cultivation of major rice, while the remainder came from the second crop of rice. The reason is that only irrigated land is used to produce a second rice crop, and only about one-third of all irrigated land was planted to second rice in 1994.

Table 3.6 Methane Emission from Paddy Fields in Thailand in 1994

Category	Sub-category		Seasonal flux (g CH_4/sq m)	Cultivation area (Ha)	CH_4 emission (Gg)
Major rice					
Upland	Rainfed	–	0.00	34,048	0.00
	Irrigated	Continuously flooded + OM	44.04	1,121,492	493.90
		Continuously flooded	18.72	1,121,492	209.94
Low land	Rainfed	Flood prone + OM	14.98	1,100,926	164.87
		Flood prone	35.23	1,100,926	387.88
		Drought prone + OM	17.62	2,184,333	384.79
		Drought prone	7.49	2,184,333	163.56
	Deep water	Water depth > 100 cm	15.31	39,478	6.04
		Total		**8,887,028**	**1,810.98**
Second rice	Irrigated	Continuously flooded	44.04	680,123	299.53
		Grand Total		**9,567,151**	**2,110.51**

Note OM = Organic matter

Source: Center for Applied Economic Research, 2000a

Statistics for 1994 show that only about one-quarter of Thailand's total rice area was irrigated. The majority of paddy fields were still rainfed. Nonetheless, irrigated areas were estimated to produce about 39 percent of the methane emitted from the major rice crop, and about 33 percent of total methane emissions from total rice cultivation. Of the four types of water regimes, only upland farming did not produce methane due to the absence of flooding during cropping periods. Experimental data indicate that continuous flooding of paddy fields induces higher methane emissions.

Despite the use of local values for emission factors, cropping periods and harvesting area, the uncertainty of these estimates is still high. This is due mainly to the extreme spatial and temporal variability of methane fluxes throughout the cropping season; soil characteristics; water and crop management practices; organic matter amendments; and, fertilizer application. Actual measurements of methane emissions conducted in four provinces in different regions of Thailand indicate a wide divergence in results. For example, methane emissions from paddy fields without fertilizer application vary from 7.49 Gg/sq m to 35.23 Gg/sq m. Field measurements also showed that the addition of organic matter to rice paddies with chemical fertilizer further increased methane emissions by as much as 135 percent compared to those without organic fertilization.

Livestock

Animal raising provides protein essential in the diet of Thai people and to the national economy. The growing demand for meat and dairy products, together with an increase in livestock feed production and improved reproduction techniques, have increased significantly the number of livestock in Thailand. Consequently, emissions of GHGs from animal raising also have increased.

The two main sources of GHGs from livestock raising are enteric fermentation and manure management. Methane gas is produced from enteric fermentation and from animal feces, while N_2O is produced from the management of animal manure.

Enteric fermentation is a process of digestion in herbivores or plant-eating animals, which produces methane as a by-product. Both ruminant livestock (e.g., cattle and buffalo) and some non-ruminants (e.g., pigs and horses) produce methane, but ruminants are the main source. The amount of methane produced, however, is a function of several factors, including livestock species and body size as well as the quantity and quality of feed digested.

Methane and nitrous oxide are produced from anaerobic decomposition of manure. These conditions often occur when a large number of animals are managed in a confined area such as dairy farms, beef feedlots or pig and poultry farms.

Methane emissions from enteric fermentation in livestock were estimated at 630 Gg in 1994 (see Table 3.7). The largest source of enteric methane among ruminants was non-dairy cattle, followed by buffalo, dairy cattle, goat and sheep. Swine, which had a larger population than non-dairy cattle, emitted only about 13 Gg of enteric CH_4. The measurement of enteric methane emitted could have been conducted directly through use of a facemask or respiratory chamber. But in the absence of special facilities and instrumentation, the amount of methane gas produced was indirectly calculated by using emission factors that estimate the amount of energy intake that is converted into methane.

Fecal CH_4 emissions amounted to around 140 Gg in 1994, while N_2O emissions from various manure management systems was estimated at 19 Gg. The largest source of fecal CH_4 was swine, which accounted for 78 percent of total CH_4 emitted from manure management. This is to be expected, since most pigs are confined on pig farms where manure is collected and usually left to decompose under anaerobic conditions, while most of cattle and buffalo graze in open pastures.

Table 3.7 Methane and Nitrous Oxide Emissions from Livestock in 1994 (Gg)

Livestock	Number	Enteric Methane	Fecal Methane	Nitrous oxide
Ruminants:		*616.808*	*25.929*	*15.035*
Dairy Cattle	265,776	17.897	2.658	0.454
Non-dairy cattle	7,371,477	349.163	13.555	9.270
Buffalo	4,224,791	249.748	9.716	5.311
Non-ruminants:		*12.719*	*113.440*	*4.157*
Swine	8,479,400	12.719	109.477	2.516
Poultry	152,269,312	0.000	3.492	1.641
Total		**629.527**	**139.639**	**19.192**

Source: Center for Applied Economic Research, 2000a

Agricultural Soils

Cultivated soils produce N_2O, a very potent greenhouse gas. The emissions of N_2O depend mainly on the amount of synthetic or chemical nitrogen fertilizers used in agricultural soils as well as on the organic fertilizers such as animal manure and crop residues that are applied to the soils. They are emitted through fractions volatilized directly from cultivated soils and from indirect formation of N_2O from leached or contaminated groundwater.

Several other factors influence the amount of N_2O emissions. They include climate conditions, cultivation practices, soil and water management, and crop type. For example, frequent application of nitrogen and organic fertilizers, combined with intensive watering as in the case of vegetable farms, tend to generate more N_2O emissions than practices used in upland crop farming. On the other hand, the application of nitrogen fertilizer on irrigated paddy fields tend to produce minimal N_2O emissions due to continuous flooding, as N_2O emissions occur only during the drainage period.

Total emissions of N_2O from agricultural soils were estimated at 35 Gg in 1994 (see Table 3.8). Of this amount, 44 percent came from direct sources through the incorporation of synthetic nitrogen fertilizer, animal manure and crop residues into the soil. About 30 percent of N_2O emissions were from indirect sources through their formation in leached/runoff water and fertilized soils. The remaining emissions were emitted from animal waste discharged in pastures.

3.5 FORESTS AND LAND USE

Forests act both as a source and a store (or sink) for CO_2. CO_2 is produced when forested land is cleared for non-forest uses such as for agriculture and settlement; while CO_2 is stored when trees absorb CO_2 from the atmosphere through the process of photosynthesis. The amounts of CO_2 emitted and sequestered from forests are very difficult to estimate because of complex biological factors and the lack of reliable data, especially with regard to the rate of change of land use, the use of converted forest land, and the biomass density of forests.

The amounts of GHGs emitted and sequestered in Thailand during 1994 were estimated using the currently available methodologies developed by the IPCC. Local activity data were used to the maximum extent possible. The IPCC methodology was modified, under specific assumptons, in order to improve the accuracy of estimates and to ensure an accurate reflection of conditions prevailing in local forests.

Total CO_2 emitted from Thai forests was 99,577 Gg in 1994, while total CO_2 sequestered was estimated at 39,102 Gg, resulting in net CO_2 emissions of 60,476 Gg (see Table 3.9). The consumption of wood as fuel accounted for about 41 percent of total CO_2 emissions, while the natural decay of timber utilized, for example, in construction accounted for 30 percent. The remaining CO_2 emissions came from off-site and on-site burning of biomass.

The fundamental causes for forest conversion in Thailand include a combination of increased demand for agricultural land and the mismanagement of forest concessions. However, since assessments of forests are not conducted annually, the more than 100,000 hectares of forest area lost in 1994 was estimated using average forest loss in 1993 and 1995, the years for which satellite data were available.

The total amount of CO_2 emitted is partly offset by reforestation, forest plantation activities, and natural regeneration of vegetation on abandoned lands. In 1994, reforestation activities accounted for about 45 percent of the uptake of CO_2, while the natural regernation vegetation on abandoned lands accounted for the balance. Data for 1994 shows that the total area covered by various reforestation programs and commercial forest plantation activities was about 681,200 hectares, six times larger than the amount of forest lost per year. Although this indicates gradual reclamation of denuded forest areas, the amount of CO_2 stored in forests is diminished as a result of the slower growth rate of trees when compared with on-going felling and burning of vegetation.

The amount of carbon uptake also depends on types of trees planted. For example, about 37 percent of reforested areas in Thailand are planted using teak (*tectona grandis*), while about one-third are planted using eucalyptus (*eucalyptus camaldulensis*), a particular species

Table 3.8 Total N_2O Emissions from Agricultural Soils in 1994 (Gg)

Source of N_2O	Direct sources	Grazing animals	Indirect sources	Total N_2O Emissions
Synthetic fertilizer	6.85	–	3.65	10.50
Animals	4.79	10.11	7.12	22.01
Crops	2.92	–	–	2.92
Total	**14.56**	**10.11**	**10.77**	**35.43**

Source: Center for Applied Economic Research, 2000a

of fast growing trees preferred by the private sector. Both teak and eucalyptus species are estimated to yield between 15-17 tonnes of dry matter per hectare per year (t-dm/year), more than twice that for slow-growing species of trees (6.8 t-dm/year).

Apart from the difficulty of estimating the area of abandoned land due to lack of inventory data on land use in the past, assumptions were made regarding the amount of carbon uptake from trees or crops planted on abandoned land. Only 5.9 million hectares of forested land were assumed to experience a natural regeneration. Biomass accumulation was also assumed to be faster during the first 20 years and slower thereafter, so that forests are restored to 20 percent of original forest biomass during the first twenty years and reach 80 percent in 100 years.

The on-site and off-site burning of aboveground biomass after forest conversion produces a number of trace gases. In 1994, the emissions of CH_4, CO, N_2O and NO_x were estimated at 60 Gg, 521 Gg, 0.4 Gg and 15 Gg, respectively (see Table 3.10).

3.6 WASTES

The disposal of wastes and the processes employed to treat wastes give rise to greenhouse gases, the most significant of which is methane. Methane is produced via anaerobic decomposition of organic matter. The amount of methane emitted therefore depends mainly on the physical characteristics of waste and the anaerobic activities in the waste disposal system and treatment process.

The two main sources of CH_4 emissions in Thailand are land disposal of solid waste (both landfill and open dumping methods), and the treatment of wastewater from the domestic and industrial sectors. Although landfill is the most common disposal system for solid waste in other countries, data for Thailand in 1994 indicates that less than one-quarter of wastes are disposed using this method. About 40 percent of solid wastes are burned, while 30 percent are dumped in trenches or at open sites. Moreover, out of the 137 solid wastes disposal systems throughout the country (excluding Bangkok), only 22 are landfills.

Table 3.9 Estimates of Carbon Emission and Sequestration from Thai Forests in 1994

	C (Gg)	CO_2 (Gg)
Net Emission	**+16,493.39**	**+60,475.75**
Carbon sequestration	-10,664.07	-39,101.60
Uptake from plantation	-4,761.07	-17,457.26
Uptake from secondary forest	-5,903.00	-21,644.34
Total emission	+27,157.46	+99,577.35
Change in woody biomass	+10,958.32	+40,180.51
Wood and fuelwood consumption	+10,958.32	+40,180.51
Forest conversion	+16,199.14	+59,396.84
Biomass burning on site	+3,722.94	+13,650.78
Biomass burning off site	+3,956.75	+14,508.08
Decay of timber biomass	+8,519.45	+31,237.98

Source: Center for Applied Economic Research, 2000a

Table 3.10 Non-CO_2 Trace Gase Emissions from Forest Clearing in 1994

Trace gas	Emissions (Gg)
CH_4	59.57
CO	521.21
N_2O	0.41
NO_x	14.80

Source: Center for Applied Economic Research, 2000a

Estimates of the amount of CH_4 emissions from wastes amounted to 35 Gg in 1994 (see Table 3.11). Of these, about 20 Gg were emitted from solid waste disposal and about 16 Gg came from wastewater treatment. In spite of the small number of landfill sites available nationwide and the relatively small volume of solid waste disposed in this manner, CH_4 emissions from landfill sites were estimated at 8 Gg or 43 percent of the total, suggesting that emissions of CH_4 from landfill systems are quite significant.

Earlier estimates of the amount of CH_4 emissions from solid waste disposal indicated much higher figures than is currently estimated. This is due to earlier estimates used to develop theoretical gas yields based on the mass balance approach. These estimates did not incorporate any time factor into the methodology and did not take into account various categories and ages of disposal sites. Present estimates, on the other hand, use the theoretical first-order kinetics method that take into consideration the long period of release, rather than the instantaneous emissions, of methane.

Meanwhile, about 16 Gg of CH_4 were emitted from wastewater treatment. Of these, almost 90 percent came from industrial wastewater treatment facilities. Methane emissions from domestic wastewater handling came primarily from sludge handling.

The estimate of methane emissions from solid waste disposal and wastewater handling has benefited greatly from the availability of more accurate statistics and expanding coverage. The latest estimates of emissions from wastewater treatment, for example, are based on the actual number of factories that use anaerobic wastewater treatment facilities. Moreover, the latest methodology for estimating CH_4 emissions from industrial wastewater treatment facilities distinguishes between wastewater and sludge handling systems, thus eliminating the previously substanstial emissions from sludge. It also indicates the degradable organic component and identifies the fraction of organic sludge handled by drying and composting, a method that eliminates the emissions from sludge handling.

Table 3.11 Estimates of Methane Emissions from Wastes in 1994

Source	Methane Emissions (Gg)	Share (percent)
Solid Waste Disposal	19.567	55.6
Municipalities	6.726	19.1
Trench dump	1.851	5.3
Open dump	0.371	1.0
Landfill	4.505	12.8
Bangkok	12.841	36.5
Open dump (Nongkham)	4.458	12.7
Open dump (On-nuch)	4.425	12.6
Landfill (Kampaengsaen)	3.958	11.2
Wastewater Treatment	15.65	44.4
Domestic Wastewater	1.77	5.0
Wastewater handling	0.85	2.4
Sludge handling	0.92	2.6
Industrial Wastewater	13.88	39.4
Total	**35.22**	**100.0**

Source: Center for Applied Economic Research, 2000a

THAILAND's
INITIAL NATIONAL COMMUNICATION
UNDER THE UNFCCC

Chapter

4

Greenhouse Gas Projections and Mitigation Options

- GHG Projections
- GHG Projections Estimates from Other Studies
- GHG Mitigation Options

4.1 GHG PROJECTIONS

Greenhose gas projections here emphasize the main sources of emissions of two gases. Emissions of CO_2 and CH_4 from three sectors-energy, agriculture (rice and livestock) and forestry are projected to 2020. For livestock subsector, emissions of N_2O are also projected. Mitigation options for these sectors are also discussed.

Energy Sector

Because CO_2 emissions depend on the type and amount of energy consumed, and because energy consumption is closely linked to the socioeconomic development of a country, forecasts of CO_2 emissions from the energy sector must start with a projection of the economic growth of a country over a specific period in the future.

In the case of Thailand, the 1997 economic and financial crises have changed the trend of economic growth drastically (Table 4.1). The growth of GDP in 1998 is estimated to have dropped to a negative 7 percent, compared to the initial target of 7.8 percent. A modest economic recovery is expected and GDP is projected to increase by an average of about 5 percent annually during the first two and half decades of the 21st century. This projection is close to the moderate economic recovery projection of TDRI. The forecasts of final energy demand, by sector, have been derived basing on the recent projection of GDP (Table 4.1) and the the present energy utilization structure (Table 4.2).

Of the total projected final energy demand, the transport sector is expected to consume the largest proportion, estimated to be about one-third of demand, followed by the industrial, residential and commercial sectors. Agriculture will remain the smallest user of final energy (Table 4.2).

Energy consumption in the transport sector can be separated into four transport mode categories, namely: air, rail, road and water. Energy consumption in the transport sector is projected to increase from 18,763 ktoe in 1995 to 33,543 ktoe by 2020. Road transport will continue to be the major mode of transport and diesel will be the main fuel used. LPG, a cleaner fuel, is expected to contribute only a small share due to its limited potential uses and impact on engine performance. Electricity as an energy source for light-rail transit system has just started.

There are three main categories of energy used in the industrial sector: thermal, mechanical and other electric use. The industrial sector will continue to be the second largest energy-consuming sector. Final energy demand in this sector is projected to rise from 15,741 ktoe in 1995 to 29,998 ktoe in 2020, equivalent to an average growth rate of 2.6 percent per year.

Table 4.1 Projected Growth Rates of Gross Domestic Product (GDP) (percent)

	1998	1999	2000	2001-2005	2005-2010	2010-2015	2015-2020	2020-2025
Before Economic Crisis/1	7.8	7.7	7.7	7.6	7.2	6.4	6.1	5.8
After Economic Crisis/2								
Initial Estimates	-0.7	3.9	5.9	5.9	7.2	6.4	6.1	5.8
Recent Estimates	-7.0	-2.0	2.0	5.0	5.0	5.0	5.0	5.0

Note: The recent estimates for the period 1999-2030 were made by SIIT
Source: 1/ TDRI (1997); 2/ NESDB (1998).

Table 4.2 Projections of Final Energy Demand by Economic Sector (ktoe)

Sector	1995	2000	2005	2010	2015	2020
Agriculture	1,573	1,557	1,558	1,566	1,589	1,595
Commercial	2,489	2,882	4,375	5,848	7,956	10,523
Industrial	15,741	14,762	17,327	20,467	24,797	29,998
Residential	9,853	11,865	13,767	15,486	16,962	16,546
Transport	18,763	17,232	21,214	25,374	29,503	33,543
Total	**48,418**	**48,298**	**58,242**	**68,742**	**80,807**	**92,204**

Note: The sum does not equal to total due to rounding error.
Source: SIIT 1998

The main fuel used for cooking in the residential sector at present is biomass. Biomass use is especially widespread in rural areas. However, consistent with the development paths observed in other countries, the forecast shows a declining trend of biomass use in recent years due to increased substitution with LPG and electricity. Fuel consumption in the residential sector is expected to reach 16,546 ktoe by 2020.

In the commercial sector, energy consumption is estimated based on 6 building types and 5 end-uses. The building types include office, retail, education, hotel, hospital, and others. Small commercial buildings of all types fall into the category of "other". The end-uses are lighting, cooling, water heating, cooking, and miscellaneous. Cooling includes the energy used in air conditioning systems. Total energy consumption is projected to reach 10,523 ktoe by 2020, of which more than 80 percent will be in the form of electricity .

The agriculture sector uses the smallest volume of energy, accounting for only 2-3 percent of total final energy consumption in the country. Energy in the agricultural sector is used mainly for farming equipment such as water pumps, tractors, and other farm equipment. By 2020, the agriculture sector is expected to use about 1,600 ktoe of energy.

CO_2 Emissions from the Energy Sector

The estimated volume of CO_2 emissions from projected energy consumption up to the year 2020 are shown on Table 4.3. Emissions of CO_2 from the burning of biomass are discounted from the total amount of CO_2 emissions from the energy sector, following IPCC guidelines for national GHG inventories. In addition, the CO_2 emissions presented here exclude those from fossil fuel extraction, production, transportation and distribution, which are often referred to as fugitive losses.

Emissions of CO_2 from the energy sector are expected to increase from about 151 Tg in 1995, to 475 Tg in 2020. The power sector could contribute substantially to total emissions and comprise more than 0ne-half of total CO_2 emissions from the energy sector in the year 2020. The second largest contributor could be the transport sector at 26 percent, followed by the industrial, residential, commercial, and agriculture sectors, respectively (Table 4.3 and Figure 4.1).

Figure 4.1 Share of Energy-related CO_2 Emissions, by Sector.

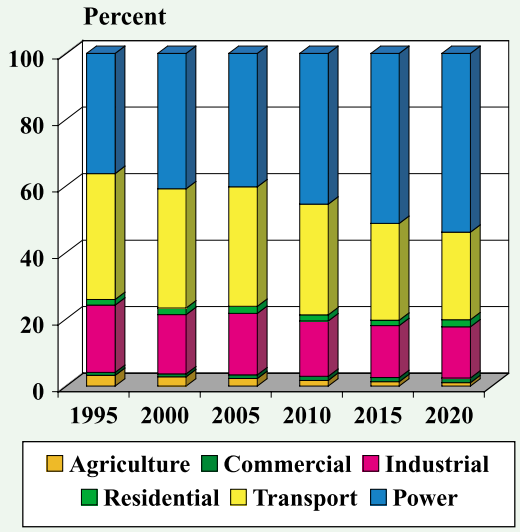


Table 4.3 Projected Carbon Dioxide Emissions from Energy Consumption (Tg).

Sector	1995	2000	2005	2010	2015	2020
Agriculture	4.84	4.79	4.80	4.82	4.89	4.91
Commercial	1.34	1.43	2.26	3.40	4.86	6.64
Industrial	30.50	30.50	39.10	47.05	59.09	73.22
Residential	2.57	3.48	4.47	5.22	6.15	9.98
Transport	57.15	61.36	76.12	94.09	110.21	125.01
Power	54.45	69.69	84.76	127.90	193.39	255.61
Total	**150.85**	**171.25**	**211.51**	**282.48**	**378.59**	**475.37**

Source: SIIT 1998.

Agriculture Sector

Rice Sub-Sector

According to a 1993 policy statement prepared by the Office of Agricultural Economics, the area used for cultivating main-season rice will stabilize at around 8.8 million hectares. The off-season rice crop also will be reduced from 0.608 to 0.462 million hectares during the period from 1994 to 2001 and will be maintained at about the same level until 2020. To compensate for the reduction in cultivation area and to maintain the level of production, rice productivity (grain yield per area) must increase to meet domestic and export demand. Rice productivity and cultivated area, as projected by the Office of Agricultural Economics, are shown on Table 4.4.

Based on the assumptions regarding rice cultivation areas above, an increase in rice production could be achieved through various soil and fertilizer management practices. Further assuming that the irrigation area for rice cultivation increases steadily at the rate of 1 percent annually, and that the use of both chemical and organic fertilizers increases to maximize the grain yield of rice, the cultivation area with fertilizer application would expand at the rate of 20 percent per year.

Table 4.5 shows the estimates of CH_4 emission from paddy fields from 1994 to 2020. Although the rice cultivation area remains constant, CH_4 emissions are predicted to increase during the period due to an expansion in irrigated area and increased fertilizer application. Total CH_4 emissions are estimated to increase by about 1.3 percent from 1994 to 2020. The estimated emission rate will change according to the assumptions made.

Table 4.4 Projected Rice Production based on Local Demand and Exports from 1994 to 2020

Year	Production (million tonnes)			Planting Area (million ha)		Average
	Consumption	Export	Total	Main-season Rice	Off-season Rice	Yield, (kg/ha)
1994	13.579	6.060	19.639	8.800	0.680	2,087
1995	13.747	6.060	19.807	8.800	0.590	2,109
1996	13.913	6.060	19.973	8.800	0.556	2,135
1997	14.368	6.060	20.428	8.800	0.528	2,190
1998	14.485	6.060	20.545	8.800	0.496	2,210
1999	14.659	6.060	20.719	8.800	0.493	2,230
2000	14.776	6.060	20.836	8.800	0.470	2,248
2001	14.950	6.060	21.010	8.800	0.462	2,269
2005	15.425	6.060	21.485	8.800	0.462	2,320
2010	16.018	6.060	22.078	8.800	0.462	2,384
2015	16.612	6.060	22.672	8.800	0.462	2,448
2020	17.205	6.060	23.265	8.800	0.462	2,512

Source: Office of Agricultural Economics, 1993.

Table 4.5 Projections of Methane Emissions from Paddy Fields (Gg), 1994-2020

Year	Methane Emission
1994	2,110
2000	2,157
2005	2,177
2010	2,198
2015	2,220
2020	2,244

Livestock Sub-Sector

Forecasts of CH_4 emissions from the livestock sub-sector are based on the emission rate of each type of animal derived from the 1994 inventory (Table 4.6). The projected number of livestock between 1998-2009 is based on historic average growth rates over the past 6 to 9 years. For the period 2010-2020, it is assumed that growth rates would be reduced by one-half (Table 4.7). Using these growth rates, the numbers of livestock and the emissions are projected as shown in Table 4.8 and Table 4.9 respectively. The trends for emission of CH_4 and N_2O between 1994 to 2000 are shown in Figure 4.2 and Figure 4.3.

Methane emissions from the livestock sub-sector in Thailand are projected to decline gradually from 748 Gg in 1994, to about 606 Gg in 2005. This is due primarily to a rapid decline of emissions from buffalo, but with a simultaneous increase in that of cattle. With an increasing trend of fecal emissions, especially from swine, total CH_4 emissions are expected to rise again from 2005 to 2020. About 691 Gg of CH_4 are expected to be emitted in the year 2020 (Figure 4.2). By contrast, N_2O emissions are expected to drop from 19 Gg. in 1994 to 17 Gg in 2000. The trend is likely to pick up again until 2020, when the total N_2O emissions are estimated to reach about 22 Gg in the last year of the projection (Figure 4.3).

Table 4.6 Estimated Emission Rates by Type of Livestock (Kg/head/yr)

	Buffalo	Cattle	Swine	Poultry
Enteric methane	59.11	47.37	1.50	0.00
Fecal methane	2.3	1.84	12.91	0.02
Nitrous oxide	1.26	1.26	0.30	0.01

Source: Derived from Vijchulata, Pravee (1999)

Table 4.7 Base Values and Assumed Growth Rates of Livestock Population

Type	Base, 1997* (thousand heads)	Growth rate (percent)	
		1998-2009	2010-2020
Non-dairy cattle	6,778.44	1	0.5
Buffalo	2,983.92	-9	-4.5
Swine	6,893.59	5	2.5
Poultry	194,114	6	3.0

*Source: Office of Agricultural Economics, 1998

Table 4.8 Projected Livestock Population (heads)

Sector	1994*	2000	2005	2010	2015	2020
Cattle	7,371,477	6,980,482	7,330,689	7,661,581	7,855,046	8,053,396
Buffalo	4,224,791	2,248,308	1,402,717	918,470	729,595	579,560
Swine	8,479,400	8,086,314	10,550,163	13,377,960	15,135,934	17,124,920
Poultry	151,808,913	231,720,051	311,273,065	405,995,395	470,659,936	545,623,862

* Source: Center for Applied Economics, 2000a.

Table 4.9 Projected Methane and Nitrous Oxide Emissions from Livestock (Gg)

Year	1994	2000	2005	2010	2015	2020
Enteric Methane emission						
Buffalo	249.75	132.91	82.92	54.30	43.13	34.26
Cattle	349.16	330.64	347.23	362.90	372.07	381.46
Swine	12.72	12.13	15.83	20.07	22.70	25.69
Poultry	-	-	-	-	-	-
Total	**611.63**	**475.68**	**445.98**	**437.27**	**437.90**	**441.41**
Fecal Methane emission						
Buffalo	9.72	5.17	3.23	2.11	1.68	1.33
Cattle	13.56	12.83	13.48	14.08	14.44	14.80
Swine	109.95	104.40	136.21	172.72	195.42	221.10
Poultry	3.49	5.35	7.18	9.37	10.86	12.59
Total	**136.72**	**127.75**	**160.10**	**198.28**	**222.40**	**249.82**
Total (CH_4)	**748.35**	**603.43**	**606.08**	**635.55**	**660.30**	**691.23**
Nitrous oxide						
Buffalo	5.31	2.83	1.76	1.15	0.92	0.73
Cattle	9.27	8.78	9.22	9.63	9.88	10.13
Swine	2.52	2.40	3.13	3.97	4.49	5.08
Poultry	1.64	2.50	3.36	4.39	5.09	5.90
Total (N_2O)	**18.74**	**16.51**	**17.47**	**19.14**	**20.38**	**21.84**

Note: Daily cattle are not included

Figure 4.2 Projected Methane Emissions from Livestock, 1994-2020

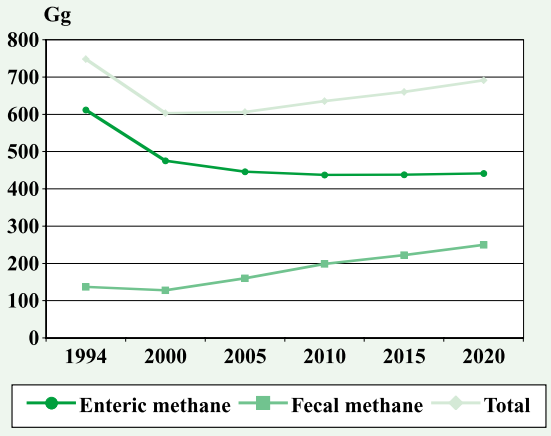
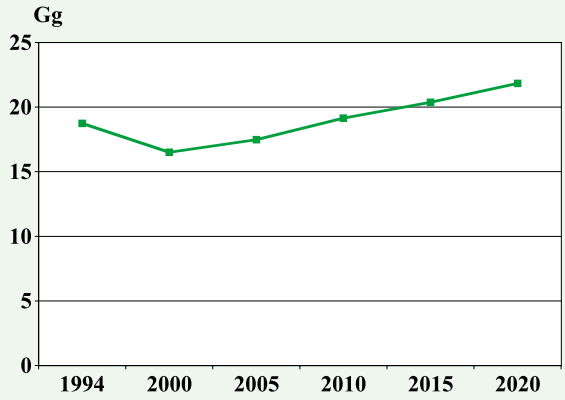


Figure 4.3 Projected Nitrous Oxide Emissions from Livestock, 1994-2020



Forestry Sector

The net emissions from the forestry sector depend on the extent of conversion of forest land to other types of land use and vice versa. The GHG inventory from the forestry sector in Thailand for the period between 1990 and 1994 indicates clearly that Thailand has increased its sequestration capability by expanding reforestation and preventing deforestation. As a result, net CO_2 emissions declined from 78 Tg in 1990, to 60 Tg in 1994. The only source in the forestry sector that indicated increasing emissions was wood and fuelwood consumption.

There are several factors contributing to a decline in the net emissions from forests in Thailand. Increasing the small proportion of protected forests to total country area is critical for the functioning of ecological systems. This has prompted the public to demand serious control of deforestation. Reforestation activities, especially to mark auspicious occasions of Thailand's Royal family, have increased reforested areas significantly since 1990. The 20-year Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, and the National Economic and Social Development Plans also indicate clearly that at least 25 percent of the total land area should be retained as conservation forests, and total forest cover should be 40 percent of the land area. A draft forest law being considered by Parliament also proposes to change the forest protection system. Under the proposed law, community forests will be legalized and communities will be allowed to manage their own forests. It is believed that rural communities, by applying their indigenous knowledge, can use forest resources sustainably and promote appropriate forest conservation. The diversification of agriculture from annual crops to permanent fruit trees, rubber and oil palm also will contribute to GHG sequestration in the future.

Various uncertainties are encountered when forecasting emissions from forests. They include the rate of change in forest areas for each forest type; the use of land after forest conversion; biomass density; fate of biomass after deforestation; as well as the amounts of soil carbon and underground biomass. Deforestation and reforestation trends in recent years indicate increasing amounts of sequestration relative to emission. Hence, a further reduction of net emissions could be achieved over the next few decades, provided that those areas are maintained. The difference in levels of emissions between 1990 and 1994 indicates emission rates are being reduced by about 1 percent per year. Based on this assumption, net emissions in the year 2000 should be about 56 Tg of CO_2. Emissions will continue to drop to about 53 Tg, 51 Tg, and 46 Tg in 2005, 2010 and 2020, respectively. Note that the growth rate of sequestration could be even higher during this period, depending on the growth rates of the trees.

Summary of GHG Emission Projections from Major Sources

The forecasts of GHG emissions from major sources, namely, energy consumption, forestry, agriculture, and livestock are aggregated to allow a broader perspective of the future emissions of GHG from Thailand. Trends are shown on Figure 4.4 and Figure 4.5 below.

Despite a reduction of net emissions from the forestry sector, total CO_2 emissions from both the energy and forestry sectors are predicted to increase from about 185 Tg in 1994, to more than 220 Tg in 2000. Emissions would continue to increase because of a more than two-fold increase in energy consumption between the years 2000 and 2020. The average increase from the energy and forestry sectors is about 5 percent annually. Unlike emissions of CO_2, emissions of CH_4 from agriculture and livestock tend to stabilize at between 2.6 -2.9 Tg per year. This is due mainly to the trade-off of emissions between buffaloes and other types of livestock. As a result, methane emissions from agriculture and livestock increase at an average rate of less than 0.1 percent per year.

Figure 4.4 Projection of CO_2 emissions, 1994-2020

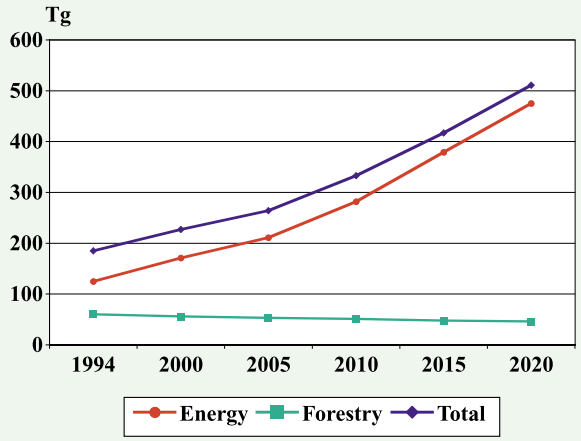
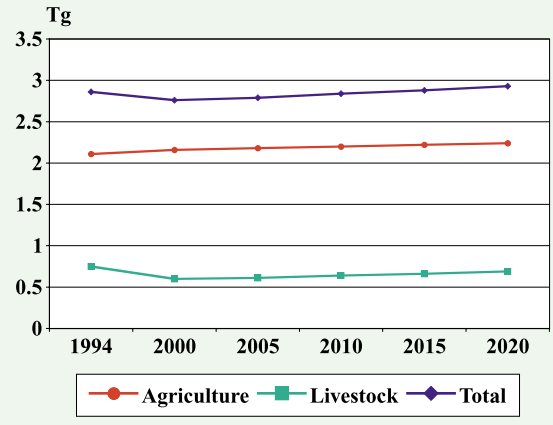


Figure 4.5 Projection of CH_4 Emissions, 1994-2020



4.2 GHG PROJECTION ESTIMATES FROM OTHER STUDIES

Several other studies have been conducted to evaluate potential for GHG reduction in Thailand. Each study projects emissions trends over the long-term, with some sectors covering the period until 2030. The approaches, models and assumptions used in making projections varied. For example, one early study prepared only one set of projections (TDRI/TEI, 1992), while both the Thailand Country Study and the ALGAS study used different scenarios to predict future emissions trends (TEI, 1997a, 1997b). Moreover, due to a lack of appropriate formal models for analysis, mitigation options were evaluated and ranked only for the energy and forestry sectors. Forecasts of emissions from the rice, livestock and waste sectors were limited to identifying and reviewing the technical potential of GHG reduction options.

The projections of GHG emissions in each of these studies were somewhat optimistic, having been prepared during a period of rapid growth in the Thai economy. The Thailand Country Study, for instance, projected CO_2 emissions from the energy sector by 2020 to grow by seven-and-a-half times its level in 1990 under the base case scenario, while the ALGAS Study estimated CO_2 emissions to increase by ten times during the same period.

Underlying these projections were optimistic assumptions regarding economic growth, which fueled the demand for energy. In one early study, for example, the economy was assumed to grow in real terms by an average of 7.4 percent annually over the period up to 2006. In both the Thailand Country Study and the ALGAS Study, economic growth was assumed to average about 7.7 percent annually between 1996-2000, then gradually slowdown to 6.8 percent between 2011-2020 (Table 4.10). Earlier studies made optimistic projections of energy demand and CO_2 emissions. One study estimated final energy demand to grow in the base case scenario by about 4.2 percent annually between 2000-2020, while another study projected it to grow by 3.9 percent per year during the same period. Projected CO_2 emissions ranged from 583 Tg to 777 Tg by 2020.

It is important to note, however, that all these projections indicate increases in the intensity of carbon energy utilization. This will occur as electricity use in commercial, industrial and other activities expands and as more coal is used for producing electricity. The power and energy sector is forecast to eventually replace the transportation sector as the largest source of CO_2 emissions and would account for almost half of total CO_2 emissions by 2020. Meanwhile, the transport sector would gradually reduce its share from about 37 percent in 1994 to about 25 percent by 2020.

In view of the economic crisis that occurred in Thailand beginning in 1997, an updated calculation of CO_2 emissions from the energy sector was made. The most recent figures assume more moderate economic growth of 5 percent annually. In this scenario, total CO_2 emissions would reach only 475 Tg by 2020, or about four times its level in 1994 (SIIT, 1998).

Emissions projections were also made using a number of other assumptions pertaining to the structure of the economy, population growth and fuel substitution, as well as the rates of technology penetration and efficiency improvement. All were assumed to be naturally-occurring and to follow historical trends, since the base case scenario represented a situation where present trends continued and no policy measures were implemented deliberately to reduce or sequester CO_2 from the atmosphere.

Table 4.10 GDP Growth Rates Up to the Year 2020 (percent)

	1998	1999	2000	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020
TDRI/TEI Study						n.a.	n.a.	n.a.
Thailand Country Study	n.a.	n.a.	n.a.	7.7	7.5	7.5	6.8	6.8
ALGAS Study	n.a.	n.a.	n.a.	7.7	7.5	7.5	6.8	6.8
SIIT Study	-7.0	-2.0	2.0	-2.3*	5.0	5.0	5.0	5.0

*1998-2000

Source: TDRI/TEI, 1992; TEI, 1997a, 1997b and SIIT, 1998

4.3 GHG MITIGATION OPTIONS

A number of studies have been undertaken since the early 1990s to assess greenhouse gas emissions and measures for their reduction. Yet few studies have actually evaluated mitigation options in terms of their suitability and cost-effectiveness for adoption and implementation in the Thai context. The initial study to analyze implications of implementing mitigation measures in response to global climate change was prepared in 1992 (TDRI/TEI, 1992). The report identified and assessed various options to reduce greenhouse gas emissions. In 1997, two studies (TEI, 1997a and 1997b) were undertaken to forecast GHG emissions and to estimate potential emission reductions to be achieved through the implementation of selected mitigation options. An analysis of cost-effectiveness was applied to certain sectors.

Studies that have analyzed options for reducing GHG in Thailand have identified mitigation options in five sectors: energy, forest and land use, rice cultivation, livestock, and wastes. Due to a lack of appropriate formal models for analysis, however, mitigation options have been evaluated and ranked only for the energy and forestry sectors. For rice cultivation, livestock and waste, only a review of potential GHG reduction options has been undertaken.

Most of these studies point out the fundamental difficulty of choosing the most effective and desirable options. Some mitigation measures may be technically feasible, but are incompatible with existing policies or are uneconomic. Apart from the many weaknesses in the techniques presently used to estimate GHG emissions, the choice of options also is limited by their availability and by other barriers to implementation. An assessment of the regulatory, legal and institutional needs to implement least-cost GHG abatement initiatives in both the energy and non-energy sectors revealed that policy and institutional barriers are major impediments to implementation of GHG mitigation measures.

These obstacles suggest that a number of factors should be considered when selecting the most effective and desirable options. There is a need to consider not only the narrowly-defined costs of mitigation options (i.e., direct costs such as investment and operating and maintenance costs) but also the broader concept of costs in terms of impacts on the economy and society of implementing such measures.

The obstacles to implementation only serve to highlight the importance of identifying, understanding and designing policies and strategies that would lower or eliminate the many barriers to implementing cost-effective and desirable options. Besides pushing for research and development and clean and efficient technologies in the energy sector, for example, widespread information campaigns should be conducted to educate the consumers. A combination of market-based and regulatory instruments also should be used. Implementation of mitigation options in non-energy sectors, meanwhile, would benefit from wider public participation in the management of natural resources as well as from involvement of the private sector, particularly in managing wastes.

Energy Sector

The energy sector has become the largest source of CO_2 emissions in Thailand, accounting for more than half of the country's total CO_2 emissions in recent years. Recent projections show that, if present trends continue and policies changes were not adopted specifically to encourage the reduction of CO_2 emissions ("Base Case Scenario"), demand for energy would continue to grow over the next twenty years, albeit at a lower annual rate of about 3.3 percent per year. Consequently, CO_2 emissions would rise fourfold from about 125 Tg in 1994 to 475 Tg by 2020.

In order to reduce the growing amount of CO_2 emissions, a number of mitigation options have been identified and evaluated on both the demand and supply sides. Detailed analyses of the various mitigation options were undertaken at a sectoral level, identifying technically feasible solutions and estimating their corresponding potentials for reducing CO_2 emissions. In some cases and whenever data allowed, economic analysis was made to identify cost-effective and "no-regrets" options.

Most of the measures identified in the different studies are similar and vary only in terms of estimated CO_2 reduction potentials. These potential reductions, in turn, depend mainly on assumptions regarding the efficiency of technologies and their extent of penetration.

Demand-side Management

Managing demand for energy becomes increasingly important to supplement the supply management. Options to curbing demand include improving energy efficiency through demand side management (DSM). In the residential, commercial and industrial sectors, for instance, demand side management measures are being proposed for various electricity end-uses such as cooling, lighting and refrigeration.

Table 4.11 shows the estimated CO_2 mitigation cost of various demand side management initiatives. Except for a DSM cooling program in residential sector, DSM lighting, cooling and refrigerator programs are expected to be "no-regrets" options. DSM lighting and cooling in the commercial sector, with its higher consumption of power, if successful, will likely to reduce a much larger amount of CO_2, when compared to the residential sector. In terms of costs, lighting programs in the residential sector are likely to be the most profitable, followed by lighting and cooling in commercial sector. The DSM programs in residential and commercial sectors can totally mitigate about 57 million tons of CO_2 (Table 4.11).

Improving Supply and Efficiency

As far as climate change is concerned, on the supply side, mitigation options include switching to lower carbon fuels such as natural gas, as well as greater use of renewable energy sources and more efficient technologies for power generation. The switching of fuels also is being proposed in the cement industry as well as in the transport sector, to reduce emissions of CO_2 and other trace gases.

Many of the mitigation options identified are already in place. In addition to the DSM program being implemented by the Electricity Generating Authority of Thailand (EGAT), the Department of Energy Development and Promotion (DEDP) is implementing an energy conservation (ECON) program under the 1992 Energy Conservation Promotion Act. Moreover, the Thai Government currently is implementing a policy to promote the use of natural gas for power generation and is encouraging the private sector to use cleaner fuels under the IPP and SPP schemes. It recently inaugurated an elevated rail system for Bangkok, and is constructing an underground rail system, that are designed to ease traffic and reduce fuel consumption and CO_2 emissions.

Though higher amounts of CO_2 reductions are technically possible to achieve, the choice of mitigation options to implement is difficult because the most effective option may not be consistent with national policy or may be uneconomic. Some particula studies, for example showed that reducing CO_2 emissions by an additional 42 percent, is estimated to cost an additional US dollar 25 billion and would require the substitution of coal-fired plants with nuclear energy. Nonetheless, some options like DSM measures are generally regarded as economic, especially when compared to the cost of constructing a new power plant. A least-cost analysis of mitigation options showed that most DSM measures for lighting and cooling end-uses even have negative abatement costs (see Table 4.11).

Renewable Energy

Renewable energy has been an important source of energy in Thailand. In addition to the generation of electricity from hydro-power, which contributes about 1,600 ktoe a year, biomass energy also accounts for more than 44 percent of the domestic supply of primary energy supply, or more than 20 thousand ktoe a year (Figure 4.6). In addition, other potential renewable sources of energy for Thailand include solar, wind, and the processing of animal and industrial wastes for generating energy. Thailand has just completed updating solar radiation map.

To enhance the use of renewable energy, Thailand has formulated a plan for the Demonstration and Promotion of Alternative Energy Production and Utilization for implementation during the period 1997-2001, with a budget of 4,880 million baht. The Plan emphasizes development of renewable energy resources including:

- Solid and industrial wastes (budget of 162 million baht)
- Solar energy (budget of 441 million baht)
- Hydro power (budget of 4,190 million baht)
- Biomass energy (budget of 81 million baht)
- Others

Table 4.11 Least-cost Analysis of CO_2 Mitigation Options under Demand Side Management

Option	CO_2 mitigation (million tonnes)	Accumulated CO_2 mitigation (million tonnes)	Abatement Cost (US$/tonne-$CO_2$)
Residential lighting	2.0	2.0	-323.1
Commercial lighting	22.7	24.7	-204.5
Commercial cooling	19.7	44.4	-136.4
Refrigerators	4.1	48.5	-46.1
Residential cooling	8.5	57.0	3.6

Source: TEI, 1997b

Unfortunately, the financial and economic crises have delayed implementation of these plans.

Thailand also has encouraged the private sector to participate in developing supplies of renewable energy through the SPP Program. Through the SPP Program, the private sector will invest in power generation projects using commercial or renewable energy and sell the electricity to EGAT. At present 23 power purchase agreements (PPA) of SPP using renewable energy sources have been signed with EGAT (Table 4.13). If all renewable energy projects are completed, the total amount purchased would be 150 MW. Note that the SPP implemented under the renewable energy program constitutes only a small portion of the potential SPP projects. The baht devaluation and the economic crisis that began in 1997 have delayed the development of many SPP. Nevertheless, Thailand still is promoting renewable energy use by developing SPP projects using sources of renewable energy.

Thailand sees renewable energy resources as important options to mitigate GHGs. There remains a large source of untapped renewable energy with high potential for development in Thailand. Studies on cost implications for these options will support the GHG mitigation policy of Thailand.

Figure 4.6 Renewable Energy Supply in Thailand, 1988-1997

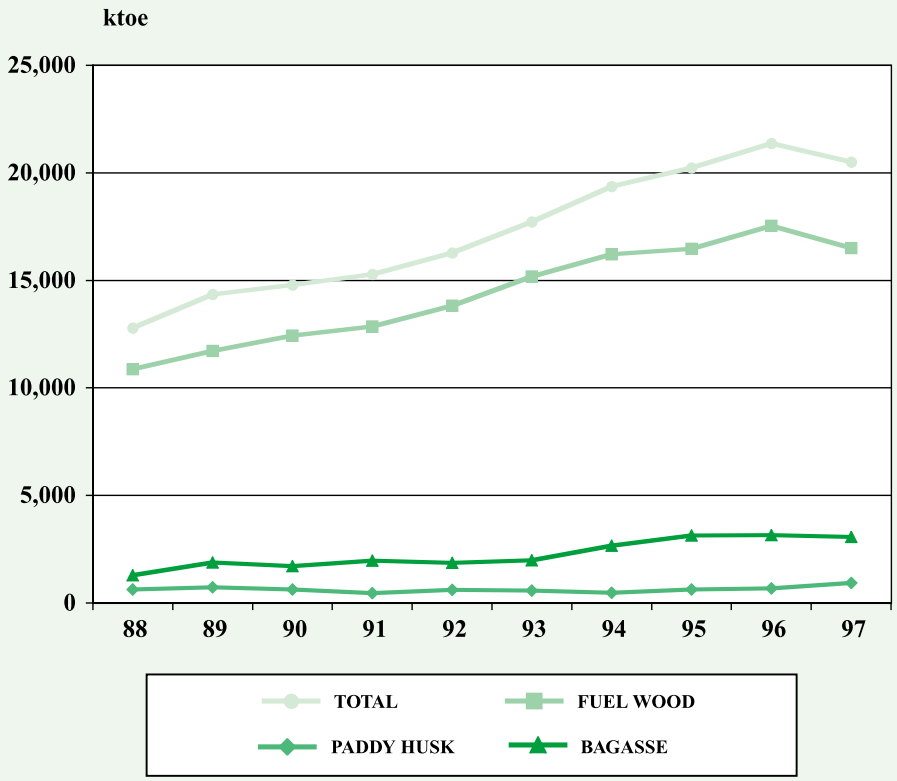


Table 4.12 SPP Projects Using Renewable Energy Accepted by EGAT by Type of Energy Supply

	Number of Projects	Generating Capacity (MW)	Sale to EGAT (MW)
Commercial energy	**34**	**4208**	**2305**
Renewable energy	**23**	**481**	**150**
Bagasse	14	301	67.5
Paddy Husk, Wood Chips, Saw Dust	6	144.3	57
Municipal Waste	1	3	1
Biogas	1	0.06	0.045
Black Liquor	1	32.9	25
Renewable as Percent to Total SPP projects	**40**	**10**	**6**

Forestry Sector

Thailand deems it suitable to maintain at least 40 percent of the country's land area as forests. Concurrently, it has a policy to protect about 25 percent of the total land area as conservation forests and to retain about 15 percent as economic forests. The Thai Forestry Sector Master Plan (TFSMP) designates some 14.1 million hectares as protected areas for environmental/ecological reasons, as well as 4.6 million hectares and 3.7 million hectares of land as community forests and commercial forests, respectively.

Uncontrolled logging and deforestation from widespread conversion of forests into agricultural land, and other uses, have reduced the total forest cover significantly. Satellite data for 1995 showed that only 13.15 million hectares or around 26 percent of the total area remained forested. Different studies predicted varying impacts of existing economic development trends on the total forest area. One study indicated that if the current trend of forest management continued, the total forest area would be only 15.61 million hectares by 2020. Another study predicted the total forest area to stabilize at 18.71 million hectares in year 2024 (about 36 percent of the total land area). However, in the latter study, the amount of carbon stored in forests would decline because of the disproportionate decline in natural and secondary forest areas compared with the expansion of non-forest areas.

Two major factors determine the amount of carbon reduction - the rate of reforestation and natural rate of regeneration. The regeneration rate depends largely on the type of vegetation that emerges on the land. Data for 1994 shows that reforestation accounted for about 45 percent of the uptake of CO_2, while the re-growth of vegetation on abandoned lands accounted for the balance.

In response to global warming, two broad categories of GHG mitigation options are being considered:

- maintenance of the existing forest cover by controlling deforestation; and
- planting more trees or increasing forest area.

Aggressive reforestation programs in deforested areas are being pursued, together with the planting of commercial forests and the enhanced protection of conservation forests. Reforestation is considered one of the better "no-regrets" options because it is in line with the government's policy on reforestation. Since the start of the 1st National Economic and Social Development Plan in 1961, the country's reforestation program has expanded rapidly. Today, there are four main groups involved in the country's reforestation programs, namely: the Royal Forest Department (RFD), Forestry Industries Organization (FIO), Thai Plywood Company (TPC), and the private sector. The total area covered by the various reforestation programs and commercial forest plantations at present is about 681,200 hectares, six times larger than the amount of forest lost per year.

Despite the logging ban imposed since 1989, forest loss continues albeit at a slower rate. From an estimated 450,000 hectares lost annually during 1961-1975, forest loss has gone down to less than 150,000 hectares per year in recent years. The loss has been moderated further by the various reforestation and afforestation programs, in which the private sector participates actively.

The most prominent of these reforestation activities is the program launched in 1994 to celebrate the 50th anniversary of the King's Accession to the Throne. The program aims to rehabilitate 5 million rai (0.8 million hectares) of conservation and non-conservation areas and to plant trees along the roadsides within 5 years. To date, this program has been behind schedule. It is expected that the final target will not be met fully due to administrative problems, difficulty of access to deforested sites, and institutional barriers such as obsolete laws and regulations that make it difficult for private individuals to benefit from participating in the program.

In order to achieve the targeted forest cover and to reduce or sequester carbon from the atmosphere at the same time, various scenarios, including the TFSMP Scenario, were identified and evaluated for the most cost-effective set of mitigation options. In the most recent assessment, the scenario that entails the planting of short-

rotation tree species in community forests in order to remain self-sufficient in forest products produced the largest benefits in terms of forest cover and carbon storage. It is also the most cost-effective-entailing costs ranging from only US dollar 2.5-2.9 per tonne of carbon. The implementation of these least cost mitigation options will be difficult, not only because of the limited area available for planting short-rotation tree species, but also because of opposition from some NGOs to commercial cultivation of fast-growing non-indigenous tree species.

While the mitigation potential from planting short-rotation tree species in community forests is estimated to be highest, the provision of effective protection for standing forests or conservation forests is considered the most attractive option. As much as 39 tonnes of carbon per hectare could be reduced at a cost of about US dollar 7.5 per tonne of carbon. The protection of conservation forests, however, is economically uncertain because of unknown biodiversity benefits. Mitigation options that include forest protection are found to be uneconomic, yielding large negative net present values, because the calculated benefits are limited to quantifiable and direct benefits.

Agriculture Sector

Rice Cultivation

In the analysis of mitigation options for rice cultivation, total CH_4 emissions are projected to rise from 2,110 Gg in 1994 to 2,244 Gg by 2020 if current trends continue. This increase in CH_4 emissions would result mainly from an expansion in irrigated area and an increase of fertilizer applications as a means to boost rice productivity to meet domestic and export demand. These projections also reflect a policy by the Thai government to stabilize the main-season rice cultivation area at around 8.8 million hectares, and to gradually reduce the rice crop grown in upland areas from 0.606 million hectares in 1994, to 0.462 million hectares by 2001.

In order to minimize the amount of CH_4 emissions, several mitigation options and their potential for CH_4 emission reductions from paddy fields have been identified by both local and foreign researchers. These include:

- improved water management through soil aeration and periodic drainage of paddy fields;
- incorporation of pre-fermented farm residues in organic matter amendment;
- use of sulfate-containing nitrogen fertilizers in mineral fertilization;
- proper selection of rice cultivars;
- use of chemical compounds to inhibit the production of methane;
- crop rotation; and
- changes in traditional planting practices.

Experiments conducted in other countries indicate that up to 90 percent of CH_4 emissions can be reduced by some of these options. However, some of the proposed measures require special application, while others are more costly or difficult to undertake. The effectiveness of some options also depends on soil characteristics as well as on the methods and conditions of application. Further studies and field testing are needed to assess the impact of different soil types and water management regimes on CH_4 emissions in order to assess their suitability for local application.

To evaluate the long-term impact of implementing CH_4 emission mitigation options, an analysis was made using two technical options considered feasible for implementation in Thailand:

- water management in irrigated areas;
- improvement in fertilizer amendment; and
- the combination of the two technical options

The results show that water management in irrigated areas could reduce total CH_4 emissions by about 20 percent. The substitution of green manure or readily decomposable organic matter with pre-fermented organic matter as well as the use of ammonium sulfate as nitrogenous fertilizer instead of urea could diminish CH_4 emissions by 11 to 23 percent. When both mitigation options are implemented for rice cultivation in irrigated and rainfed areas, total CH_4 emissions are estimated to be reduced by approximately 34 percent. The study, however, has not taken into account the cost implications of these options.

Livestock

The projected GHG emissions from livestock show total CH_4 emissions stabilizing at around 691 Gg by 2020. Enteric CH_4 emissions are estimated to gradually fall from more than 600 Gg in 1994, to 441 Gg in 2020, due to an anticipated rapid decline in the population of buffalos. Lower enteric CH_4 emissions from changing herd composition would thus partly offset the increasing trend in fecal CH_4 emissions arising from the growth in swine and poultry population.

Based on studies conducted in Thailand and abroad, the following options to reduce CH_4 emissions from enteric fermentation were identified:

- the use of mineral supplements to reduce the amount of feed but at the same time meet the minimum nutrient requirements;
- supplementing poor quality roughage with urea-molasses, legumes and/or low-cost agriculture by-products;
- chemical treatment of low-quality roughage, particularly with urea solution, in order to improve its digestibility and to increase the non-protein nitrogen content of fibrous feeds;

- expansion of pasture and forage conservation for dry season feeding, particularly for dairy cattle; and
- the use of ionophore, particularly monensic acid, to reduce CH_4 production from ruminant fermentation.

Since over 85 percent of estimated fecal CH_4 emissions were from swine, the waste management system that is currently in place also requires improvement. This can be achieved through the introduction of zoning regulations, particularly for small and medium-sized farms; the provision of central wastewater treatment facilities; and the harvesting of CH_4 gas produced as fuel for heating, electricity and other energy purposes. A recent study proposed introducing the delineation of zones for swine farms in the area north of Lamphun province in northern Thailand, together with the providing of central wastewater treatment facilities.

Some of the options identified, like the use of monensin, a broad-spectrum antibiotic, were found in studies by researchers outside Thailand to reduce CH_4 emissions by as much as 40 percent. Biogas digesters also have long been in use on large swine farms in Thailand, but there has been no comprehensive study made of the amounts of CH_4 captured by such projects. Moreover, size requirements constrain the viability of biogas plants. Many smaller projects have received support through bilateral technical cooperation arrangements.

Most of these measures have not actually been tested locally and thus could not be evaluated for their effectiveness and cost. The potential for application and the influence of enteric methane depressants on CH_4 emissions and feed utilization efficiency in ruminants, for example, have not been studied locally. Also, the impact of animal manure degradation on CH_4 emissions have not yet been assessed. Rearing practices and differences in animal species, particularly in a tropical climate, may result in different rates of CH_4 emissions. Surveys and research under local conditions should be undertaken to properly evaluate these options.

Domestic and Industrial Wastes

Population increases and the growing volume of solid waste, coupled with gradual phase-out of open dumping facilities in favor of sanitary landfill, were forecast to increase CH_4 emissions from solid wastes and domestic wastewater handling from about 35 Gg in 1994 to 102 Gg by 2010. However, forecasts of CH_4 emissions from industrial wastewaters were not attempted because of uncertainties regarding investments in anaerobic treatment facilities and wastewater characteristics of the industry as well as the location, types, technologies and processes involved.

Four options to reduce CH_4 emissions from landfill sites were identified, namely:

- recycling;
- control of waste generation rates;
- control of waste generation rates combined with recycling; and
- conversion of waste into energy.

The results of analysis indicated that the first three options, particularly the control of waste generation rates with recycling, provided significant reductions of CH_4 emissions and helped to limit CH_4 emissions in this sector at their present levels. The technical option of using landfill gas for production of electricity or pipeline gas was also found to be effective in reducing CH_4 emissions by up to 79 percent, though a capacity of at least one million tonnes of solid wastes a year is required to ensure economic feasibility.

Since 1995, the Thai Government has promoted electricity generation by the private sector through the SPP and IPP production schemes. Electric generation plants utilizing CH_4 from landfills are potential SPP projects, and about 75 MW of potential electricity generating capacity have been identified. To be viable, though, such projects require landfill sites to be sufficiently large and that solid waste management operations are implemented systematically. To reduce waste generation, the Bangkok Metropolitan Administration has promoted recycling and reuse of wastes strongly, with a target of 20 percent increase of reuse of wastes over the period 1997-2001.

For wastewater treatment facilities, basically two options are available-aerobic and anaerobic treatment systems. The choice as to which system to develop depends on a number of factors, including wastewater characteristics and properties, water volume, organic loading, budget, etc. If the anaerobic system is chosen, it should be equipped with energy recovery devices for heat or electricity generation. As with solid wastes, however, the viability of the project depends on the size of the methane recovery site.

Chapter

5

Vulnerability and Adaptation

- Introduction
- The Climate Scenarios
- Potential Impact of Climate Change and Adaptation Options
- Future Research Issues

5.1 INTRODUCTION

The second scientific assessment report of the IPCC (IPCC, 1995) indicated that a doubling of the CO_2 equivalent of greenhouse gases in the atmosphere would increase the global temperature by 1.5 to 3.5ºC, and would raise the mean surface sea level by between 15 to 95 cm by the year 2100. Such changes would alter the global climate system and would have varying impacts on regions and continents.

Various General Circulation Models (GCMs) were used to simulate climate change scenarios resulting from the accumulation of greenhouse gases. The recent GCMs use transient models to derive the year-to-year climate change scenarios. The vulnerability of forest, coastal and water resources as well as agriculture and health to climate change scenarios were then evaluated over a period of time and potential adaptation measures were identified and assessed to minimize climate change impacts.

In Thailand, the process of understanding vulnerability and adaptation resulting from climate change has just begun. Many studies have been conducted involving the application of scientific, technical and socioeconomic models. Each model has its own limitation due to simplifying assumptions, data constraints, etc. The various scenarios generated from different GCMs further contribute to the uncertainty of the outcomes. Considering the current level of development in this field in Thailand, the most useful way to interpret the results presented below is to appreciate the order of magnitude of the issues by drawing out their qualitative inferences rather than interpreting the numerical values per se.

5.2 THE CLIMATE SCENARIOS

The General Circulation Models (GCMs)

Climate scenarios were used to analyze the potential impacts of climate change on different sectors. In the absence of more detailed climate models showing climate scenarios at the local level, the scenarios generated from the GCMs were translated into location-specific data by direct interpolation method. Due to high uncertainty of the scenarios, however, the results from a few GCMs were used for comparison and validation purposes and for analyzing the potential impacts. Nevertheless, the results of analyses should be viewed more as indicative rather than as giving the precise magnitude of the potential impacts.

Earlier climate change impact studies used several GCMs, such as GISS, UK89, UKMO. These GCMs provided two climate scenarios - a controlled scenario ($1xCO_2$) and a doubling of carbon dioxide emissions ($2xCO_2$) scenario. The two scenarios were then used to analyze the potential impacts.

In the more recent studies, transient climate models were used. In this case, CO_2 is assumed to increase by 1 percent per year and the climate scenario is derived every year, usually over a 100 years. Scenarios derived from four GCM models were used in the analysis of impact on agriculture in Thailand. The four models were (1) CSIRO global coupled ocean-atmosphere-sea-ice model (CSIRO coupled GCMs or CGCM), (2) HadCM2 model, (3) ECHAM4/OPYC3 model and (4) CCCMA's First Generation Couple General Circulation model (CGCM1). Scenarios from only one model (ECHAM4) were used in the analysis of impacts on water resources and health. A description of these GCMs is presented (Table 5.1)

To derive local climate scenarios, the monthly mean values of climate variables generated by the GCMs were interpolated over the period 1990-2099. To avoid short-term climate effects, 30-year average monthly values were derived for four interval periods, namely, 1960-1989, 2010-2039, 2040-2069 and 2070-2099. Interpolation of global grid points was executed for four provinces where the potential impact on crops was analyzed, namely, Nakhon Sawan, Roi Et, Nakhon Ratchasima and Surin provinces (Table 5.2). The four variables used for the analysis in each model were maximum and minimum temperature, precipitation and solar radiation. The maximum and minimum temperatures used are shown on Table 5.3.

To derive values for each location, the climate values of the nearest grid points from the GCMs were directly interpolated to each analysis point or study location. The process is performed by means of a distance-weighted average of points in a search circle that encompass at least 3 grid points in at least 3 different quadrants for every analysis points.

Comparison of Temperature Data

Temperature is one of the most important climate variables used in the impact analysis. A comparison of the actual 30-year (1961-1990) monthly average maximum and minimum temperatures at local stations, with values derived from models for the period 1960-1989 is shown below. The data indicates that temperatures are more comparable during the six months of the middle of the year, particularly when temperatures ranged between 20-30ºC. The lower the minimum temperature, the wider the differences are between the actual data and the GCMs' estimates. Moreover, estimates obtained from ECHAM4 and HadCM2 were closer to actual values, compared with those of CGCM and CGCM1, especially

Table 5.1 General Circulation Models From Which the Climate Scenarios Derived

Model	Type	Model resolution (latitude x longitude)	Performed at
CGCM	Spectral (R21)	3.19˚ x 5.63˚	CSIRO
HadCM2	Grid	2.5˚ x 3.75˚	HCCPR
ECHAM4/OPYC3	Spectral (T42)	2.77˚ x 2.81˚	MPI
CGCM1	Spectral (T32)	3.68˚ x 3.75˚	CCCMA

Note: CSIRO = Commonwealth Scientific and Industrial Research Organization, Australia
HCCPR = Hadley Centre for Climate Prediction and Research, UK
MPI = Max-Planck-Institut fur Meteorologie, Germany
CCCMA = Canadian Center for Climate Modeling and Analysis, Canada

Table 5.2 Location of Weather Observation Stations in the Studied Areas

Name of Station	Location	
	Latitude (degree)	Longitude (degree)
Nakhon Sawan	15.80 N	100.16 E
Roi Et	16.05 N	103.68 E
Nakhon Ratchasima	14.96 N	102.08 E
Surin	14.88 N	103.50 E

Source: Center for Applied Economic Research, 2000b

Table 5.3 Temperature Variables of GCMs used in the Analysis

Model	Maximum Temperature (unit)	Minimum Temperature (unit)
CGCM	2 meter maximum Temperature (K)	2 meter minimum Temperature (K)
HadCM2	1.5 meter maximum Temperature (K)	1.5 meter minimum Temperature (K)
ECHAM4/OPYC3	2 meter maximum Temperature (K)	2 meter minimum Temperature (K)
CGCM1	2 meter maximum Temperature (K)	2 meter minimum Temperature (K)

Source: Center for Applied Economic Research, 2000b

in the lower temperature range. Figure 5.1 and Figure 5.2 show the comparison of minimum temperatures in the two provinces used as the study sites for maize.

Similar results were observed in the case of maximum temperatures. The model results and the actual maximum temperatures were more consistent in the middle of the year. But the differences widened during the months closer to the beginning or the end of the year. The maximum temperature data from ECHAM4 and HadCM2 were more compatible to the actual ones, than those of CGCM or CGCM1. Figure 5.3 and Figure 5.4 compare the maximum temperatures of the two provinces used as the study sites for rice.

Large variations in the minimum and maximum temperatures during the first and last three months of the year indicate increasing uncertainty in the analysis when making use of data during these periods. As the crop seasons for rice and maize fall from May to November, the analysis of the two crops tend to be less affected. But this is not the case for dry season crops. The high levels of variation also influence the analysis of potential climate change impacts on health when the temperature for the whole year is used.

Figure 5.1 Monthly Minimum Temerature, 1960-1989, Nakhonsawan Province

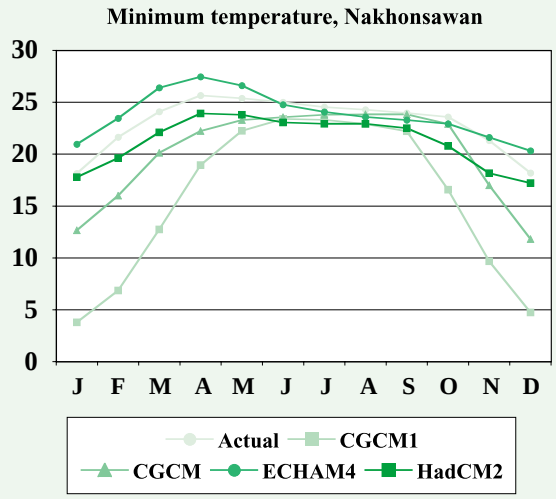


Figure 5.2 Monthly Minimum Temperature, 1960-1989, Nakhonrachasima Province

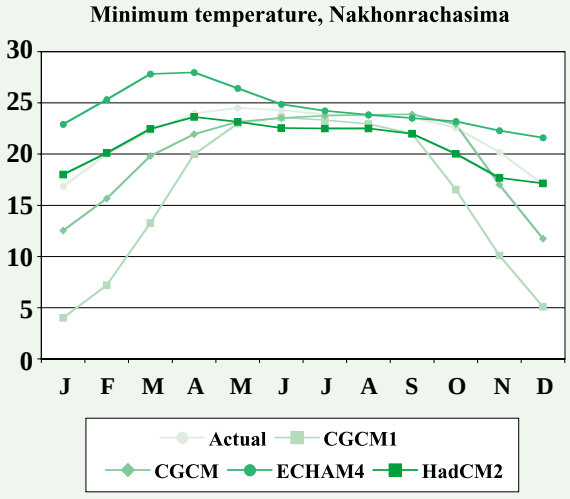


Figure 5.3 Monthly Maximum Temperature, 1960-1989, Roi-et Province

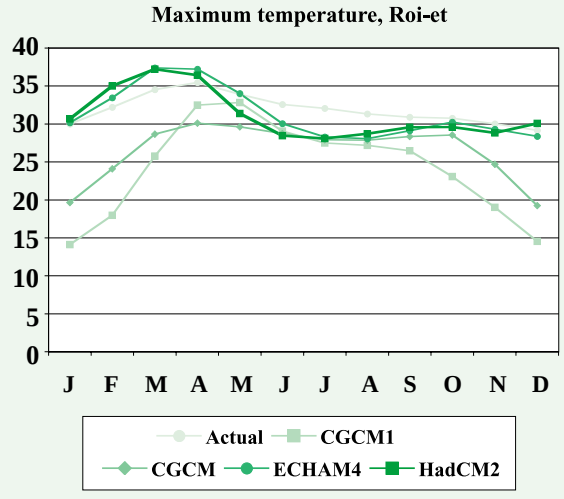
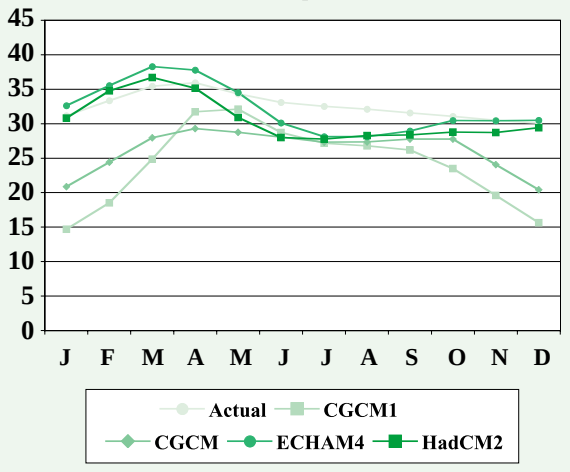


Figure 5.4 Monthly Maximum Temperature, 1960-1989, Surin Province



5.3 POTENTIAL IMPACT OF CLIMATE CHANGE AND ADAPTATION OPTIONS

The potential impact of climate change depends on several factors, including the topographical nature, economic and social characteristics, and the national endowment of natural resources and environment of a particular country. In general, an economic and social structure that is more natural resource-based has a higher potential for vulnerability to climate change.

Thailand is located in the tropical monsoon region. The country has more than 2,500 kilometers of coastline. The regional topography varies from the mountainous terrain of the North and the relatively dry and high land plateau of the Northeast, to the flat and low land of the Central plains and the coastal areas of the South. More than half of its 62 million inhabitants depend on agriculture, where less than 20 percent of agricultural land is fully or partially irrigated. These irrigated areas are relatively productive, and land use intensity is high. There also is a large number of small fisher households who live by artisan fisheries.

Such diversified characteristics suggest a wide range of potential impacts of climate change between regions and activities. The structure of natural resource use in different regions already causes different susceptibilities to environmental change. In the northern region of Thailand, for instance, forest protection and soil conservation are a priority for sustaining the environment. In the southern region, the conservation of mangrove forests, protection of coastal resources and nature-based tourism, and sustainable shrimp farming system are important for sustainable development of the region. The relative scarcity of water resources and low soil fertility of land in the northeastern region, on the other hand, require efficient allocation and utilization of water resources and conservation of land resources.

The potential impacts of climate change have been studied for five major areas in Thailand, namely, natural forests, agriculture, water resources, coastal areas, and health. They are discussed below.

Natural Forests

At present, natural forests in Thailand are under serious stress due to human activities. Over the past four decades, forest cover in Thailand has declined substantially from more than one-half of the country's total land area to less than one-fourth. The government's imposition of a logging ban beginning in 1989 has reduced the deforestation rate to a certain extent. Forests also have been recognized as an important sink for CO_2. Hence, the conservation of forests serves the dual purpose of absorbing CO_2 from the atmosphere and reducing emissions.

Potential Impact on Forests

Climate change could have a marked impact on natural forests. In the analysis of climate change impacts on forests, the monthly climate variables produced by three GCMs (UK89, UKMO and GISS) under $1 \times CO_2$ and $2 \times CO_2$ cases were down-scaled by direct interpolation method to derive the local climate scenarios. The 30-year average monthly climate data for 1950-1980 were used as a base to derive climate scenarios. This is to avoid the effects of climate extremes on average temperature which occurred more frequently after the 1980s. These local climate data were incorporated into the Holdridge Life Zone Classification, a vegetation model (TEI, 1997a). A comparative analysis of "with" and "without" the doubling of CO_2 shows that while total forest area remained the same, the composition of forests, by type, changed markedly. In general, subtropical life zones were found to decline, while tropical life zones, toward the southern region of Thailand, increased due to expected intensification of precipitation. Subtropical dry forests, which currently occupy 1.2 percent of total forest area, might completely disappear and be replaced by tropical dry forests. A new type of forest, tropical very dry forest, also emerged in the North and the Northeast (Table 5.4).

The results based on the three different sets of climate data derived from three GCMs generally were consistent, i.e., a poleward shift in vegetation boundaries and the replacement of subtropical life zones with tropical life zones. The differences lie only in the extent of the boundaries of change.

Some limitations in this first attempt to study the impacts on forests were observed. At the present time, there is a deficiency of reliable and comparable data and factors influencing tropical forest ecosystems are not thoroughly understood. For example, the study had difficulty in comparing local forest classifications with Holdridge Life Zones. There is also considerable uncertainty associated with the results of the models used, particularly the GCMs, because of their relatively crude treatment of the ocean and their negligence of other potentially important elements of the climate system, such as the upper atmosphere and atmospheric chemical and surface biological processes.

Changes in local vegetation also could not be predicted with confidence because of the absence of reliable plant-climate related models. Many currently available models do not capture seasonal variations, which are the important factors influencing the regeneration process of tropical forests. Current models also fail to give adequate understanding of soil characteristics, an important factor determining the local vegetation of the region.

These weaknesses and difficulties imply a need for further efforts by research communities in Thailand to achieve more reliable results to determine impacts on forest vulnerability and adaptation. The preliminary results are very useful for formulating Thailand's forest policies, however. They lend further support for the need to revitalize forest cover as well as to protect strategic forest frontiers. Until more information is available, Thailand cannot formulate an adaptation policy for forests. Nevertheless, existing forest laws and the policy regarding biodiversity that also are relevant to forest conservation, can be applied in order to accommodate initial findings from vulnerability studies on forests.

Adaptation Options

There are different types of forest areas in Thailand. The national reserve forests have long been given a degree of legal protection, but also have been the center of land use conflicts with local people in many areas. The government has implemented numerous policy measures to address the problems with little success. As indicated in the 7th and 8th National Economic and Social Development Plans, the forest policy of the country is to maintain the conservation forests at 25 percent of the country's total land area while expanding forest plantations or commercial forests to 15 percent. Protected

Table 5.4 Changes in Forest Areas, by Type, due to a Doubling of CO_2

Forest Type	Current thousand sq km	Climate change scenarios					
		thousand sq km			Percent change from current		
		UK89	GISS	UKMO	UK89	GISS	UKMO
Subtropical dry forest	5.9	0	0	0	na	na	na
Subtropicalmoist forest	234.5	87.7	9.5	59.4	-62.6	-95.9	-74.7
Subtropical wet forest	22.2	6.5	5.3	1.8	-70.7	-76.1	-91.9
Tropical very dry forest	0	0	11.9	2.9	na	na	na
Tropical dry forest	156.5	218.6	341.3	290.1	39.7	118.1	85.4
Tropical moist forest	71.5	166.8	120.5	128.1	133.3	68.5	79.2
Tropical wet forest	1.6	12.6	3.7	10	687.5	131.3	525.0
Total	**492.2**	**492.2**	**492.2**	**492.3**	**0.0**	**0.0**	**0.0**

Source: TEI, 1997a

forest areas include national parks, wildlife sanctuaries, class 1 watersheds, mangrove forests and protected wetlands. The use of protected forests is prohibited by law. Only limited activities, such as recreation, research and education, are permitted in certain types of protected forests. In practice, though, the enforcement of the law is weak and forest poaching and encroachment are not uncommon.

Thus, generally speaking, natural forests in Thailand will naturally adapt to climate change. The impacts on forests from climate change indicate a transformation from subtropical types to tropical types, and from moist forest to dry forest. The needs and adaptation options depend on the extent of the impacts and their implications on natural resources and environmental conditions, as well as on the economic welfare of the population. As there are several areas where vulnerability analysis could be improved, adaptation options here are merely indicative and should be construed as part of a learning process. Among them are:

- Capacity building on vulnerability and adaptation analysis
- Reforestation with drought and heat tolerant species
- Prioritization of protected areas for conservation
- Establishment of gene banks and the collection of various plant cultures

Good vulnerability analysis is essential for evaluating the best adaptation options. As stated earlier, there remains much room for improving vulnerability analysis, including development of regional or sub-regional climate models to improve climate scenarios. A refinement of forest models to reflect more closely the tropical forest life zones of Thailand will enhance the consistency and accuracy of the analysis. Likewise, adaptation studies also might be improved by applying benefit-cost analysis to the maximum extent.

Reforestation is an important policy measure to expand forested areas in Thailand. At the same time, non-timber products from these areas could be used to support rural livelihoods. Given the limitation of the vulnerability analysis of the forest sector, reforestation should take into account adaptation of trees to drought and heat to the greatest possible extent. Besides planting exotic fast growing trees such as Eucalyptus spp., Thailand also has replanted forest lands with indigenous species that have relatively high adaptability to local climate conditions.

One way to enhance the adaptation capability of forests is to prioritize protected areas that are relatively vulnerable to climate change. Conservation of these areas also should integrate the development of gene banks with the collection of various plant material into the ecosystem. Endangered species and endemic species that have higher risks due to climate change as well as those that have high potential for adaptation should be conserved to ensure their existence.

Agriculture

By topographical and cultural characteristics, agriculture in Thailand is highly diversified. While rice is the staple crop across the country, field crops also are common in most areas (Table 5.5). Different regions have natural comparative advantages in specific crops. The flat and well-irrigated lands in the Central Plain are suitable for cultivating rice and other cash crops. The high plateau, relatively dry and mainly rainfed lands of the Northeast are suitable for corn, cassava and sugarcane. In contrast, the long coastal area with relatively high rainfall in the South is dominated by rubber and oil palm, while the East is planted mainly to tree crops. The relatively high latitude and mountainous areas of the North, on the other hand, have a mixture of fruit trees, vegetables and other cash crops.

Table 5.5 Percentage of Land Holdings, by Type of Land Use and by Region, in 1992 and 1993

Type of Land Use	Northeast	North	Central	South	Total
1992					
Total holding	100.00	100.00	100.00	100.00	100.00
Housing area	2.23	3.10	2.83	2.76	2.62
Paddy land	65.79	52.02	44.12	19.56	52.13
Field crop land	23.00	35.32	32.60	0.65	24.84
Fruit tree and tree crop land	3.33	6.64	15.88	72.80	15.79
Vegetable and flower land	0.35	1.01	1.14	0.40	0.67
Grass land	0.78	0.39	0.54	0.22	0.57
Idle land	3.73	1.11	1.37	2.67	2.51
Others	0.79	0.40	1.51	0.94	0.88
1993					
Total holding	100.00	100.00	100.00	100.00	100.00
Housing area	2.28	3.08	2.84	2.85	2.65
Paddy land	65.61	52.06	44.02	19.51	52.06
Field crop land	22.66	35.20	32.32	0.56	24.55
Fruit tree and tree crop land	3.42	6.71	16.29	73.25	16.00
Vegetable and flower land	0.38	1.01	1.25	0.44	0.71
Grass land	0.83	0.32	0.49	0.21	0.57
Idle land	3.73	1.08	1.35	2.38	2.47
Others	1.09	0.54	1.44	0.79	1.00

Source: Center for Agricultural Economics, 1998

The diversity of agriculture in the different regions of Thailand under different topographic and climatic conditions exposes the country in vastly different ways to climate change.

Potential Impact on Crops

As early as 1987, a study was conducted to assess the potential impact of climate change on agriculture in Thailand (UNEP, 1989). Based on the "with" and "without" scenarios of a doubling of CO_2 using the GISS GCM, the study suggested that a doubling of CO_2 could increase the risk of yield variation and the loss of income to the farmers. But the estimated variations in yield levels were unusually high. Several weaknesses were identified in this study, including the use of a non-validated crop model and limited climate data.

The study on potential impact of climate change on agriculture was refined recently (Center for Applied Economic Research, 2000b). Rice and maize in two provinces each were tested using the CERES crop models and climate input data derived from different GCMs. Rice grown under rainfed conditions in Thailand was found to be highly vulnerable to climate change due to an increase in greenhouse gases. The results, which were based on climate data from four GCMs, suggest similar declining trends in rice and maize yields overtime. Their magnitudes, however, vary depending on climate conditions, soil types and crop practice. Maize yields, for example, could drop from 5 percent in Nakhon Sawan province to 44 percent in Nakhon Ratchasima province.

The impacts on rice yields could be even more extensive and diverse. Rice yields could drop by 57 percent in Roi-et province, but increase by 25 percent in Surin. The four climate models also demonstrated that climate change could increase temperature in areas during the flowering period of crops by 1 to 7ºC. This will reduce flowering and harvesting periods as well as crop yields in general. The accumulation of CO_2 in the atmosphere also increases crop yields through the feedback effect, but only to a limited extent. Climate scenarios from different GCMs produced different magnitudes of impacts and, in some cases, opposite results such as those obtained from the Hadley model[1].

Given the uncertainty of the GCMs, the wide differences of impacts on yields between crops and between provinces suggest that the vulnerability of agriculture to climate change varies according to crops and location characteristics, in addition to the climate

[1] The results from the HadCM2 were unusual and opposite the others, due to radiation factors and were not presented here.

conditions. As land use and soil capacity in a particular area are suitable for many types of crops, the agriculture sector's vulnerability to climate change depends on the ability of farmers to diversify their crops as well. The present vulnerability research in Thailand is limited only to certain areas and crops and more comprehensive studies are required to understand potential impacts on different economic crops and areas, especially permanent trees, fruit trees and livestock.

Adaptation Options

The analysis of potential climate change impacts on rice and maize, despite its limitations, suggests that Thailand is exposed to the risk of such negative effects. Such potential impacts may have crucial implications for food production in Thailand.

The agriculture sector in Thailand has adapted to developments in domestic and international economic and social environments. Over the past few decades, the rice-dominated agriculture sector has diversified substantially to different kinds of crops, livestock and fishery production activities. Agriculture in Thailand also has adapted to local environmental conditions. Soil conservation, reduction in the application of chemical pesticides and fertilizers, and even chemical-free or organic agriculture have been promoted. Certainly, autonomous adaptation to climate change will occur as well. But the extent of such adaptation is difficult to assess, especially in the long-term.

Since climate change impacts are expected to occur over a long-term horizon, vulnerability and adaptation also depends on future structural changes in the agriculture sector. It is difficult to envisage the structure of agriculture in Thailand over the next 50-100 years. Approximately 40 percent of the population are expected to still be dependent on the agriculture sector for their livelihoods over the next 25 years (OAE, 1996). The main economic crops in Thailand would be rice, maize, cassava and sugarcane, though other crops such as fruit trees and vegetables would still be grown. Livestock also would be important in the future.

Precautionary measures could be taken as a preliminary adaptation option while research and development of the issues are continuously refined and improved. Such precautionary measures include:

- Conservation and improvement of local drought-resistant varieties
- Improvement of cropping practices to minimize water use
- Application of risk averse cropping systems
- Analysis of potential crop substitution in different regions
- Promotion of crop diversification program

Water Resources

Potential Impacts on Water Supply

Conflicts over the allocation of surface water in Thailand have now become a critical issue due to the expansion of demand and a shortage of supply. Variations in the frequency and intensity of rainfall in a monsoon region like Thailand also have imposed high risks of drought and flood in the dry and wet seasons. Damage due to flooding in Thailand vary from year to year (Figure 5.5). The risks are intensified by the increasing degradation of natural resources and the environment in the country. The damage varies in each region, with the most severe damage wreaked in the South, followed by the North and the Northeast (Figure 5.6). The Southern region has greater potential to be affected by a series of typhoons emerging from the South China Sea. Climate change due to GHG accumulation could further impose higher risks to water resources in Thailand.

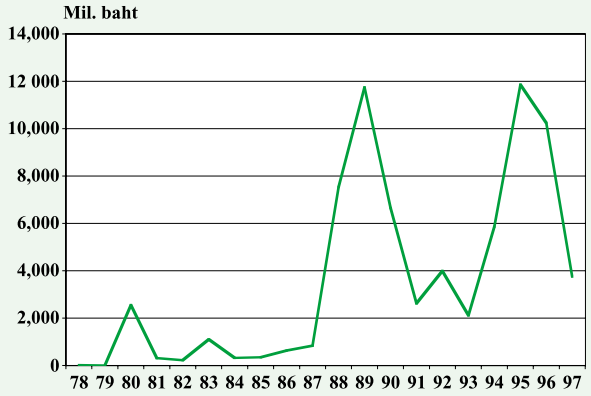
Climate change alters precipitation patterns and potentially increases temperature. Changing rainfall patterns, in turn, affect the level and intensity of surface runoff, while increasing temperature increases the rate of evapo-transpiration and hence reduces the water storage capability of the rivers and reservoirs.

In a case study of the potential climate change impact on water storage capacity of the reservoir of the Sri Nakarin Dam, it was found that doubling CO_2 levels could result in possible shortages of water in the watershed area above the Sri Nakarin Dam in 10 to 15 years, unless water management is critically improved. The main cause of the shortage was the loss of water flow into the reservoir due to evapo-transpiration. Moreover, it was found that direct evaporation of surface water in the reservoir was insignificant (TEI, 1997a).

Based on the climate data generated by the ECHAM4 GCM, a doubling of CO_2 potentially could increase temperature and reduce annual rainfall in the Chao Phraya basin in the Central Plain of Thailand. As a result of the doubling of CO_2 emissions, temperatures could increase by 2 to 4ºC, while annual rainfall could decrease from 960-1,290 mm, to 800-900 mm, from the control case. Average annual runoff could drop from the controlled case by 34-44 percent. The reduction of annual runoff could be more than 50 percent in certain areas of the lower basin. The potential reduction in runoff will amplify water scarcity in the Central Plain, especially during the dry season. Note that the results are based on only one GCM and limited observed locations in the basin. High uncertainty is observed (TEI, 2000).

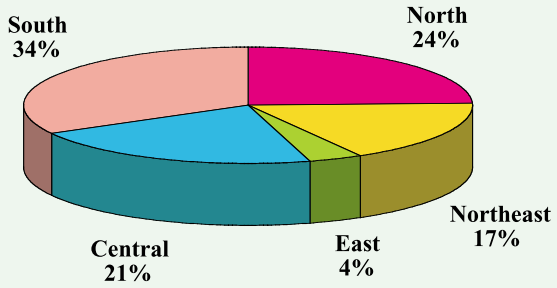
The most notable impacts of the climate change scenarios on water resources are variations in precipitation and their intensity in different regions. More extreme flooding and drought could emerge. The impacts on water resources could affect agricultural development substantially. Lower water levels in the dams require

Figure 5.5 Damage Due to Flood, 1978-1997



Source: OEPP, 1999

Figure 5.6 Flood Damage by Region, During 1992-1997 (billion Baht)



Source: OEPP, 1999

serious water resource management. Crop yields and cropping pattern could be severely affected. Water for irrigated areas may need to be rationed to allow for other uses. A study of climate change impacts on rice in a province in the Central region has already suggested a higher variation of yield due to climate change could occur (UNEP, 1989). The impacts on yields could be even more serious in the relatively drought-prone areas of the Northeast (Center for Applied Economic Research, 2000b).

Research in this area in Thailand is just beginning and covers only a small part of a watershed. As climatic conditions vary in different regions of the country, it is necessary to conduct a more comprehensive study in each region. Reducing high levels of uncertainty of climate change results from different models also is needed.

Adaptation Options

Even without the climate change issue, Thailand is already facing serious water resource management problems. Total water demand is expected to increase from about 71.1 billion cu m in 1996, to more than 80 billion cu m in 2006 (OEPP, 1999). Water use conflicts between different users are increasing, especially in the dry season. The excessive use of groundwater in the Bangkok Metropolitan Region also is causing serious land subsidence in the area. Several measures and policies therefore have been implemented to mitigate water resource problems. These measures and policies, while addressing the immediate problems posed by the growing scarcity and inefficient/improper use of water, also support measures to adapt to climate change. In addition to direct measures to improve water resource management, policies to enhance environmental and ecological quality, such as reforestation, afforestation, protection of conservation forests, and land and water conservation also support the adaptation process.

At present, the Royal Irrigation Department, in cooperation with other agencies, allocates water in dams and reservoirs to different users in the dry season. About 60 percent of the water is allocated for agriculture, while only 10 percent is distributed as raw water for production of pipe water. As a general rule, water for agriculture will be partially diverted to other higher priority uses when water is scarce. Under such a situation, the government would encourage farmers to reduce areas under cultivation or to switch to less water-consuming crops. Several policies and plans are being implemented or prepared to improve water resources management. The emphasis currently is to improve water resource management on the demand side. They are:

- A proposed water act
- Water resources pricing and water rights
- Integrated watershed management
- Community-based resources management
- Water conservation and crop diversification in agriculture

The proposed water act has been drafted and is currently being considered by all related agencies. Under the proposed law, a more unified management system will be established, having a water resource committee as the highest policy formulating body. A river basin committee also will be formed for each basin as a water resource management body. But the proposed law still has not adequately addressed the issue of local participation in water management.

Appropriate water pricing, especially for non-agriculture use, is another important measure that is being proposed. In addition, harmonizing prices between pipe and ground water is needed to ensure appropriate use of the resource. Water rights could be critical in the future, when highly-competing uses of water exist. At present,

though, public water bodies are considered open access resources.

An integrated watershed management system was introduced on an experimental basis only a few years ago. At present, the system is being tested in three watersheds on a pilot basis. Under this system, land and forest resources in the upper watershed areas are controlled more strictly, to ensure water resource conservation, while water utilization is managed using a basin approach. Initial results from the pilot study suggest that it is vital to strengthen institutions and organizations to support such system. The effectiveness of such a system can be seen in the northern region, where local communities have initiated networks to coordinate and cooperate in the management of water resources in the basin.

An improvement in the water use efficiency of the agriculture sector that is the largest water consumer, would result in savings for others. Farmers are encouraged to diversify crop production or to replace off-season rice with other crops such as soybeans or peanuts.

Coastal Resources

Besides being affected by higher temperatures, greater precipitation and flooding, coastal areas are also vulnerable to rises in the sea level. An accumulation of greenhouse gases in the atmosphere would make the world warmer. The three major factors contributing to a rise in sea levels are thermal expansion of the ocean, melting of non-polar glaciers, and a change in the volume of ice in Greenland and Antarctica. The greatest impact among the three comes from thermal expansion of water in the oceans. As the oceans warm, water expands and the sea level rises. Recent models project that the sea level could rise by between 15 and 95 cm over the next 100 years. The current best estimate is that the sea level will rise by about 0.5 m by the year 2100 (McGregor and Nieuwolt, 1998, cited in TEI, 2000). A rise in the sea level is of great concern to Thailand, where the shoreline is more than 2,500 km long, and where significant land areas are prone to flooding and intrusion of seawater.

Potential Impacts on Coastal Resources

There are several types of coasts in Thailand: steep coasts, sandy beaches, mangrove scrub and mangrove forests. A rise in the sea level is unlikely to have significant economic and social impacts on steep coastal slopes with rocky shores due to their limited uses. For the cliffs in hard rock such as limestone, found mostly in southern Thailand, a rise in the sea level could cause them to recede slowly. The rate will be higher in the case of cliffs in soft rock such as those found along the coast of Rayong in the eastern region.

Narrow fringing beaches can be found mostly in the eastern region of the country, especially along the Eastern Seaboard and on off-shore islands. A rising sea level will erode and submerge narrow beaches, possibly washing some of them landwards, and waves will reach to the hinterland. Low-lying coasts are likely to be cut back and modified by marine inundation, a rising water table and increased saline intrusion. Beaches will be narrowed and eventually disappear, if severely affected.

Sectors of sandy coastal plain, marked by ridges built successively, parallel to a prograding shore, occur behind many beaches, particularly on the coast north of Songkhla, between Hua Hin and Cha-am, and in bays on the east coast, notably Rayong Bay. A rising sea will reduce the existing beach, so that the coastline recedes through the beach ridge plain.

For mangrove swamps and salt marshes, a sea level rise will submerge their outer margins, destroying or cutting back their size. The inner margins will spread landwards, if they are backed by underdeveloped lowland, but will not occur if they are backed by rising ground or developed land.

Sea level rise will increase saltwater intrusion into the estuaries of Thailand. At present, saltwater intrusion in Thailand is already critical during the dry season, especially in the Chao Phraya River, where water is used to produce pipe water. Another site which could be severely affected is Songkhla Lake, the shores of which would be inundated and the lagoon expanded.

Aquaculture is one of the most important sources of foreign exchange earnings of Thailand. A large portion of the areas under aquaculture production was formerly mangrove areas and mudflats. These areas are vulnerable to inundation as well. There also are other coastal areas that are occupied by different activities, including agriculture, communities, ports and resorts, among others. These areas would, in one way or another, be affected by a rise in the sea level.

Coral reefs can be found both in the Gulf of Thailand as well as in the Andaman Sea. Increased sea surface temperatures, due to global warming will lead to coral bleaching and ultimately, the widespread destruction of coral reefs. Thailand has already experienced coral reef bleaching due to the El Nino Southern Oscillation (ENSO) in the 1980s. Monitoring of coral reefs in the Gulf of Thailand during the ENSO Events in May 1998 found that the unusual increase of maximum temperature by just 1-2ºC, due to ENSO, partly resulted in widespread coral bleaching in the Gulf of Thailand. On the other hand, the coral reef bleaching in Andaman Sea area, where the ENSO influence was marginal. This suggests that climate change can threaten the survival of marine resources like coral reef of Thailand.

Where inner land areas are lower than the shoreline or very low lying, inundation or saltwater intrusion would occur through small waterways connecting the sea to inland areas. This would occur especially during the wet season, when the sea level rises and salinity barriers would obstruct the flow of water into the sea, subjecting the irrigated lowlands of East Bangkok along the Bangpakong River, to probable flooding of more than two meters. The impact would be even more serious for some parts of Bangkok due to the fact that Bangkok has been gradually subsiding.

This assessment, however, relies to a large extent upon qualitative reviews of the potential impact. A study currently is being conducted using hydrodynamic and salinity intrusion models with information and data on hydrological and oceanographic variables as well as topographic and land-use characteristics of selected areas to evaluate potential impacts of sea level rise. (TEI, 2000) Preliminary results confirm that strategic coastal areas of the Gulf of Thailand and major rivers draining into the Gulf could come under threat from sea level rise, triggered by climate change. If mean sea level at the center of the Gulf of Thailand rises by 25 cm in the year 2050 and 50 cm in the year 2100, the same rises are likely to occur along the coastlines of the Upper Gulf of Thailand.

Assuming that the rate of fresh water inflow at the upstream boundary in constant, the salinity model indicates that when sea water level rises, salt water can intrude further upstream of the tidal river. This is due to the increase in cross-sectional area of the rivers that result in a small decrease in flow velocity. Tidal speed could also increase, causing more severe damage to shorelines. Salinity could be worse than under a normal situation.

As aquaculture earns several billion dollars annually, coastal resources are very important to the Thai economy. In addition, almost one-half of the foreign tourists coming to Thailand spend their time at beaches or on islands. Diving has been one of the most popular activities among the tourists. The main tourist resources related to Thai seas and coastal areas are (OEPP, 1999):

- Beaches and coastal scenery
- Islands especially those with coral reefs and clean beaches
- Protected marine parks
- Surface and underwater diving
- Marine archeology
- Activities related to coastal tourism areas, such as fun parks, marine museums, sailing, etc.

An increase in the sea level imposes certain risks to the coastal resources of Thailand. The major impacts, among others, are briefly discussed below.

Impacts from Inundation of Coastal Areas

An analysis of potential impacts resulting from inundation of coastal areas on the Gulf of Thailand indicates that several areas are endangered along a nearly 300 km stretch of coastline. Along the coastlines of the Gulf of Thailand are several important beaches important for the tourist industry including Pattaya, Cha-Am and Hua Hin. A rise in the sea level will reduce the width of the beaches, cause more erosion and increase the risk of temporary flooding during storm surges.

The coastal areas characterized by mudlands are low or flat and are either covered in mangrove forests or used for brackishwater aquaculture. The impacts likely to occur as a result of a sea level rise are inundation of the brackishwater aquaculture ponds, coastal erosion, a decrease in mangrove areas, and/or a higher risk of damage from storm surges. The impacts on coastlines between many river mouths in the Upper Gulf are likely to be moderate to very significant. In addition, residential, commercial, agricultural and industrial land along the coastlines also will be inundated or exposed to higher risk of damage from storm surges.

Impacts on Existing Drainage and Flood Control Facilities

The areas along the coastlines in the northern part of the Upper Gulf frequently have experienced flooding. A rise in the sea level will increase the risk from flood damage. Similarly, there will be impacts on the Monkey Cheek Project, designed to collect floodwater run-off during high tides, in storage reservoirs located in coastal areas. A rise in the sea level will reduce the storage capacity of these reservoirs.

Impacts on Increasing Salinity Intrusion

The salinity model shows that saltwater intrusion, due to a rise in the sea level, will be more pronounced in the principal rivers flowing into the Upper Gulf. If freshwater flow rates were constant at current rates, saltwater intrusion would increase by within 2 km. At present, saltwater intrusion has already been severe during the dry season, due to high demand for, and low supply of freshwater. A rise in the sea level will exacerbate these problems.

Other Impacts

The are other impacts potentially generated by a rise in the sea level in the Gulf of Thailand including saltwater intrusion into the groundwater aquifer, coastal wetland loss, coastal erosion and changes in coastal profiles and coastal ecology.

Adaptation Options

The options to adapt to sea level rise are limited. In the areas of steep coastal slopes with rocky shores where the socioeconomic impacts are negligible, adaptation may not be required. However, in areas where socio-economic activities are intensive, such as in population centers, tourist sites, or aquaculture areas, a basal wall or rock rampart may be required, or eroded beaches may require replacement with artificial beaches, depending on coastal characteristics.

The vulnerability analysis conducted so far does not provide sufficient basis to draw conclusions and policy recommendations for concrete, reasonable and specific requirements and measures to be adopted. The adaptation discussion above is general. It does not provide any comparative analysis of "with" and "without" scenarios. The time factor has not been sufficiently considered either. An autonomous change in the socio-economic structure over a hundred years could have important implications for the potential impacts of a rise in the sea level and hence adaptation potential. Additional investments in capacity strengthening and institution building are required to understand the processes of climate change and the rise in sea level and to undertake meaningful adaptation analysis. The analysis of vulnerability and adaptation of coastal resources suggests the following adaptation options:

- Establishing a coastal hazard management sub-committee to develop policies, strategies and guidelines for coastal hazard management, to provide guidelines on management and development of coastal areas
- Improving drainage and flood control facilities
- Improving cropping systems suitable to such environmental change, using organic matter to improve salty soil conditions
- Improving crop cultural practices.

Health

Human health is already at risk from a wide range of diseases, malnutrition and other major events caused by human beings themselves. The rapidly changing world economy also has accelerated transboundary environmental risks. Pollution is transported across boundaries by wind and water flow, while plant and animal diseases follow trade routes between continents. Deforestation, desertification and over fishing have environmental consequences to whole regions and sub-regions.

Climate change can be another major threat to human health, and the process through which such a threat is realized can be so complex that modeling its impact can be extremely difficult, if not impossible. Climate change can cause both direct and indirect impacts on human health. The principal health effect of climate change is heat waves and other extreme weather events. They cause mortality and incapacitating diseases such as chronic respiratory and cardiovascular disorders, especially in cities with greater exposure to "heat islands". Fluctuations of climate variables influence the spread of infectious diseases. The impacts of changes in disease incidence such as malaria, schistosomiasis and yellow fever would be intense particularly in developing countries.

Measuring the impacts of climate change on human health must begin with establishing a scientific relationship between climate change indicators and health indicators. This is often accomplished through a complex system of equations representing the natural system and health conditions. Indirect threats of climate change to health may start from crop damage or water shortage. More direct impacts are diseases that are vector borne, which, again, can be worsened by the indirect impacts. Rising temperature may trigger certain diseases to be active and to begin to attack people.

Potential Impacts on Health

Given the generally poor state of health services, adverse climatic conditions and open exposure to diseases in developing countries, for example, public health can indeed be at high risk from adverse climate change. In the tropics, malaria and dengue fever are the two most common vector-borne diseases that have been researched extensively.

In 1967, the death rate from malaria was about 7.21 percent of total infections compared to the national death rate from other causes of about 0.7 percent. However, the death rate from malaria infection substantially declined to 0.91 percent in 1981 and 0.61 percent in 1997. The reduction of the death rate reflected improvements in the treatment of malaria patients and advances in the malaria control.

The mosquito is a vector of malaria disease. When a mosquito vector bites a malaria-infected human, the disease lives in the mosquito host to incubate for a certain period. At the time of incubation, if the malaria-infected mosquito takes blood from other humans, the disease will be transmitted to the malaria susceptible humans. The incubation period, the frequency of mosquito bites, and the survival probability of the mosquito depend on temperature and non-temperature related factors.

The analysis of climate change impacts on health uses such a link to derive the potential risk of a malaria outbreak. Three temperature related factors were included: the incubation period of malaria parasite in a mosquito, the number of blood meals a mosquito takes from human beings and the survival probability of the female mosquito.

Temperatures of 40ºC or higher could kill mosquitoes and prevent parasites to develop. On the other hand, temperatures of between 22.40-32.36ºC are suitable for diseases to develop and to complete their cycle

while those above 32-34ºC could reduce their survival rates substantially (Horsfall (1955), Macdonald (1957), Detinova et.al, (1962)). The range of temperature in Thailand is, in fact, suitable for the development of the parasites. In a malaria endemic region like Thailand, the number of blood meals a mosquito takes from humans is estimated at 0.1893 at average temperatures. The frequency decreases to 0.0246 at the average maximum temperature and to 0.0137 at the average minimum temperature.

The survival probability has an inverse relationship with temperature. At the average minimum temperature, the probability of survival is 0.9038. At the average maximum temperature, the probability is 0.859. The actual survival probability of a mosquito can be determined by the probability function of a mosquito's survival based on average annual temperature. The distribution pattern of the survival probability over the 1965-97 period shows an increasing trend of survival probability during the period 1965-75, but a decline after that. The survival pattern shows an inverse relationship with the average temperature over those two periods.

Based on projected temperatures for 1998-2050 under the climate change scenario, the projected number of infections due to temperature increases substantially. However, the results are very preliminary and more research is required[2]. Given the above limitations, the potential damage, estimated by hospitalization and opportunity costs of the patients over a 50 year period, could be in the hundreds of million dollars (TEI, 2000).

Adaptation Options

Adaptation to climate change in this case could possibly make use of experience that already exists in the country. However, serious consideration must be taken of the potential side effects of such adaptation measures, such as the use of chemicals to control malaria. While DDT has been the most effective chemical to control malaria in developing countries, the residues from DDT are very toxic and remain in the environment for a long time. The reappearance of malaria on a widespread basis will require aggressive control of the disease. Research and development of alternative approaches to cure and eliminate malaria are needed in order to reduce the negative impacts of chemicals. All these need substantial human and capital resources. The magnitude of the problem will be even greater if the re-emergent diseases are increasingly resistant to the chemicals. Thailand has already experienced the emergence of mosquitoes resistant to chemicals, and many new types of control measures must be introduced. An aggressive campaign of preventive measures also should be undertaken.

The potential impacts of a widespread outbreak of malaria also could increase if climate change enhances the development of forests and natural conditions suitable for the development of the disease.

5.4 FUTURE RESEARCH ISSUES

The discussion of vulnerability and adaptation analysis above highlights several points regarding research and development on the subject. Despite fairly extensive research and development that Thailand has undertaken over past decades, the highly dynamic nature of climate change issues requires that additional efforts be made to catch up with the progress of analyses and discussions about climate change and its impacts on the natural, social and economic environment.

Improvement of Climate modeling

The most fundamental basis for all vulnerability studies is the climate scenarios. The high level of variation in the climate scenarios from different climate models, especially in the long-term, lend uncertainty to the results. Some approaches to reduce such uncertainties have been suggested. Among them is the use of regional or sub-regional climate models to help reduce uncertainties generated by the models at the global level. The application of appropriate downscaling techniques could enhance the quality of the climate scenarios derived. However, additional resources are needed to enhance the technical capability of local researchers. Cooperative efforts between countries in the region also are important to support such development.

Not only should climate models and their scenarios be improved, local climate data are also very important for development of local climate scenarios for impact assessment. Local climate data also are required for development of regional and sub-regional climate scenarios. The lack of sufficient spatial and historical local climate data can hinder the development of climate scenarios in Thailand as well.

Besides improving and refining the vulnerability and adaptation assessment of natural forests, a similar study is needed for economic forests, particularly for community forests. Climate change could alter the types and composition of trees that are important for the livelihood of rural households. The vulnerability and adaptation of economic forests could be widely different between regions in Thailand. In this case, the adoption of region-specific adaptation options may also be appropriate.

[2] The estimated number of infections is unusually high, from less than 70 thousand cases to millions over 50 years. Many areas for improvement are identified and will be refined in the future.

It is important to note that such development has been progressively pursued in many regions of the world, especially among the Annex 1 countries. Cooperation in terms of transfer of technologies and capacity building should be enhanced.

Development of Impact Modeling

Modeling is commonly used to assess the potential impacts of climate change on specific sectors. In the past, developments related to crop modeling in Thailand have not been directed at the assessment of climate change impacts. While many important economic crops are cultivated, only a few crop growth models have been developed and validated. Models capable of assessing the risks of permanent damage to trees from climate change have yet to be developed. Similarly, models for suitable forest management for application in the monsoon region will improve research in the sector greatly.

Thailand has 25 watersheds with different natural characteristics. At present, only the Chao Phraya basin has been assessed at a preliminary stage. As management of water resources becomes increasingly critical for sustainable development, Thailand will need to expand the understanding of potential impacts of climate change on water resources. Development of water resource models capable of analyzing social and economic implications of such vulnerability is one of the priorities.

Further research and development is required to evaluate vulnerability and adaptation in other areas such as coastal resources management and health. Impact studies on coastlines in the southern peninsula, including those along the Andaman Sea, should be conducted. More detailed risk assessment is needed, especially on coastal ecology, erosion, sediment transport, and saltwater intrusion into canal networks connected to various estuaries. Methods for assessing the potential impacts of seawater intrusion on different types of coastal land resources have not yet been sufficiently developed, especially in major tourism areas. In addition, research on potential health effects is at a very early stage and much more could be done to improve the quality.

Vulnerability and Adaptation Studies

A high quality and comprehensive vulnerability study would provide important support for the analysis and evaluation of adaptation options. Climate change involves long-term analysis, and it is politically very difficult to pursue policies such as adaptation options that involve long-term planning and research. Experiences with vulnerability and adaptation studies in Thailand suggest the need to refine vulnerability analysis to the greatest extent possible. The high level of uncertainty in vulnerability studies hinders the advancement of adaptation analysis that can lead to more meaningful policy recommendations.

Besides the need to improve and refine the existing vulnerability and adaptation research, there are other areas where vulnerability and adaptation studies should be undertaken, including:

- Energy
- Biodiversity and timber and non-timber products
- Tourism
- Permanent crops and livestock
- Coastal resources such as beach, coastal ecology, coral reef, and land use change
- Direct and indirect health effects such as heat-related death and illness, physical and psychological trauma due to disasters, vector-borne and non-vector-borne diseases

Vulnerability and adaptation studies are not necessarily limited to the national level. Such research also should be undertaken at the sub-regional and regional levels as appropriate.

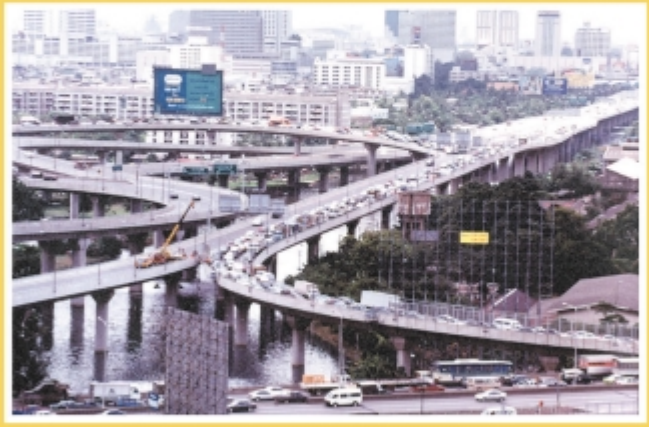
Social and Economic Issues

An important question related to the impacts of climate change that has not been fully addressed in Thailand is the social and economic implications of climate change. This involves not only the assessment of vulnerability and adaptation to climate change impacts, but also the development of means and measures to cope with climate change, including new mechanisms to implement the Kyoto Protocol.

Research on the socioeconomic impacts of climate change and measures to mitigate greenhouse gases has been conducted in many countries and regions. An export-oriented economy like that of Thailand is relatively sensitive to external effects of international developments. Moreover, the high proportion of population in agriculture constrains the ability of the economy to absorb such effects. Further research on the social and economic impacts of actions related to climate change can help policy makers to avoid or minimize potential problems. Thailand has yet to conduct research in this area.

Chapter

6



Policies and Measures

- **National Sustainable Development Policy**
- **Policies and Measures Related to Climate Change**

6.1 NATIONAL SUSTAINABLE DEVELOPMENT POLICY

For more than 30 years, the Royal Thai Government has been implementing 5-year National Economic and Social Development Plans to guide the social and economic development of the country. Increasing deterioration of natural resources and environment during the 1960s prompted the government to seriously act on natural resource and environmental conservation. Sustainable development effort has been intensified in the 1980s and early 1990s. The Enhancement and Conservation of Environmental Quality Act promulgated in 1992 has substantially strengthened natural resource and environmental conservation of the country. Under the Act, the 20-year natural resource and environmental policy and 5-year action plan have been introduced. Balance between economic and social development and conservation of natural resources and environment has been the basis for sustainable development policy of Thailand.

Thailand's Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, 1997-2016

The Enhancement and Conservation of Environmental Quality Act (1992) is a key factor promoting natural resources conservation and environmental protection in Thailand. The Act expands the Office of National Environmental Board into three departments - the Office of Environmental Policy and Planning, Pollution Control Department and Department of Environmental Quality Promotion. The Act also empowers the authorities to declare areas where environmental or natural resource conditions are critical as "Pollution Control Zones" or "Environmental Conservation Zones". These declared areas are given priority in terms of financial and human resources assistance to protect natural resources and the environment.

To further promote sustainable development, the Act also requires preparation of long-term environmental policies and medium-term action plans. These policies and plans encourage environmental protection along with economic and social development. Thailand has just issued its first 20-year Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality (20-Year Environment Plan). This document provides the principal set of guidelines for national resources conservation and environmental protection in Thailand.

Based on this 20-Year Environment Plan, a 5-year Environmental Quality Management Plan is prepared to guide natural resources conservation and environmental protection. This plan will complement the 5-year National Economic and Social Development Plan, thus giving equal emphasis to both natural resources conservation and environment protection, and economic and social development of the country.

5-year National Economic and Social Development Plans

In general, the National Economic and Social Development Plans of Thailand have been consistent with the important Agreement on Environment and Development adopted in Rio de Janeiro in 1992 - Agenda 21. Conservation of natural resources and the environment has been an integral part of the national plans since the 1980s. Even so, natural resources conservation and environmental protection have been insufficient, particularly during recent years of rapid economic growth.

During the 1960s and 1970s, Thailand sustained an aggregate GDP growth rate of nearly 8 percent per year. Agricultural production grew rapidly, mostly through expansion of cultivated areas, and agroindustry advanced following agricultural diversification. The industrial sector gradually shifted from import substitution to export expansion.

The 1980s were a period of structural adjustment and industrial take-off for Thailand. In the late 1980s, exports grew strongly, and manufactured products became the main exports of the country. The rapidly growing economy increased demands for infrastructure and highly skilled workers, pushing up wages which gradually eroded the comparative advantage of labor intensive industries. At the same time, capital intensive industries faced strong competition from abroad.

The rapidly growing economy has had serious consequences for the quality of natural resources and environmental conditions in Thailand. Forest areas declined at alarming rates, land fertility dropped, water and air pollution intensified. Efforts to combat worsening environmental conditions resulted in development of a natural resources conservation and environmental policy in the 1990s that emphasized sustainable development. The Enhancement and Conservation of National Environmental Quality Act promulgated in 1992 has been the principal instrument employed to address environmental issues. New strategies to improve local capability in natural resource and environmental management have been promoted.

The conservation of natural resources and protection of the environment continue to be emphasized in the current 8th National Economic and Social Development Plan. It is notable that the 8th Plan also broadens the

development philosophy to include human resource issues. The 8th Plan also includes requirements for monitoring and evaluating each development component. Unfortunately, the financial and economic crises mid-way through implementation of the 8th Plan forced the Government to revise the plan, giving priority to economic recovery and stability. The 8th Plan will end in 2001, and Thailand is now in the process of preparing its 9th National Economic and Social Development Plan.

Laws and Other Regulatory Measures

In addition to the 5-Year National Economic and Social Development Plans and the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality, several policies and measures have been implemented to address climate change issues in Thailand over the past decade both directly and indirectly.

The most fundamental recent advancement in the development of Thai society was adoption of the new Thai Constitution in 1997. This document is of historical significance to the development of Thailand's political system because it is the first constitution ever to be drafted by the Constitution Drafting Assembly, a body representing all the Thai people. The Assembly consisted of 99 members: 76 delegates from each province, 8 political scientists, 8 legal experts and 7 experienced politicians selected from the Parliament. Unlike previous constitutions, the drafting process of the new constitution also involved public participation and public relations activities to increase public awareness.

On natural resources and the environment, the new constitution validates the rights of the people with regard to at least six management issues. These include:

- the rights of local communities in conserving natural resources;
- the right of the public to a good environment and the responsibility of the project developers to properly carry out environmental impact assessments;
- the right to access public information;
- the right to receive information and to participate in the planning of development projects that may have environmental impacts;
- the responsibility of the government to promote and support local participation in conservation and utilization of natural resources; and,
- the decentralization of power to local administrative bodies to manage, maintain and utilize natural resources within their respective jurisdictions.

There are other laws that enhance the environmentally friendly sustainable development process. These laws promote efficient uses of energy, water and forest resources. For instance, the Energy Conservation and Promotion Act, was promulgated in 1992 with the main objective of promoting energy efficiency. Four main components to support energy efficiency have been prescribed: 1) energy conservation in factories; 2) energy conservation in large building; 3) energy conservation in machinery, equipment and promotion of energy efficient materials; and 4) fund for promotion of energy conservation. To further enhance development of the system, Thailand is considering establishment of "Energy Service Companies" to support implementation of energy conservation.

There are other bills promoting sustainable development that are being considered by either the government or the Parliament. For example, the proposed new water act is aimed at establishing water resource management committees at the watershed level to oversee the use of water resources, while the proposed community forest law will enhance the role of the communities in forest resource management. Under Agenda 21 concepts, both the National Agenda 21 Action Plans and the Environmental Quality Management Plans have been developed and integrated into the National Economic and Social Development Plan. These will sustain the longer-term social and economic development of Thailand.

6.2 POLICIES AND MEASURES RELATED TO CLIMATE CHANGE

Immediately following ratification of the UNFCCC, the Royal Thai Government set up a National Climate Change Committee (NCCC) and a Climate Change Expert Committee (CCEC) to prepare the country's response to climate change. The NCCC is chaired by the Permanent Secretary of the Ministry of Science, Technology and Environment (MOSTE). The CCEC is headed by the Secretary General of the Office of Environmental Policy and Planning (OEPP), which is the agency that serves as Thailand's focal point for the Climate Change Convention and serves also as the Secretariat to the National Environment Board chaired by the Prime Minister. The National Environment Board is the highest decision making body on all matters relating to the environment.

The Royal Thai Government takes into account the principles of the Convention in formulating policies related to climate change in Thailand. Climate change policies and issues have been integrated into economic and social development since the 7th National Economic and Social Development Plan (1992-1996). They have also been incorporated in environmental policies and plans of the country where appropriate.

International and Regional Cooperation

Climate change is an important global environmental issue. To address it, however, Thailand believes in the principle of "common but differentiated responsibilities" as the basis for taking collective action. Efficiency and equity considerations must be carefully and simultaneously taken into consideration when pursuing climate change policies and measures. As a non-Annex I party to the Convention, Thailand will take all possible steps within the Framework Convention to actively participate in international and regional cooperation activities to address climate change issues.

On the technical aspects of climate change, Thailand has been actively involved, through bilateral and multilateral cooperation, in research and development of inventory and mitigation as well as vulnerability and adaptation aspects since the late 1980s. National experts have participated in the technical working groups of IPCC as well as UNFCCC. On several occasions, Thailand hosted international and regional workshops related to climate change issues.

In 1999, Thailand received financial support from GEF to prepare its first national communication to the UNFCCC. To enhance capacity building, Thailand has cooperated and exchanged experiences with other countries, regionally and internationally. Thai experts also have participated actively in the review process of the National Communications of Annex I countries.

Regarding implementation of activities related to climate change, Thailand welcomes the AIJ activities and has conducted pilot AIJ projects in cooperation with Annex I parties to understand the process. The first AIJ project implemented in early 1998 was the "Model project on effective utilisation of energy in re-heating furnaces in the steel industry in Thailand". Three other AIJ projects agreed to between Japan and Thailand in 1999 included: (i) a model project on equipment for recovery of heat from the combustion of waste at paper and pulp mills; (ii) Bangna intersection traffic congestion improvement project; and, (iii) a model project for utilisation of waste heat from incineration of industrial waste at industrial estates.

Implementation of the first AIJ project is underway with equipment having been installed and the project has been operated satisfactorily. The performance is now being evaluated. The latter three projects remain in progress. Understanding the AIJ implementation process will help Thailand to understand the potential and constraints of pursuing international cooperation in reducing greenhouse gas emissions.

Similarly, Thailand is involved in the process of understanding and developing the concept of "flexibility mechanisms" - CDM. At present, Thailand's concept of sustainable development take into consideration the climate change aspect. Clearer rules and procedures will enhance the applicability of CDM. Nevertheless, the principles of the Convention, which include "common but differentiated responsibility" and equity, must be fully taken into consideration in the development of the mechanisms encompassed in the Kyoto Protocol.

Asia, being the largest continent, has an important role to play in solving climate change problems. Thailand supports the use of regional cooperation as a means of sharing information and experiences on climate change issues. At the sub-regional level, Thailand views ASEAN as an important forum for offering support for implementation of the climate change convention. Sub-regional cooperation could focus on cooperation in research and development on climate change issues. The similarity of cultures and economic structures among ASEAN member countries could enhance the application of models to the sub-region. Such cooperation also will optimize use of resources required for developing complex models for analyzing multiple climate change scenarios, crop or hydrological models, etc. The exchange of information and experiences will accelerate the capacity building process in the sub-region and the region.

Mitigation and Adaptation

As a developing country, Thailand must maintain social and economic growth to eradicate poverty and improve the quality of life of its people. Since the 1992 Rio Summit, Thailand has adopted two national strategies to address climate change issues. In so far as greenhouse gas mitigation options are concerned, the "no-regrets" or "win-win" options have primarily been used to identify possible actions that Thailand could pursue. With regard to climate change impacts, Thailand gives priority to advancing research and development to understand the potential impacts of climate change on different sectors of the economy, their vulnerabilities and the possible adaptation options to reduce such impacts. Developments in these two areas are discussed below.

Mitigation

Mitigation measures are usually developed following inventory assessment. In the 1990s, several inventory studies were conducted in Thailand. Initially, Thailand applied the OECD approach to estimate the 1990 GHG emissions. The COPATH model developed by LBL for forest sector emissions and absorption was also applied to compare estimates in the forest sector. Default emission factors were mostly used at this stage.

More recent studies have applied local emission factors for agriculture. The estimated results based on default and local emission factors were substantially different and underscored the need to use local emission factors in estimating GHG emissions. Besides the lack of local emission factors, limited data also hindered the quality of estimates. Priority is being given to the

development of local emission factors, especially on rice, livestock and wastes.

Through the Thailand Research Fund, several research projects to refine local emission factors for rice have been conducted. Development of database and the application of geographical information system to enhance the estimation of emissions have also been promoted.

Most inventories conducted to date have been accompanied by an analysis of mitigation options. Thailand has adopted the principle of "no-regrets" in the selection of GHG mitigation options. Potential mitigation options identified generally were similar to those of other developing countries. These included improvements in energy efficiency; fuel substitution; development of renewable energy; reforestation, afforestation and protection of conservation forests. An analysis of least-cost options was attempted in the energy sector, but the results were considered preliminary. Thailand has now begun to focus on a more comprehensive least-cost modeling of emission mitigation options in the energy sector.

The analysis of mitigation options for other sectors also requires comprehensive analytical tools and information on alternative technologies for agriculture, data development for the waste sector, forestry, etc. Many of these studies emphasize "no-regrets" options that could be pursued immediately and that take into consideration national development priorities. In fact, several of these projects already have been implemented in Thailand. The most prominent policies and measures contributing to greenhouse gas reduction are those related to energy and forestry.

Energy Sector

Trends in energy consumption generally follow the economic growth of the country. The basic energy policy of Thailand is to ensure a sufficient supply of energy while improving the efficiency of energy use. Under the guidelines of the 8th National Economic and Social Development Plan, the National Energy Policy Office and energy-related agencies jointly prepare an energy operational plan with clearly specified targets, strategies, plans and measures for energy development. The Plan serves as a framework for the development of energy-related projects and for monitoring operation of the plans.

As the development of Thailand's international competitiveness is a prime concern and energy is a crucial production input, there is a need to maintain a sufficient supply of energy at reasonable prices to meet increasing demands of economic activity. The targets for energy development in Thailand up to the year 2001 are as follows:

- Increase commercial primary energy production at a rate of three percent annually during the 8th National Plan period;
- Adjust the growth rate of domestic primary commercial energy consumption to be compatible with GDP growth during the 8th National Plan, which has been revised to correspond with the changing economic conditions;
- Maintain the ratio of imported energy dependency at no more than 64 percent by the year 2001;
- Set targets for domestic production and import of energy;
- Set targets for the electricity generating capacity of the country to correspond with the decreasing demand;
- Increase the electricity generating capacity by employing solar energy at a minimum capacity of 4 MW nationwide by the end of the 8th National Plan period (2001);
- Reduce power consumption through demand side management measures by 1,400 MW during the 8th National Plan period, and reduce energy consumption through the implementation under the Energy Conservation Promotion Act by approximately one million tons of crude oil equivalent per year by 2001;
- Establish reliability standards for the power system; and,
- Reduce emissions of sulfur dioxide from commercial energy consumption by transportation, electricity generation, industry and other economic sectors from a total level of 982,000 tonnes in 1996 to 365,000 tonnes in 2001.

To achieve these targets, the following strategies for energy development were developed:

- Provide energy sufficient to meet increases in demand at reasonable prices while ensuring quality and security of supply.
- Promote efficient and economic use of energy.
- Promote competition in the energy supply industry and increase the private sector's role.
- Prevent and mitigate environmental problems arising from energy development and utilization, and improve the safety of energy-related activities.
- Develop legislation related to energy and energy administration mechanisms.

Implementation of this Plan has been initiated and was revised during the second half of the 8th National Plan due to the economic crisis. Among the changes introduced were the lowering of targets for production and demand growth and the postponement of exploration and exploitation activities for fossil fuels and natural gas. Demand-side management (DSM) activities, however, have been retained.

Demand-Side Management

One of the most important policy measures introduced in Thailand to address the energy efficiency issue is the DSM program. A five-year DSM program (1994-1998), that was launched during the 7th National Economic and Social Development Plan, targeted a reduction of 238 MW peak demand, 1,427 GWh of electricity, and 1.06 million tons of CO_2 emissions[1]. The 5-year DSM program started with a budget of US dollar 189 million and was financed from internal and external sources (Table 6.1).

The achievements of the DSM program were highly successful, compared to the targets (Table 6.2). The reduction in peak demand was double the target. Energy saving and CO_2 emission reduction was 65 percent higher than expected.

Under the 8th National Plan, peak demand and power consumption of the DSM Program (1997-2001) are targeted to be reduced by 1,400 MW and 5,370 GWh, respectively. If these targets were met, then total CO_2 reductions could be more than 4 million tonnes, assuming the same emission ratio. During the first two years of the program (as of December 1999), approximately 130 MW of power consumption (about 55 percent of the target) and about 0.71 million tonnes of CO_2 had already been saved (NEPO, 2000). These savings were accomplished through several measures, among which are:

- Replacement of energy-efficient fluorescent lamps from 40 and 20 watts to 36 and 18 watts, respectively, saving about 89 MW of capacity and 690 GWh of electricity
- Campaign for energy-efficient electrical appliances, saving about 41 MW of capacity and 259 GWh of electricity

In addition to the DSM program, Thailand also uses fiscal measures to intervene consumer demand to environmental friendly products. The excise tax incentives have been introduced for machines, equipment and materials conserving energy or the environment. The restructure of electricity tariff to regulate consumption and to promote efficiency, such as time of day, time of use or interruptible tariff, has been adopted since 1990s. An automatic adjustment mechanism has been imposed to reflect the market prices of energy resources used in electricity production. These measures improve energy efficiency and hence GHG mitigation.

Energy Conservation

In the 7th National Economic and Social Development Plan (1992-1996), the Government defined short and medium-term targets and strategies for the development of the energy sector. Starting in 1992, however, the government has embarked on a comprehensive Energy Conservation Program, adopting the Energy Conservation and Promotion Act. The Energy Conservation Act states that the energy conservation program should contribute to the "saving of energy, the sustainable use of natural resources, and the protection of the environment."

Specifically, the objectives of the program include:

- Promotion of more efficient use of energy;
- Development and use of renewable energy sources;
- Development and dissemination of energy conservation technology; and

Table 6.1 Budget for DSM Program (1994-1998) in Thailand

Source	US dollar million
Global Environment Facility	15.5
Overseas Economic Cooperation Fund	25.0
Internal sources (EGAT and NEPO)	148.5
Total	**189.0**

Source: DSM office, EGAT

Table 6.2 Targets and Actual Achievements of the DSM Program (1994-1998)

Indicator	Target	Actual (As of December 1998)
Reduction in Peak Demand (MW)	238	503
Energy saving (GWh)	1,427	2,345
CO_2 emission reduction (Million tonnes)	1.06	1.75

Source: DSM office, EGAT

[1] Assuming 1 GWh saving equals to a reduction of 746.1 tonnes of CO_2.

- Promotion of sustainable use of natural resources and environmental protection.

Thailand's Energy Conservation Program consists of a compulsory program, a voluntary program, and a complementary program. Under the compulsory program, large factories and buildings are required to conduct energy audits and report to the Department of Energy Development and Promotion. Energy conservation plans are then drawn from the energy audits and submitted to the Department for approval. As of end-1996, 459 private commercial building have completed energy audits and have applied for support to implement energy conservation projects. About three-fourths of the applications were approved. Public buildings also are included in the energy conservation program, and a total of 415 public buildings have been audited, 274 of which were granted energy conservation projects. Large factories are in the process of registering for this program.

Despite the government commitment to energy conservation, energy efficiency investments in the commercial and industrial sector have been limited. To help address deficiency in the regulatory approach to efficiency investment and remove some implementation bottlenecks, DEDP has proposed that a portion of Energy Conservation Fund be allocated to help initiate and leverage commercial financing to support efficiency investments in private sector. This can be achieved through leveraging commercial financing or private sector delivery mechanisms such as ESCOs (Energy Service Companies). Including such instruments can help ensure the sustainability of energy efficiency improvement.

Under the voluntary program, the government provides financial assistance and seeks the cooperation of the private sector to conduct research and development on methods and means to efficiently conserve energy, to develop renewable energy sources, and to produce energy from agricultural wastes and livestock manure. In 1997, more than ten research and development projects were initiated involving both the private and public sector. The number increased substantially to 40 in 1999. This year, an "energy conservation through management technology project" is being launched for small and medium scale industry. An initial budget of 30 million baht is provided through the Energy Conservation Fund to improve energy efficiency in 150 establishments. The initial phase is expected to conservation energy equivalent to 16 million litres of crude oil.

Under the complementary program, the government lays out a work plan for personnel development and public relations activities to promote public understanding and awareness of energy conservation and efficiency. An important part of this scheme is the Public Relations Program called "Divide Energy by 2" which was initiated in 1996, designating the National Energy Policy Office (NEPO) as the implementing organization.

Evaluations of the 1997 Energy Conservation Public Relations Program were highly encouraging in that 74 percent of the country were aware of the "Divide Energy by 2" program, with the majority understanding the main objectives of the program. In addition, in comparing pre- and post-program measurements, the evaluation shows that the program resulted in:

- Deeper understanding of the meaning of energy conservation;
- Greater knowledge in terms of the different ways one can save energy;
- Improvements in energy saving attitudinal and behavioral patterns;

Fuel Switching

Thailand began developing long-term power development plans during the 1st National Economic and Social Development Plan. The main objective of the long-term power plan was to ensure a consistent supply of power to support economic and social development. Alternative sources of energy for power development were also explored. Given the criteria of cost effectiveness and environmental friendliness, several alternatives have been considered, including the expanded use of hydroelectricity, gas turbine systems, and low sulfur coal, as well as joint-venture projects between neighboring countries for other sources. Thailand has also attempted to introduce solar energy, especially in remote areas. It has spent 90 million baht in promoting the system to the market.

Energy switching has been emphasized in the 8th Plan. Several alternative energy sources increasingly are expected to replace the domestic use of fossil fuels and coal, including the importation of high-quality coal and the use of more natural gas and hydropower. The independent and small power producers will play a greater role in power supply over the next decade. Thailand will also increasingly purchase power from neighboring countries (Table 6.3). Thailand foresees the private sector as an important contributor to increasing the efficiency of power development in Thailand (NEPO, 1997).

Improving Transportation

Thailand has implemented policies and measures to increase the efficiency of the transportation sector and to reduce pollution from this sector. For instance, less GHG fuels like liquefied petroleum gas and natural gas for vehicles have been promoted in the public bus and taxi. More stringent standards on sulfur content in diesel oil quality have been imposed. More stringent vehicle emission standards have been imposed. The new emission vehicle standards for all types of vehicles have now been fully effective. Capture of gaseous emissions from stationary sources has been enforced for service stations etc. Thailand will continue its efforts to increase the energy efficiency in transportation sector.

Table 6.3 Forecast of Power Generation by Sources of Supply, Power Development Plan

Source of Supply	1997		2001		2006	
	MW	percent	MW	percent	MW	percent
EGAT-hydro	2,874	16.73	3,384	13.28	3,384	11.86
EGAT-thermal	11,825	68.85	16,217	63.65	15,797	55.34
EGCO	2,056	11.97	2,056	8.07	2,056	7.20
IPP	-	0.00	1,400	5.50	4,597	16.10
SPP	224	1.30	1,807	7.09	2,097	7.35
Lao PDR+Malaysia	195	1.14	613	2.41	613	2.15
Total	**17,174**	**100.00**	**25,477**	**100.00**	**28,544**	**100.00**

Source: NEPO, 1999

Forest Sector

Forests serve as important carbon sinks. An expansion of forested areas increases the amount of CO_2 emissions absorbed from the atmosphere. The principal policy of Thailand is to conserve both terrestrial and coastal forest resources. As forest resources are important to the natural ecosystems as well as to the livelihood of the rural communities, it is vital to introduce policies that harmonize forest utilization and conservation. More intensive conservation and reforestation approaches are required to ensure that at least 25 percent of inland areas retain forest cover and to preserve 160,000 hectares (1 million rai) of mangrove forest,

Protecting the Forest

Improperly managed forest concessions combined with the expansion of agriculture and conversion of forest lands to other uses, as well as population growth and economic expansion, have resulted in a serious decline of forest cover. The reduction of forests to critical levels has prompted the government to change its policy from efficient forest utilization, to conservation and preservation. The Royal Thai Government has formulated several policies and measures to expand forest areas in the country since the 1970s. Massive landslides in the South prompted the government to take serious action against deforestation, with the result that logging in Thailand has been banned since 1989. Thailand has also stepped up management capability to protect conservation forests from encroachment and to control damage from natural causes such as forest fire in recent years.

The Royal Thai Government has declared a policy of maintaining no less than 25 percent of the total land area as conservation forests. These areas include national parks, non-hunting areas, wildlife sanctuaries, class 1 watersheds, and mangrove forests. Various measures have been employed to protect the conservation forests. But the large area covered by protected forests makes protection efforts by the Royal Forest Department a formidable task. Strict enforcement of the law has not been effective enough to contain deforestation, and deforestation still continues although at a slower rate.

Thailand recently introduced legislation regarding community forests. The rationale behind the bill is that with appropriate property rights, the communities that directly and indirectly depend on forest resources will ensure that their sources of supply are sustained. The government is now considering the draft law before submitting it to parliament.

Like the terrestrial forests, mangrove forests are threatened by aquaculture and other land uses. The Royal Thai Government therefore has refused to extend any agreement with concessionaires operating in mangrove forests. The areas will soon be declared protected mangrove forests. As mangroves are vital to coastal ecosystems, the role of local communities, especially small fishing households, in the conservation of mangrove forests will be promoted.

Another measure to protect mangrove forests is to clearly demarcate boundaries of protected areas. With the participation of all stakeholders, particularly communities and local governments, the boundaries of protected mangrove forests will be identified and accepted. Unfortunately, the process requires substantial amounts of resources and is time consuming. Thus, limited progress has been made.

Reforestation and Afforestation

Reforestation programs have been an important part of the country's economic and social development programs since the 1st National Economic and Social Development Plan. In earlier years reforestation was aimed at compensating for deforestation that resulted from logging concessions. As the government shifted its policy towards the conservation of the forests, reforestation or afforestation has been the primary means to achieve this goal.

Despite considerable promotion over a long period of time, reforestation and afforestation activities lagged far behind those of deforestation. Up until 1998, only 8,741 sq km of denuded areas were reforested (Table 6.4). This indicates that much more effort is required to increase forest cover in the country.

Table 6.4 Annual Reforestation by Sources of Fund (sq km)

Item	Up to 1992	1993	1994	1995	1996	1997	1998	Total
Government Budget	5,551.47	304.83	309.78	191.49	94.27	50.72	48.64	6,551.20
Concessionaire	1,451.45	7.01	4.85	2.68	2.98	-	-	1,468.97
Forest Industry Organization*	323.81	6.73	2.58	0.72	0.40	0.4**	0.4**	334.24
Thai Plywood Co., Ltd.*	1.65	0.30	6.24	1.20	2.35	7.01	6.19	24.94
Required by Regulations	116.05	2.23	0.61	1.54	5.21	2.34	9.71	137.69
Concessionaire's Budget	153.05	10.72	6.40	30.28	8.24	6.51	8.98	224.18
Total	**7,597.48**	**331.82**	**330.46**	**227.91**	**113.45**	**66.58**	**73.52**	**8,741.22**

* Excluding reforestation by concessionaire

** Estimates

Source: Royal Forest Department

In addition to the legal requirement for reforestation, during the period 1994-1996, another reforestation promotion program was launched to encourage rural households to plant trees on their land. Farmers were granted subsidies of 3,000 baht per rai over a period of 5 years to plant trees, and were allowed to harvest the trees after a certain period. The project was aimed at covering 800,000 hectares (5 million rai), but only about 320,000 hectares (2 million rai) of land actually were reforested under the program.

Thailand will continue to pursue its existing forestry policies while increasing efforts to expand forest cover, in spite of various constraints to accomplishing this task. One of the serious problems facing the program is the deteriorating social and economic conditions of rural households. The expansion of forest areas must not retard their ability to earn a living, otherwise, the program would never succeed.

Mangrove reforestation has also been pursued despite difficulties posed by strong industrial development, expansion of coastal aquaculture, and lack of sufficient protection from natural and manmade impacts. The government targeted an area of 400 sq km for reforestation between 1992-1996, but only about 130 sq km or about one-third of the target was achieved. Local communities play an important role in mangrove reforestation, as illustrated in the provinces of Trang and Samut Songkram, where mangrove reforestation activities were conducted successfully, however on a relatively small scale. The replanting of mangroves has continued and intensified during the latter half of the 1990s.

Sustainable Shrimp Farming

Concerted efforts are being made to introduce techniques for sustainable shrimp farming. Measures implemented in the 1990s have included new water treatment technologies, registration of farmers, and seawater irrigation systems. These efforts have met with limited success due to the difficulty in controlling land use in light of the high profits and short-term nature of shrimp farming. In addition to the regulatory approach, Thailand is studying the potential of implementing fiscal and economic policies measures to moderate adverse environmental impacts of shrimp farming.

Coastal and Marine Environmental Control

Various policies and measures have been implemented to reduce the wastewater discharge from aquaculture, industries, and tourist services, and to protect coastal environments. Central treatment plants for domestic wastewater were constructed in many coastal urban centers during the 1990s. Also, more stringent controls on natural resources and the environment have been imposed in environmentally fragile areas such as Phuket, Pattaya and various islands, by declaring them "Environmental Protection Zones." Many critical coastal areas such as Pattaya, Phuket, Phi Phi Island, Petchaburi, Prachuab Kirikhan and Songkhla, also have been declared "Pollution Control Zones." These areas have been given priority in the allocation of human and financial resources to improve the management of natural resources and the environment.

Vulnerability and Adaptation

The magnitude of policies and measures for climate adaptation is strongly dependent on the ability to identify the vulnerability to climate change of economic and social systems, both in space and time. While research and development activities related to greenhouse gas inventory and mitigation in Thailand have progressed satisfactorily, those that address vulnerability and adaptation, although started earlier, have proceeded relatively slowly. Various constraints have been identified, the most important of which is the lack of technical capability to apply the results of global climate models to local areas. At present, all studies on vulnerability and adaptation have used a direct interpolation approach to analyze climate data from the general circulation models at the local level.

Another constraint is the limited time and resources devoted to the development and use of analytical models for specific issues. In the agriculture sector, for instance, very few economic crop models were verified as appropriate; and even those were applicable only to limited areas. The vulnerability assessment of forests also was based on a relatively simple analytical method. Moreover, studies on the potential impacts of climate change on health, coastal areas and domestic water resources have just started. Vulnerability studies are important for analyzing potential adaptation measures that are vital for sustainable development in Thailand, particularly for the agriculture sector. The lack of comprehensive research in this area seriously limits the ability to make appropriate policy recommendations.

In view of the foregoing, the policies and measures required for climate adaptation are discussed below.

Vulnerability Assessment

Further research and development on vulnerability are essential to assess the potential impacts of sudden changes in climate on economic and social system. Thailand will intensify efforts to enhance the research and development capacity of local experts in this area. As vulnerability research is highly dynamic, Thailand needs substantial support from other parties, especially from countries that have undertaken advanced research in this area. As agriculture is vital to the livelihood of more than half of the population, the vulnerability of agriculture, water resources and coastal areas to climate change and sea level rise will also be given priority. Other sectors that also are important and require assessment are tourism and energy.

To enhance local research capability on climate vulnerability and adaptation, the development of climate models suitable to the area should be undertaken. A regional climate model will better reflect regional climate conditions than a global model. Some attempts are now underway to develop regional climate models for Asia. The application of climate impact models also should be intensified to cover the largest possible area of the country.

Adaptation Analysis

Despite the significant uncertainties associated with impact studies, preliminary studies can be conducted to evaluate adaptation potentials. The accumulation of basic information related to adaptation options in different sectors is important to support future studies. Among the areas that could be considered for research are climate change related genetic properties of plants, cultural influences on agriculture, and progressive water resource management.

In addition to reviewing potential adaptation measures to climate change, studies pertaining to the economic and social development process over the very long-term must be carefully pursued. Undertaking these adaptation studies at the same time as those on vulnerability, would greatly enhance the learning process. International and regional cooperation in capacity building must also be continuously fostered. In this connection, Thailand will continue to strengthen the capacity of national experts and personnel and will encourage various parties, especially from the developed countries, to actively participate in this area.

Public Awareness

The general public's perception of climate change is much lower than that pertaining to more localized environmental issues. Not only is the nature of the impact relatively distant from the daily lives of people, the time scale and uncertainties of potential impacts are also more difficult to predict. Moreover, mitigation measures in response to climate change taken domestically or internationally could have possible adverse effects on the Thai economy. Thus, convincing the general public and policy makers to take serious action is a difficult task. Continuous public awareness campaigns will be needed to increase the general public's understanding of the complex and dynamic issues involved.

In view of this, Thailand considers the launching of a public awareness program as one of the important policies and measures related to climate change. In addition to disseminating information to different agencies through the National Climate Change Committee and the Climate Change Expert Committee, workshops and seminars are being organized regularly to promote the exchange of views and information between the public and private sectors and NGOs.

A program to update local personnel on technical and political developments will be designed to keep the public constantly alert to climate change issues. Thailand requires international support for the experts and related officials to contribute effectively in technical discussions and to participate actively in the process of international negotiation.

THAILAND's
INITIAL NATIONAL COMMUNICATION
UNDER THE UNFCCC

Chapter

7

Financial Resources, Technology Transfer and Capacity Building

- Financial Resources
- Technology Transfer
- Capacity Building
- Opportunities for Investment and Private Sector Participation

7.1 FINANCIAL RESOURCES

The national budget is the main source of funding for sustainable development activities in Thailand. During the period of rapid economic growth in the 1980s and early 1990s, Thailand enjoyed a balance of payments surplus and a balanced government budget that continued until the first half of the 1990s. However, the economic crisis has reversed the situation from one of surplus to deficit.

Among all socio-economic sectors, Thailand attaches the highest importance to community and social services. Between 30-40 percent of the national budget is allocated to these sectors, particularly for education and health. Another 25-30 percent usually is allocated to economic sectors, mainly for communications and agriculture. In the 8th National Economic and Social Development Plan, human resource development has been given top priority in the development agenda. The development of human resource potentials, especially in the field of science and technology, is viewed as essential to sustain Thailand's economic and social development. This policy has thus been maintained despite the economic difficulties of the last few years.

The economic crisis has forced Thailand to revise its 8th National Plan targets, which included a scaling down of the investment plan. Under the original plan, total investment was expected to be double that of the 7th National Plan. Instead, investment by the private and public sectors was reduced by one-fourth (Table 7.1). Of greater concern, however, is that the smaller amount of investment was channeled to reducing the social and economic impacts of the economic crisis and to supporting economic recovery, rather than for enhancing human capacity and developing science and technology.

In terms of international technical assistance, from the early 1960s to the late 1980s, Thailand received considerable Official Development Assistance (ODA) through bilateral and multilateral agreements (Table 7.2). This assistance has declined dramatically over the past few years as the rapid economic growth moved the country up to the status of a middle income nation. Total ODA to Thailand under the 7th National Plan fell from more than US dollar 1,000 million to about US dollar 715 million, or by about two-thirds of that of the 6th National Plan. The trend is likely to continue under the 8th National Plan.

The main sources of ODA to Thailand during most of the 1990s were Japan and the countries of the European Union (Table 7.3). Thailand also has borrowed from various sources, especially OECF, the World Bank, ADB, and international financial markets, to invest in various development activities. The decline in assistance from sources of international cooperation assistance through bilateral and multilateral schemes, coinciding with the period of the economic crisis, further hampered the ability of Thailand to pursue a path toward sustainable development.

Bilateral and multilateral technical cooperation for climate change in Thailand began in the early 1990s. Most of the assistance was in the form of so-called "soft technologies" to enable Thailand to inventory GHG emissions and to identify mitigation options. Some assistance also was used to increase the capacity of local institutions to assess climate change impacts and adaptation options. The Global Environment Facility (GEF) is the principal source of multilateral funding used to address problems arising from climate change. The GEF has channeled financial support through the ADB, UNDP, UNEP or the World Bank. The amount of assistance, however, has been relatively small compared to the needs of Thailand.

Table 7.1 Investment Targets for the 7th and the 8th National Plans (million baht)

	7th Plan	8th Plan		
		Original	Revised	Reduced
1. Private	5,860,552	11,214,800	8,405,535	2,809,265
2. Public	1,608,940	4,106,300	2,985,038	1,121,262
Government	921,348	2,572,188	1,707,649	864,539
Public enterprises	687,592	1,534,112	1,277,389	256,723
3. Total	7,469,492	15,321,100	11,390,573	3,930,527

Source: NESDB

Table 7.2 **International Technical Assistance to Thailand, by the period of National Plan (US dollar million)**

	1st Plan 1961-66	2nd Plan 1967-71	3rd Plan 1972-76	4th Plan 1977-81	5th Plan 1982-86	6th Plan 1987-91	7th Plan 1992-96	8th Plan 1997-98***
USA	132.30	197.95	61.36	69.83	98.34	95.75	23.60	3.88
United Nations	7.33	24.07	36.73	73.82	75.09	100.05	89.75	32.00
Japan		7.90	12.77	210.09	416.17	618.91	255.94	60.89
Australia		11.19	12.14	24.16	38.26	74.10	51.96	7.19
Canada		1.95	0.64	0.35	9.07	29.48	9.39	1.51
United Kingdom		3.73	4.07	8.83	9.94	14.99	5.87	2.19
New Zealand		3.88	2.27	4.35	2.85	2.78	1.42	1.23
Germany		7.54	12.22	41.30	51.77	59.36	48.50	27.90
Netherlands		1.00	1.73	1.80	4.28	8.95	4.01	0.64
France		2.28	4.52	6.07	6.59	7.18	16.69	12.35
Denmark		1.27	1.80	1.31	0.62	2.74	36.20	17.61
Belgium		0.02	0.02	0.17	5.45	5.65	12.26	4.33
Italy		0.05	0.04	0.22	1.36	5.49	4.88	
European Union				40.64	57.78	27.49	27.99	4.34
Volunteers		8.59	8.73	9.17	16.02	23.20	27.95	8.81
NGOs	6.95	11.16	10.14	44.28	8.17	81.74	23.58	
ASEAN				0.13	0.31	1.23	0.87	0.02
Colombo Plan*	11.87							
Third country**	3.54							
Others		2.20	3.23	2.01	4.77	9.12	16.11	10.26
Total US$ mil.	155.03	280.57	173.42	504.39	842.96	1,094.63	715.13	218.73
Total Baht mil.	3,101	5,611	3,468	10,088	22,085	27,913	18,236	7,874
Exchange rate	20.00	20.00	20.00	20.00	26.20	25.50	25.50	36.00

* Total figures for all the members of the Colombo plan

** Total figures for countries in European Union

*** For the fiscal year 1998

Source: DTEC, 1999

Table 7.3 Total Assistance to Thailand by Donor Governments, 1993-1997 (US dollar thousand)

Donor	1993	1994	1995	1996	1997	Total
Japan	48,768	50,665	47,821	33,292	32,469	213,015
Germany	9,742	9,714	10,823	8,858	12,583	51,720
United Nations	22,000	18,000	15,000	12,750	14,000	81,750
Denmark	938	10,649	13,417	10,045	11,887	46,935
France	1,087	4,485	3,653	4,172	5,156	18,551
U.S.A.	8,994	5,867	3,291	3,914	3,580	25,647
Australia	11,012	10,318	9,886	6,788	3,323	41,327
European Union	6,407	9,288	3,749	3,723	2,786	25,953
Sweden	746	2,324	3,070	1,161	2,126	9,428
Belgium	8,453	469	958	1,785	2,077	13,742
United Kingdom	763	1,409	1,267	825	1,061	5,325
Canada	1,961	1,249	1,187	980	833	6,210
New Zealand	654	361	60	135	625	1,836
Netherlands	779	663	602	567	549	3,159
Austria	11	-	6	997	315	1,329
Finland	-	391	418	-	-	809
Switzerland	241	450	30	240	17	977
Italy	1,259	321	-	-	-	1,579
Others	29,342	28,325	26,201	22,593	19,409	125,869
Total	**153,156**	**154,947**	**141,439**	**112,823**	**112,797**	**675,162**

Source: DTEC, 1999

7.2 TECHNOLOGY TRANSFER

Technology refers to knowledge, skills and practices involved in the production, consumption and distribution of goods and services in an economic development process. In relation to climate change, technology transfer refers to the communication of knowledge, skills and practices to deal with climate change issues, namely inventory and mitigation, vulnerability and adaptation.

During the 7th Plan period, Thailand concentrated on strengthening local manpower in science and technology to support national development. The country also promoted the use of new technologies to increase industrial and agricultural productivity and used fiscal policy measures to promote environmentally friendly technologies. Total investment in the direct procurement of technology, machines and equipment under the 7th National Plan was several billion baht[1].

Technology transfer in the context of climate change must be viewed differently from the process of technology transfer that occurs in normal trading and commercial activities. Technology transfer in the climate change context must be perceived within the principle of the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Serious consideration must therefore be given to equity issues that could arise from climate change impacts or mitigation measures. The developed countries that are mainly responsible for the present accumulation of GHGs in the atmosphere and that are highly capable of adapting to climate change must assist less developed ones like Thailand to cope with the phenomena. Thus the transfer of technology through market mechanisms alone will not be sufficient, and some form of market intervention is necessary. In particular, barriers to technology transfer should be eliminated to enhance favorable conditions.

In fact, cooperation in climate change research is accompanied by technological transfer and exchange of knowledge to a certain extent. Countries that participate in climate change research, in one way or another, gain certain knowledge and skills. While undertaking climate change research and development, Thailand has been able to access "soft technologies" in terms of improved

[1] In the first two years of the 7th National Plan, more than 600 billion Baht had already been estimated to be invested in this area (MOSTE, 1997).

research methodologies. Thailand also has accumulated knowledge and experience in the Activities Implemented Jointly (AIJ) pilot phase.

Assessment of Technological Needs

The knowledge and experience gained from research and development on climate change issues has enabled Thailand to identify areas requiring improvement. As climate issues are focused mainly on mitigation and adaptation aspects, technology and capacity building needs are discussed in these two areas.

Inventory and Mitigation

The main constraints to developing a more accurate and reliable inventory of greenhouse gases in Thailand are the absence of local emission factors for the key sectors such as agriculture, energy and forests, and the lack of sufficient data for inventory estimation. Thailand also has encountered a problem of identifying people to undertake inventory work on a regular basis. The more complex the inventory methodology, the more difficult it is to find researchers to undertake the work.

The determination of local emission factors requires intensive research work. While Thailand has conducted extensive research work on emission factors for the rice sector, there is a need to develop local emission factors for other sectors, including livestock, energy and wastes. The setting up of an international network for information and technological exchange could facilitate this work. Building the capacity of the staff of relevant agencies to update the GHG inventory on regular basis also is vital to enhancing national inventory work.

The national greenhouse gase inventory shows the status of emissions and provides the background for development of mitigation options. In the case of Thailand, mitigation options were identified mainly on the basis of their technical potential, and the so-called "no-regrets" options were used to specify the more practical alternatives for Thailand (see Chapter 4). The choice of "no-regrets" options has long been adopted as Thailand's main strategy for climate change. These options do not add higher costs to a particular activity but contribute to climate change benefits. They also conform to Thailand's sustainable development goals.

The technology used in these "no-regrets" mitigation options are easily acquired from the market. But as options to reduce larger amounts of greenhouse gas emissions become increasingly costly, favorable conditions for technological transfer must be created so that the options become economically viable and socially feasible for developing countries like Thailand.

Vulnerability and Adaptation

Assessment of vulnerability to climate change and adaptation measures in Thailand is at an early stage of development. Technological improvement is critically needed. Experience suggests that the development of regional or sub-regional climate models that reduce the level of uncertainty is vital for reliable vulnerability analysis. Specific models to analyze the vulnerability of major areas such as rice, water resources, forests, coastal resources and health also must be developed to make reasonable scenario assessments. The critical absence of technology in these areas highlight the importance of transferring soft technology.

Technology transfer is required at all stages of research and development of climate change issues. Thailand has yet to develop experience, knowledge, skills and capacity not only to inventory greenhouse gases, but also to design methods for vulnerability assessment as well as in the conduct of vulnerability assessment itself. Many of the issues cut across several sectors and demand experts in various fields. The implementation of a climate change agreement also requires building different aspects of institutional capacity.

Barriers to Technology Transfer

A short list of potential barriers to technology transfer has been identified by a UNFCCC's consultation in 1998 (UNFCCC, 1998/1). Barriers could be viewed from the context of the recipient, supplier or the international community.

Domestic Barriers

Thailand has participated actively in the climate change convention process and has established basic institutional structures, such as a national focal point and a national committee, to handle climate change issues. The institutional setting in Thailand is therefore generally supportive of participation in climate change activities, including the transfer of technology. The domestic political environment is also conducive to international co-operation.

Several Thai research and development organizations are supporting technology transfer and capacity building. The National Science and Technology Development Agency is an important promoter of research and development in the areas of engineering, science and technology that are critical to the country's development. The Environmental Research and Training Center of the Department of Environmental Quality Promotion provides support for environmental training and promotes research related to climate change. Other governmental and non-governmental research and development institutes concerned with various aspects of climate change issues include: the National Research Council of Thailand, the

Thailand Research Fund, the Thailand Productivity Institute, and the Thailand Institute for Scientific and Technological Research.

Among the potential barriers to technology transfer in Thailand are the recent economic crisis and the lack of information networks. The economic crisis, for instance, has forced the government to cut the budgets of public agencies, thereby seriously constraining their proposed action plans or development programs. Another potential barrier to technology transfer in Thailand is the insufficient flow of technical and financial information related to climate change technology. There is a need to regularly update and disseminate the technical and financial information available to the related agencies as well as to the general public. The regular and up-to-date information flow requires not only sufficient human resources, but good information systems and strong international support.

External Barriers

While some domestic barriers could hinder the transfer of technology and constrain capacity building, external barriers are even more critical to the success of transferring technology. Since most advanced technologies are in the hands of suppliers, technologies that are transferred should be certified to be environmentally sound. Experience suggests that without appropriate verification mechanisms, the possibility exists of transferring outdated and inappropriate technologies to the recipient countries. This is of particular concern to Thailand. Potential recipient countries like Thailand must therefore be given sufficient information at the international level to choose the technologies that are deemed to be appropriate for distinct socio-economic status and cultural conditions.

The role of the private sector is believed to be critical for effective technology transfer. Unfortunately, the private sector is driven mainly by the profit motive. Business secrets and patent rights are principal concerns of the private sector. It is thus difficult to envisage the transfer of very costly and advanced technologies without strong public policy support from developed countries.

Possible Actions and Initiatives to Remove Barriers

Thailand has tried all means available to promote international co-operation and technology transfer. To support environmental protection, Thailand is now critically evaluating the use of fiscal mechanisms, i.e., environmental taxes through the application of "Polluter Pays Principle" and "User Pays Principle" in the management of natural resources and the environment. At the regional level, Thailand fully supports ASEAN initiatives on climate change.

The continued development of research and conduct of policy studies would pave the way for national initiatives in setting the agenda for research and development related to climate change. Through capacity building and technological transfer, developing countries like Thailand would be able to meaningfully identify their own priorities and needs with respect to sustainable development. In this way, the mitigation or adaptation options identified could easily be integrated into the national economic and social development process.

As domestic development initiatives tend to encounter less resistance than those originating externally, the maximum utilization of local expertise is highly recommended. One possible means of reducing barriers to transferring technology is to promote local capacity as much as possible. It is the task of the international community to promote such capacity building process.

A more active stance to eliminate or reduce the barriers could also be taken by the investing countries. These countries could at least consider facilitating technology transfer via public policy measures. They could intervene when environmentally sound technologies, under free market conditions, are not feasible to implement in developing countries. They could also initiate measures to ensure that the application of technology is sustained beyond the project life cycle.

7.3 CAPACITY BUILDING

Capacity building is an integral part of technology transfer and is very important in enabling Thailand to participate effectively in the climate change convention. Climate change issues are relatively recent and very dynamic and complex. New technical issues are constantly emerging. The dynamic nature of the issues and their technical complexity require that national experts be updated continuously to ensure the latest developments are closely followed. Capacity building for national staff is vital if Thailand is to play its effective role in the global efforts to address climate change. Specific technology required to enhance the capacity of local institutions in Thailand include the following:

- development of local emission factors for inventory assessment in different sectors
- skills in comprehensive vulnerability assessment
- skills in choosing suitable mitigation and adaptation options
- skills in dealing with CDM related issues
- skills in operating transferred technologies

The transfer of technology to strengthen local capacity must not be one way. Exchanges of information and experiences and participation at regional and international forums should be promoted. The interaction

and exchange of research experiences contribute immensely to capacity building. Technology transfer must also be comprehensive enough for adoption and sustained operation by local personnel. Significant losses can be incurred if transferred technologies are terminated after the co-operation period due to the lack of capable personnel to carry out necessary tasks.

Property rights or patent issues could be the main constraint to technology transfer, and unless these issues are resolved favorably, technology transfer could result in the erosion of financial resources of recipient countries. The capacity of recipients to develop their own technology or to adapt imported technology utilizing local resources must therefore be supported.

7.4 OPPORTUNITIES FOR INVESTMENT AND PRIVATE SECTOR PARTICIPATION

The identification and selection of greenhouse gas mitigation measures in Thailand in the past were conducted primarily within the framework of a "no-regrets" policy. Previous studies were required to ensure that mitigation options were consistent with national development objectives, and greenhouse gas reductions were regarded as fringe benefits that accrued from their implementation. While most of the options identified were developed as normal public investment projects, the private sector was active in programs concerned with power sector demand-side management, mass transit systems and reforestation.

Depending on its future commitment to mitigate climate change under the Climate Change Convention, Thailand may be required to look beyond the "no-regrets" options. However, a careful analysis must be undertaken prior to committing to any mitigation activities that would entail additional costs. Such costly options could be considered under the AIJ scheme and other project-based mechanisms of the Kyoto Protocol. This would enable Thailand not only to expedite technology transfer but also to spearhead new investment opportunities that could reduce investment requirements in the long-run. Potential cost savings could be realized from capacity building or technology transfer activities, including the management of projects. In fact, undertaking projects of this nature (i.e., with cost subsidy or cost-sharing investment) could effectively turn costly options into "no-regrets" options for Thailand, enabling it to contribute more to GHG emissions reduction activities.

The developed countries are required to take steps to promote, facilitate and finance, as appropriate, the transfer of or access to environmentally sound technologies and know-how to developing country parties. However, several elements are important to support an effective technology transfer.

Balance between Efficiency and Equity

Efficiency and equity issues must be appropriately addressed in the implementation of Climate Change Convention. As far as the issue of equity is concerned, pure market approach to solving climate change problems alone will not be acceptable. Favorable conditions for the transfer of environmentally sound technologies and know-how must be created, and their transfer from the private sector must be guided, facilitated or even financed by developed countries. Public policies or incentives could be used to minimize patent and copyright issues and to ensure the long-term sustainable application of the technologies.

Development of Local Initiatives

One of the most serious drawbacks of current methods of technology transfer is that, very often, implementation is hampered by the lack of local initiatives and by the short duration of projects. Local initiatives are vital for appropriate development of technology and its transfer. Locally initiated programs are also more likely to be in line with overall national development priorities. To promote this, strengthening the capacity of local personnel is required to assess the need for soft and hard technology. There is also a need for Thailand to refine research methodologies on inventory and mitigation as well as vulnerability and adaptation in order to improve the reliability of the analysis.

Development of a Technology Information Network

The availability of appropriate information is crucial to policy development and planning related to climate change. The establishment of a regional technology information network will facilitate technical information flows among countries in the region. Thailand encourages the establishment of such information networks.

Development of Effective Financial Mechanisms

The highly dynamic nature of climate change issues requires extensive human and financial resources to enable parties to participate effectively. The financial mechanisms that would be created under the Climate Change Convention must be sufficiently flexible for developing countries to launch and to define their needs. They must also ensure that financial resources made available are utilised effectively and appropriately. The economic crisis in Thailand has substantially reduced the country's financial capacity to meet its obligations under the Convention. Financial support is critical to capacity building and technology transfer to Thailand.

Strengthening Local Capacity

Strengthening the capacity of local researchers in Thailand will enable the country to undertake research and development of climate change issues effectively. Capacity building should not be limited to learning from the experiences of international experts. The capacity of local researchers should be developed through interaction and communication, exchange of information and experiences at the regional and international levels. The Secretariat of the Climate Change Convention should promote such development for developing countries like Thailand.

THAILAND's
INITIAL NATIONAL COMMUNICATION
UNDER THE UNFCCC

Chapter

8

Education and Public Awareness

- **Introduction**
- **Education**
- **Public Awareness and Participation**

8.1 INTRODUCTION

The United Nations Framework Convention on Climate Change emphasizes the important role that education and public awareness can play in achieving an effective response to the rapid build-up of anthropogenic greenhouse gas emissions in the atmosphere that leads to global warming. Activities to promote education and public awareness include information dissemination, public participation and training programs to address climate change and its potential effects.

Thailand considers education and public awareness as important parts of the overall policy response to the greenhouse gas issue. Responses to climate change problems require effective contributions from individuals, communities, businesses and professional groups. A prerequisite for such contributions, however, is the availability of adequate and up-to-date information on the possible courses of action to be taken as well as a clear understanding of the issues involved.

On the issue of natural resources and environmental conservation, Thailand's approach to education and public awareness comes in various ways. At the most fundamental level, there are government agencies that disseminate information on the issues to the public through different media including newspapers, radio, television, posters, and other means. Campaigns are launched extensively on appropriate occasions and public participation is solicited to the greatest extent possible. A basic knowledge of natural resources and environmental issues is emphasized in the educational system.

Public awareness on environmental issues such as climate change is raised through a systematic dissemination of information. In addition, public awareness is enhanced through direct participation in natural resources conservation and environmental protection activities. Thailand encourages different parties, public and private, to actively participate in natural resources and environmental management, as well as in discussions and activities related to climate change.

Since the early 1990s, Thailand has strongly supported the role of NGOs in natural resources and environmental management. Workshops and on-the-job training were organized by NGOs in many areas. Increasing concern over the rapid deterioration of the environment in recent years have also induced the private sector to actively participate in environmental conservation activities. Thus, public awareness and actions to promote environmental protection have become an interactive process.

8.2 EDUCATION

Environmental Learning Process

The development of the Thai educational system is guided by the 1992 National Education Scheme as described in the 8th National Education Development Plan (1997-2001). The 8th Plan, which is consistent with the National Education Scheme, contains educational objectives and policies for implementation by operational units during the period of the Plan.

The present National Education Scheme was promulgated in 1992 to direct the nation's educational system to become more efficient and responsive to the emerging needs and rapid changes occurring in Thai society. Educational development under this National Scheme is based on four fundamental principles:

1. The flourishing of individual wisdom, thinking, minds and morality are necessary and essential goals.
2. Human beings must realize the importance of judicious utilization and conservation of natural resources.
3. An understanding of the language and culture of Thai society must be ascertained.
4. The proper balance between dependency and self-reliance is an essential basis for cooperation at the individual, community and national levels.

Thailand has long incorporated natural resources and environmental education into the curricula of schools at all levels. Continuous environmental degradation has prompted the government to increase efforts to improve the situation. As shown in the above principles, Thailand fully recognizes the importance of the educational system's contribution to sustainable development processes in the country. The Ministry of Science, Technology and Environment is presently cooperating with the Ministry of Education to further expand natural resources and environmental studies in the educational curricula at all levels. Twenty-one regional centers for environmental education have been established across the country to promote environmental education system. Additionally, NEPO, in cooperation with the Ministry of Education, has launched programs for conserving energy and natural resources in schools to integrate energy saving and natural resources preservation awareness in the educational curricula. For instance, a 5-year Dawn Project was launched in 1997 with a total budget of nearly 300 million baht to promote education in energy and natural resources conservation at the schools.

The Royal Thai Government has encouraged students to exchange experiences and information through an Internet website called SchoolNet. Managed by the NECTEC. SchoolNet, the first online educational resource in Asia, was launched in Thailand in 1995 to support human resource development under the 8th Plan. The project provided Internet access to 2,500 secondary schools across the country by 1999, and aims to cover an additional 5,000 primary and the vocational schools by 2000. The project has received strong support from private companies and public enterprises. There are currently more than 1,300 schools registered as the members of the network.

Participation of Youth in Resource Conservation

Besides classroom learning, students become more environmentally aware through participation in training workshops and environmental conservation activities. Short-term basic training programs on biodiversity found in terrestrial and mangrove forests are regularly organized for students and young people. Site visits to protected areas to learn more about nature are promoted. Students also are encouraged to participate in nationwide reforestation and afforestation projects. Thailand will continue to promote environmental consciousness, including awareness of climate change issues, among the students and youth.

8.3 PUBLIC AWARENESS AND PARTICIPATION

The Role of Government Agencies

Public information dissemination programs and campaigns are commonly used to raise public awareness in resource and environmental conservation. The dissemination of information to the public is a routine activity of agencies involved in resources and environmental management. The Department of Environmental Quality Promotion (DEQP) of the Ministry of Science, Technology and Environment is the main agency responsible for implementing and coordinating public awareness campaigns and disseminating information on natural resources and environment conservation. Statements regarding the status and condition of natural resources and the environment, particularly on energy, land, forests and water, are disseminated to the public annually. The main activities implemented to promote public participation in natural resources conservation and environmental protection include:

Among the public relations activities that have been conducted are the following:

- General Media Activities
  - Television, radio and print public awareness advertising
  - Television and radio documentary programs
  - Information kits
  - Promotional materials such as T-shirts, caps, cups, etc.
- Press Activities
  - Press Tours
  - “Divide Energy by 2” Press and Information Center
  - Newsletter
- Educational/Awareness Building Activities
  - Energy Conservation Exhibitions
  - Energy Conservation Camps
  - Energy Conservation Performances at Schools and Upcountry Areas
  - Energy Conservation Cultural “Khon” (Masked Drama) Performances
  - Energy Conservation Club
  - Bicycle Rally and Marathon
  - Energy Conservation Seminars for major industries
  - Energy Conservation Contest among province

On the subject of climate change, a summary of issues related to climate change and the Convention were translated into Thai and distributed to the general public a few years ago. Several workshops and seminars were organized to raise public awareness and update the issues. These activities will continue and be intensified in the future. On related issues such as energy and forest conservation, public awareness is promoted by concerned agencies, particularly NEPO, DEDP and RFD.

Apart from information dissemination and public campaigns, the Thai Government has indirectly increased public awareness on resource and environmental issues through the aggressive development of a participatory approach to the planning, development and management of natural resources.

Bottom-up Approach in Resource Management

The last few National Economic and Social Development Plans have emphasized the bottom-up approach in resource and environmental management. The 1992 Environmental Quality Enhancement and Conservation Act established the basis for such development. Provincial authorities are now responsible for preparing their own natural resources and

environmental management action plans. Through the Ministry of Science, Technology and Environment, the plans are submitted for the allocation of government budget funds.

The decentralization of authority to the local level has been further enhanced by the passing of the Tambon Administration Organization Act in March 1995. Local administrative units now perform all legal matters, including local tax collection. They are also eligible for government budgetary support. In recent years, these local administrative units have played an important role in scrutinizing private and public investment projects to ensure environmental-sound development in their jurisdiction.

Local authorities also engage directly in environmental campaign programs. Between 30 and 40 million baht per year is allocated to provincial authorities to enhance public awareness on resource and environmental conservation.

Enhancing the Role of Local Communities

Local communities have a vital role to play in promoting public awareness. In fact, a number of laws and regulations have been proposed in Thailand in recent years to promote the participation of local communities in natural resources conservation. The proposed community forest law is aimed at strengthening the role of local communities in forest resources management. Small coastal fishing communities are being encouraged to protect their coastal resources, particularly mangroves and coastal habitats. Similarly, a proposed water law will advocate local participation in managing watersheds. Such developments will increase local participation in natural resources management and enhance awareness of sustainable development processes.

The Role of NGOs and the Private Sector

Over the past decade, NGOs in Thailand have actively participated in rural development and resource conservation. Interaction among NGOs, between NGOs and the media, between NGOs and academic institutions, and between NGOs and the government agencies have increased substantially in recent years. NGOs now play an important role in building local capacity in resource management and in enhancing environmental awareness among the local communities.

In Thailand, NGOs that are registered with the Ministry of Science, Technology and Environment are eligible for financial support from the Environment Fund to pursue development activities. The Royal Thai government has continuously encouraged NGOs to apply for support from the Fund to carry out natural resource and environmental development projects and activities. Although there are more than 200 NGOs working in the field of natural resources and environment, only about one-half of them have been registered. These NGOs are actively coordinating with local communities and related government agencies in promoting sustainable development.

Public awareness on natural resources conservation and environment protection also has increased through the efforts of the private sector. In cooperation with the Royal Forest Department and local communities, the private sector participated actively in the reforestation/ afforestation program to celebrate the King's 50th year of accession to the throne. Likewise, voluntary private sector programs on green labeling and clean technology have contributed indirectly to public education and awareness of natural resources and environmental issues.

While the Royal Thai Government has increasingly mobilized resources to promote education and public awareness for natural resources and environmental conservation, many policies and measures initiated in recent years have indirectly contributed to raising public awareness. More importantly, the participation of local communities, authorities, NGOs and the private sector have reinforced these efforts. These interactive factors have contributed greatly to education and public awareness in natural resources conservation and environmental protection in Thailand.

Chapter

9

Epilogue

Thailand recognizes the importance of international cooperative efforts to address climate change and has actively pursued research and development activities on the subject. Thailand also has integrated policies to address climate change issues into the country's economic and social development plans.

Thailand's national greenhouse gas inventory for 1994 shows gross emissions of CO_2 at about 241 Tg, with the energy sector contributing the largest share, followed by land use change and forestry. Net removals by the forestry sector reduced CO_2 emissions to 202 Tg in the same year. CH_4 emissions were estimated at 3.2 Tg in 1994, with rice cultivation and livestock as the main sources. Land use change and deforestestation as well as domestic and industrial wastes also contributed to the methane emissions. Other gas emissions, including N_2O, NO_x, CO and NMVOC, were also estimated.

Analyses of mitigation options reveal a wide range of options that are cost effective, though some of them are not economically viable to pursue at the present time. Thailand has undertaken most such options under a "no-regrets" policy. Many of the policies and measures that have been implemented to date demonstrate that Thailand has actively participated in addressing climatge change. For example, the implementation of the DSM program and the energy conservation auditing system have greatly improved energy efficiency and have prevented the emission of substantial amounts of GHG. Potential carbon sinks have been enhanced through aggressive reforestation and afforestation programs.

Voluntary initiatives to reform the educational curricula by incorporating more subjects pertaining to energy use efficiency, natural resources conservation and environmental protection have been undertaken to build a solid foundation for Thailand's sustainable development and to yield benefits beyond its national boundaries. Internationally, Thailand also has been active in the UNFCCC process, hosting several AIJ projects and developing a national policy on the CDM issue.

Nevertheless, special political and socio-economic conditions and circumstances pertinent to Thailand sometimes prevent the country from fully realizing the government's climate change related policies. Its ability to understand fully the situation and the potential impacts and opportunities of abating the climate change risks is rather limited. Thailand perceives that more extensive research and development work on climate vulnerability and adaptation is critically needed. A comprehensive evaluation of mitigation options, especially across sectors, also is important.

Technology transfer is an important mechanism to assist developing countries like Thailand to address climate change appropriately. Unfortunately, such a system suffers from a lack of initiative on the part of developed countries and is biased towards the use of market approach. Thailand believes that the application of unqualified market mechanisms will impede the achievement of the Convention's objectives, especially when equity considerations are fully taken into account. Currently, several barriers to the transfer of appropriate technology need to be addressed. Financial support, favorable terms and conditions for transfer and other forms of intervention from the governments of technology suppliers are necessary to facilitate the transfer process and to permit more useful access to appropriate technology by recipient countries.

Various technical, political, social and economic barriers exist that prevent Thailand from making greater contributions to GHG abatement. Unless the general public has a better understanding and appreciation of climate change issues and the implications of various options available to them, it is extremely difficult for Thailand to implement new policies and measures, even if they were potentially beneficial to all the parties concerned.

The economic and financial crises that Thailand faced in recent years have drained and diverted public and private funds away from investment in environmentally-friendly technologies that could reduce GHG emissions substantially. The crises also have affected the adoption of already proven technologies. The resulting liquidity crunch experienced early on in the crisis also has forced companies to allocate limited available funds for day-to-day business operations and to postpone investments in new projects, even though they are financially attractive. Even with recent improvements in the liquidity situation, most financial institutions remain cautious of extending new credits because of the present high ratio of non-performing loans. Meanwhile, the government budget has been seriously constrained by the sharp shortfall in revenues due to the economic slowdown.

The economic crisis has made it difficult for Thailand to implement progressive policies and measures to protect the local environment. This turn of events has been crucial to Thailand and has helped the country to realize the importance of pursuing sustainable development. Thailand is on its way to a strong, if not fragile, recovery that will not only bring its economy back on track, but hopefully onto a different track that leads to true sustainability. New and novel concepts of sustaining development of a "win-win" nature, such as cleaner production technologies, are encouraged to be introduced to the Kingdom.

Coping with the challenge of climate change more effectively requires both financial and other forms of "soft and hard assistance" such as technical training, research support, public education, and pilot project development and management aid from the parties to the convention and other development agencies. Consistent with the UNFCCC, Thailand strongly encourages Annex I countries to provide technical and financial support, in addition to existing ODA, to developing countries like Thailand, to effectively address climate change issues.

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3. Representative of Ministry of Interior
4. Representative of Ministry of Industry
5. Representative of Ministry of Transport and Communications
6. Representative of Ministry of Public Health
7. Representative of Office of National Economic and Social Development Board
8. Representative of National Energy Policy Office
9. Representative of Office of the Council of State
10. Director General, Department Treaties and Legal Affairs
11. Director General, Department of International Organizations
12. Director General, Department of Technical and Economic Cooperation
13. Director General, The Meteorological Department
14. Director General, Pollution Control Department
15. Director General, Department of Environmental Quality Promotion
16. Director General, Department of Energy Development and Promotion
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25. Professor Dr. Prida Wibulsawas
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27. Director, Division of International Environmental Affairs, Office of Environmental Policy and Planning (Assistant secretary)
28. Director, Air Quality and Noise Management Division, Pollution Control Department, (Assistant secretary)