CAMBODIA'S INITIAL NATIONAL COMMUNICATION

Under the United Nations Framework Convention on Climate Change

August 2002

Ministry of Environment
KINGDOM OF CAMBODIA

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Front cover photo: Angkorwat temple in Siemreap province, Cambodia

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FOREWORD

This First National Communication of Cambodia to the United Nations Framework Convention on Climate Change (UNFCCC) describes the 1994 greenhouse gas (GHG) inventory and the steps that Cambodia plans to undertake to address climate change. This National Communication was prepared by the Ministry of Environment in collaboration with a number of concerned government ministries and with support from the United Nations Development Programme (UNDP)/the Global Environment Facility (GEF)-sponsored Cambodia's Climate Change Enabling Activity Project (CCEAP), which is the first and so far the only study on climate change undertaken in Cambodia. Cambodia has lost valuable data and human resources during the decades of war, but this study has managed to piece together available data to comply with the country's obligation to the UNFCCC.

In view of this, we recognize that much work still needs to be done to improve the quality and management of data needed to evaluate climate change in Cambodia. There is a need to institutionalize a functioning inter-agency cooperation for climate change related activities. The country needs also to undertake additional activities to develop and refine activity data and local emission factors.

We value the support provided by the UNDP/GEF in the preparation of this First National Communication. With this support Cambodia was able to determine its GHG inventory, identify potential actions on how to minimize GHG emissions, assess the vulnerability and adaptation to climate change in priority sectors and prepare a national action plan for effective response measures to climate change. The plan is vital to the country since Cambodia's economy remains predominantly rural and agriculture-based, hence vulnerable to the adverse effects of climate change. Furthermore, the still widespread poverty and rapid population growth, especially in the rural areas, make the majority of the people highly vulnerable, as they do not have adequate resources to protect themselves from natural disasters.

Cambodia, as a Non-Annex 1 Party to the UNFCCC, is ready to cooperate with the international community and regional partners in addressing climate change issues in accordance with the principle of common but differentiated responsibility.

Finally, I would like to express our sincere thanks to the CCEAP team, concerned government ministries and institutions, the United Nations Development Programme, the Global Environment Facility, and other individuals and organisations for their financial and technical support and cooperation in the preparation of this First National Communication of Cambodia.

Dr. Mok Mareth
Minister of Environment

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CARDI	Cambodian Agricultural Research and Development Institute
CCEAP	Cambodia Climate Change Enabling Activity Project
CCGT	Combined Cycle Gas Turbine
CCSR	Center for Climate Research Studies (Japan)
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CO_2-eqv.	Carbon Dioxide Equivalent
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DANIDA	Danish International Development Agency
DoM	Department of Meteorology
DSM	Demand-Side Management
EDC	Electricité du Cambodge
EIA	Environmental Impact Assessment
ERA	Royal School of Administration
FAO	Food and Agriculture Organization
FP	Forest Protection
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagram
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GSP	Generalized System of Preferences
GWP	Global Warming Potential
ICS	Improved Cook Stove
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Planning
IUCN	World Conservation Union
JICA	Japan International Cooperation Agency
LEAP	Long-Range Energy Alternatives Planning programme
LUCF	Land Use Change and Forestry
MAFF	Ministry of Agriculture, Forestry and Fisheries
MIME	Ministry of Industry, Mines and Energy
MLMUC	Ministry of Land Management, Urban Planning and Construction
MoE	Ministry of Environment
MPWT	Ministry of Public Works and Transport
MW	Megawatt
MWRM	Ministry of Water Resources and Meteorology
NEAP	National Environmental Action Plan
NGO	Non-Government Organization
NMVOC	Non-Methane Volatile Organic Compound
NPRD	National Programme to Rehabilitate and Develop Cambodia
NTC	National Technical Committee
PREGA	Promotion of Renewable Energy, Energy Efficiency and GHG Abatement
RFG	Reforestation Using Fast Growing Species
RGC	Royal Government of Cambodia
RLR	Reforestation with Long Rotation
RS	Remote Sensing
RSG	Reforestation Using Slow Growing Species
RSR	Reforestation with Short Rotation
RUPP	Royal University of Phnom Penh

SEDP-II	Second Socioeconomic Development Plan, 2001-2005
SLR	Sea Level Rise
SRESA2	Special Report on Emissions Scenario, Family A2
SRESB1	Special Report on Emissions Scenario, Family B1
TA	Technical Assistance
TOE	Tons of Oil Equivalent
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
V&A	Vulnerability and Adaptation
WB	World Bank
WCS	Wildlife Conservation Society
WFP	World Food Programme
WTO	World Trade Organization
WWF	Worldwide Fund for Nature

EXECUTIVE SUMMARY

Introduction

Cambodia ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 18 December 1995. The Convention entered into force for Cambodia on 17 March 1996, thus making the country eligible under the financial mechanism of the UNFCCC. In August 1998, the Government of Cambodia and the United Nations Development Programme (UNDP)/Global Environment Facility (GEF) signed the project document *Enabling Cambodia to Prepare its First National Communication in response to the UNFCCC* (Cambodia's Climate Change Enabling Activity Project: CCEAP). This 3-year project started in January 1999 with the objective of preparing the First National Communication in response to the UNFCCC. This is seen as the first step taken by the government in the actual implementation of the UNFCCC in Cambodia.

This First National Communication describes how Cambodia, as a Non-Annex 1 Party to the Convention, is meeting its commitments under the UNFCCC. This Communication provides information on the national circumstances and national GHG inventory for 1994. It also describes Cambodia's capability to respond to the impacts of climate change and measures that have been or need to be taken to mitigate climate change in the country.

Cambodia's National Circumstances

Geography. Cambodia is located in Southeast Asia between latitudes 10^0 and 15^0 N and longitudes 102^0 and 108^0 E, and has a mainland area of 181,035 km^2 extending approximately 580 km from east to west and 450 km from north to south. Cambodia's coastal zone, which is located in the southwest of the country, has a total length of approximately 435 km.

Climate. Cambodia's climate is governed by monsoon and characterized by two major seasons: rainy season from May to early October and dry season from November to April. The annual average temperature is 28^oC, with a maximum average of 38^oC in April, and a minimum average of 17^oC in January. The country frequently experiences floods and droughts, that cause considerable economic losses and social and environmental impacts. Cambodia rarely suffers from extreme weather events such as typhoons or even severe storms because it is protected by the surrounding mountain ranges.

Population. In 1990 and in 1994, the population of Cambodia was 8.60 and 9.87 million, respectively. According to the 1998 census, the population in that year was 11,437,656 with an annual growth rate of 2.49% and the urban population contributed 15.7% of the total population of Cambodia. Poverty is a serious social problem in Cambodia. Approximately 40%, 39% and 36% of the population, respectively in 1990, 1994 and 1998, lived below the poverty line.

Human Health. Since Cambodia is tropical, the direct impact of the climate on human health is significant. Malaria and dengue fever are the two most important mosquito-borne diseases, which are found in Cambodia.

Political and Decision-Making Structure. Cambodia is a constitutional monarchy (the King is the Head of State who reigns but does not govern). The country has a democratic multi-party system. The Senate is the upper house. The National Assembly, which is the lower house, proposes the candidate for nomination for the post of Prime Minister (PM) to the King. The PM is the head of the government.

Natural Resources. Cambodia's natural resource wealth lies in the rivers and lakes, the terrestrial and inundated forests, the inland and coastal fisheries, pockets of volcanic soils and gemstones (the sapphire-ruby-zircon gems of Pailin). There are also deposits of fossil fuels (coal and offshore gas and oil) but further studies are needed to evaluate reserves worth developing. Raw materials for construction are available in Cambodia. The country also has phosphate deposits suitable for the production of phosphate fertilizer.

Water Resources. Cambodia is rich in water resources, with the Mekong River and the Tonle Sap system dominating the hydrology. The Mekong, which is the twelfth longest river in the world, flows from the Tibetan Plateau through Myanmar, Thailand and Laos, south through east and southeastern Cambodia into Vietnam where it flows into the South China Sea. Central Cambodia is occupied by the Tonle Sap lake which is an overflow system of the Mekong River.

Forests. Forests make up a major part of the country's natural resource base. Hill evergreen, tropical rain and dry land evergreen forests are found in the humid coastal ranges, humid north eastern uplands, and the very humid to sub-humid low altitude areas.

Biodiversity. Cambodia has a rich biodiversity. The forests, wetlands and other habitats support many species of flora and fauna, including 130 species of mammals, more than 600 species of birds, more than 2,300 vascular plants and an unknown number of reptiles and amphibians.

Agriculture. The agriculture sector provides direct employment to approximately 80% of the labor force. Cambodia's land area used for agricultural purposes increased by approximately 294,464 ha from 3,785,000 ha in 1990 to 4,079,464 in 1994 and continues to increase as more forest is converted for agricultural purposes and land formerly inaccessible from the war is de-mined. Approximately 50% of the increased agricultural land was on land formerly classified as shrubland. Rice, the staple food of the population, accounts for the majority of the cropping area. Livestock production is also an important agricultural activity with cattle comprising 85% of agricultural draft power. Most rural families raise pigs and poultry.

Energy. According to the World Development Index (World Bank, 1998), Cambodia uses relatively little commercial energy per person: 44 kg of oil equivalent per capita for 1994. Cambodia imports 100% of the required petroleum products from countries in the region. Petroleum products are the main source of commercial energy for power generation, industry, transport, and the residential and commercial sectors. Petroleum products imported into Cambodia for 1994 were estimated to be 415.67 kilotonnes (kt). Woodfuel and other biomass are the major energy sources for cooking for Cambodian people, especially in rural areas. It was estimated that, in 1994, indigenous and renewable biomass energy covered over 85% of the total national energy supply.

Economy. Cambodia, a least developed country, began its conversion to a free market economy in 1989. The per capita income increased from US$130 in 1990 to US$241 in 1994. The Gross Domestic Product (GDP) in 1990 was US$1,115 million and US$2,385 million in 1994. Between 1991 and 1995, Cambodia recorded an average growth rate of 6% per annum.

Trade. Since the 1993 UN-sponsored election, Cambodia has increased trade with Asian and European countries as well as with the United States of America. Cambodia qualifies for the World Trade Organization (WTO) Generalized System of Preferences (GSP) and has been granted GSP by many countries. The main imports are oil products, vehicles, construction materials and equipment, fabrics, etc. Major exported goods include garments, logs, rubber, and fish. In 1994, exported goods accounted for 12.4% of GDP and imported goods 22.3% of GDP.

Cambodia's 1994 National Greenhouse Gas (GHG) Inventory

Cambodia's 1994 GHG Inventory was established using the revised 1996 IPCC Guidelines for National GHG Inventories. Following the recommendation of the UNFCCC Secretariat, the base year of the inventory used was 1994, and would cover three mandatory GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) for five major sectors: Energy, Industrial Processes, Agriculture, Waste, and Land Use Change and Forestry (LUCF).

The result of the inventory indicated that in 1994, Cambodia removed 64,850 Gg of CO_2-eqv. and emitted 59,708 Gg of CO_2-eqv. Therefore, in 1994, Cambodia was a net carbon sink country with a net total carbon removal of 5,142 Gg of CO_2-eqv. The distribution by gas are as follows: i) carbon dioxide 74%, ii) methane 18% and iii) nitrous oxide 8%.

The main source of carbon dioxide emission was the LUCF sector (97%), followed by the energy sector (3%) while the contribution of the industry sector to the total CO_2 emissions was insignificant.

The methane emissions were about 445 Gg, of which 76% was from agriculture, 17% from LUCF, 5% from energy and 2% from waste. The agricultural emissions of methane refer mainly to domestic livestock (54%) and rice cultivation (44%).

The total nitrous oxide emissions of 12 Gg were mainly from agricultural soil (64%) and livestock (35%) under the agriculture sector.

Greenhouse Gas Projection

Results from the projection analysis of greenhouse gas emissions and removals by sectors indicated that in 2000 Cambodia was already a net emitter of GHGs. The net emissions were approximately 6,244 Gg of CO_2-eqv. In 2020, the net emissions would increase to approximately 43,848 Gg of CO_2-eqv. Among the sectors, LUCF would be the main source of GHG emissions (63.0%), followed by agriculture (27.5%). Energy would only contribute to approximately 9.0% of the total national emissions.

Energy. In 1994, CO_2-eqv. emissions from the energy sector were approximately 1,881 Gg. The largest contributor to the total emissions was the transport sub-sector followed by households. In 2020, the total CO_2-eqv. emissions would be approximately 8,761 Gg, about four times that of 1994 and the transport sub-sector would contribute to approximately 62% of the total. CO_2 dominated the emissions of GHGs from the energy sector, followed by CH_4 and N_2O. The percentage contribution of CO_2 to the total GHG emissions will increase while percentage CH_4 and N_2O will decrease. The main source of CO_2 is the transport sub-sector, while the main sources of CH_4 and N_2O are households.

Agriculture. The results of the projection showed that GHG emissions from agriculture would increase quite significantly. In 2020, methane emissions will be about three times the 1994 emissions while nitrous oxide will approximately double. The rate of increase in methane emissions for livestock would be slightly higher than that from rice paddy. In total, GHG emissions from agriculture in 2000, 2010 and 2020 would be approximately 12,030; 17,789; and 26,821 Gg of CO_2-eqv., respectively.

Waste. Projection of GHG emissions from waste indicated that t the emissions in 2020 would be approximately twice the 1994 emissions. In 1994 the CO_2-eqv. emissions were approximately 273 Gg while in 2020 it would increase to 523 Gg. The main sources of GHG emissions would be from solid waste and human sewage.

Land Use Change and Forestry (LUCF). The projection showed that the total CO_2-eqv. emissions from LUCF for the years 2000, 2010, and 2020 would be approximately 58,379; 57,627; and 61,512 Gg, respectively. During these years forests would absorb approximately 67,118; 61,090; and 53,769 Gg of CO_2-eqv., respectively. Thus, in 2020, the status of Cambodia's forests would change from a net sink to a net emitter. Net emissions of CO_2-eqv. in 1994 were approximately -17,907 Gg and in 2020 would increase to approximately 7,744 Gg.

Greenhouse Gas Mitigation Options

Energy. In the energy sector of Cambodia, CO_2 mainly comes from the combustion process of carbon-based fuels. There are no oil production activities and all oil products are imported. Four scenarios were evaluated: (i) Reference scenario, (ii) Government Plans scenario, (iii) GHG Mitigation Options scenario, and (iv) High scenario. The Reference scenario used the data from the final report of the Energy Department of the MIME. The Government Plans scenario consists of projects that are in the development plan but are not considered in the Reference scenario, which although not specifically classified as climate change projects, will reduce GHG emissions once implemented. The GHG Mitigation Options scenario lists all other options aside from the projects already identified by the government. The High scenario is composed of the Government Plans scenario and the GHG Mitigation Options scenario.

The total GHG emission reduction of the High scenario for the years 2003 to 2030 amounts to 59,650 Gg of CO_2-eqv. or 24% reduction from the reference scenario (14% under the Government Plans scenario and 10% under the GHG Mitigation Option scenario). In the analysis, only the mitigation options with sufficient data were evaluated in the calculations of the potential GHG emission reduction.

Land Use Change and Forestry. In 1994, the main source of carbon dioxide emissions in Cambodia was LUCF (97%). However, the capacity of the LUCF sector to uptake CO_2 was 43% higher than emissions, thus in total this sector could offset all other GHGs emissions from all other sectors.

In this study, five mitigation options were evaluated. Total carbon abatement under the baseline, mitigation and potential scenarios are approximately 1.24, 155.6 and 466.4 million tonnes respectively, while the cumulative investment required are approximately 0.63, 76.22, and 230.48 million US$ and the life cycle costs are approximately 0.98, 121.30 and 364.67 millions US$, respectively and cumulative net present value of benefit are approximately 1.53, 182.77 and 556.23 millions US$, respectively.

Agriculture. Greenhouse gases emitted from the agricultural sector include CH_4, NO_x, N_2O and CO. The emissions are produced by several sub-sectors such as livestock, rice fields, agricultural soils and burning of agricultural residues and grassland. Livestock and rice fields are the major source of CH_4 (78%), while agricultural soils are the main source of N_2O.

It was found that all GHG mitigation options evaluated in this study gave positive benefits, which ranged from 10 to 71US$/ha. In general, it was found that the incremental benefit per hectare increases exponentially with potential emissions reduction while incremental benefit per tonne of methane decreases exponentially with the mitigation potential.

Vulnerability and Adaptation (V&A) to Climate Change

The Vulnerability and Adaptation (V&A) study was conducted by the National Technical Committee of the CCEAP in order to assess the impacts of climate change on some priority sectors in Cambodia and to identify adaptation options in the related sectors to the changing

climate. An assessment of the impact of climate change on Cambodia's climate was also performed.

Impacts of Climate Change

Impact of Climate Change on Cambodia's Climate. The global warming scenarios used in this study are SRESA2[1] (reference) and SRESB1 (policy) and GCM models CCSR and CSIRO. The SRESA2 will lead to higher future GHG emissions while SRESB1 leads to lower future GHG emissions. The models suggested that by 2100 rainfall in Cambodia would increase by 3% to 35% from the current condition, while temperature increase would be in the range of 1.3 ^{o}C-2.5 ^{o}C. The occurrence of climate extremes may also increase.

Agriculture. In the agriculture sector, only the rice production system was assessed in four major rice producing provinces. Based on data from the past five years, rice production loss in Cambodia was mainly due to the occurrence of flooding (more than 70% loss) and followed by drought (about 20% loss) and others such as pest and diseases (10% loss). Under elevated CO_2, yields of wet season rice might increase above that of dry season rice. However, there is a chance that under changing climate, rice yield in some provinces would be more variable than under current conditions due to the increase in flood frequency and intensity, in particular in rice growing areas surrounding the Tonle Sap Lake and the Mekong River.

Forestry. According to the Holdridge Classification System, under the current climate conditions, Cambodia's forests are dominated by dry forest (60%), followed by wet forest (20%) and moist forest (20%). Under changing climate, the area of wet forest would decrease while moist forest would increase and dry forest would remain the same. This change indicated that forest productivity and biodiversity might also change. High rate of deforestation may accelerate the loss of forest biodiversity and reduce forest productivity.

Health. In the V&A study, only the impact of climate change on malaria has been assessed as this is the most serious vector-borne disease in Cambodia. The study showed that in the last four years the number of malaria cases is negatively correlated with dry season rainfall (6%), mean annual temperature (19%) and percent literate (46%), and positively correlated with wet season rainfall (29%).

Coastal Zone. Cambodia's coastal zone consists of two provinces (Kampot, and Koh Kong) and two municipalities (Sihanoukville and Kep). The total area covered by these provinces and the autonomous city is about 17,237 km^2. In this study, only Koh Kong province has been assessed since this province covers most of the coastal zone (11,160 km^2) and is the most vulnerable to the impact of sea level rise according to a preliminary analysis of the impacts of a 1 m sea level rise on Cambodia's coastal zone. This is due to the fact that most areas along the Koh Kong coastline are low-lying. The study indicated that if sea level rises by 1 m, about 0.4% of the total area of Koh Kong province would be permanently under water.

Adaptation to Climate Change

Agriculture. The impact of climate change on rice production in Cambodia would not be substantial if the government could implement the existing 1999-2010 Agriculture Development Plan. A study of the four main rice producing provinces indicated that from 2025 up to 2100, rice production would exceed demand, if current rice productivity could be increased by about 1t/ha every 25 years. Options to adapt to climate change in the agriculture sector include: (i) development of new high yielding varieties; (ii) improvement of crop management and cultural

[1] Special Report on Emissions Scenario, A2 family. The SRES scenarios has four qualitative story lines that yield four sets of scenarios called "families": A1, A2, B1 and B2. Reference: Emissions Scenarios, IPCC 2000.

practices; (iii) development of capacity to adapt to current extreme climate events such as development of early warning systems for flooding and development of maps showing rice growing areas of provinces prone to flood and drought; (iv) development of irrigation facilities in low land areas; (v) increasing planting index in suitable areas; and (vi) diversification of foods.

Forestry. In the forestry sector, three options have been recommended to reduce the impact of climate change: (i) forest plantation establishment, (ii) conservation of protected areas, and (iii) improvement of forest resource management.

Health. For the health sector, several control measures are being introduced to reduce malaria cases. These are through early diagnosis and treatment of the diseases, distribution of pyrethroid-treated mosquito nets to communities living in high-risk areas to control the vectors, strengthening programme management and supervisory practices and funding for the provision of mosquito nets and insecticide. Health education programmes are very critical and should focus on low cost preventive measures such as improvement of personal hygiene, use of bed nets and destroying the insect breeding sites.

Coastal Zone. Considering that the possible impacts of sea level rise on coastal zone would be very significant to the country, the government should:

- Develop a national strategic response to sea level rise for the coastal areas;
- Investigate further potential impacts of sea level rise on biogeophysical, socio-economy, marine resources, freshwater, infrastructure, human settlements, and agricultural production;
- Formulate a comprehensive adjustment and mitigation policy for sea level rise in the context of integrated coastal zone management;
- Develop computer-based information systems covering the results of surveys, assessments and observations in order to minimize the impact of sea level rise resulting from climate change;
- Increase public awareness on the effect of sea level rise on Cambodia's coast;
- Identify potential donors either multilateral or bilateral sources to assist the country in adaptation to sea level rise; and
- Establish cooperation frameworks, training, technology transfer, surveillance of climate change in case of sea level rise, and the sharing of experiences to assist the government in establishing preparedness response to climate change.

Government Plans, Policies and Measures

The following legal, policy, planning and institutional efforts are directly linked to sustainable development:

- 1994-95 National Programme to Rehabilitate and Develop Cambodia (NPRD)[2];
- The "First Five Year Socio-Economic Development Plan (SEDP-I) 1996–2000";
- The "Second Five Year Socio-Economic Plan 2001–2005 (SEDP-II)";
- The National Environmental Action Plan (NEAP), 1998-2002;
- The Interim Poverty Reduction Strategy Paper;
- Article 59 of the Constitution of Cambodia;
- Establishment of the Ministry of Environment in 1993;
- A Royal Decree on the Creation and Designation of Protected Areas;
- The Law on Environmental Protection and Natural Resource Management;
- Sub-decrees on pollution control and Environmental Impact Assessment (EIA);

[2] First Five Year Socioeconomic Development Plan 1996-2000 by the Royal Government of Cambodia, 1997.

- Land Law, Mineral Law and Forestry Law.

Several government ministries have direct mandates related to sustainable natural resource management. These include the Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries; Ministry of Water Resources and Meteorology; Ministry of Land Management, Urban Planning and Construction; Ministry of Industry, Mines and Energy; etc.

In addition, Cambodia has ratified a number of International Conventions related to the environment. These include:

- The Convention on Wetlands of International Importance (the Ramsar Convention);
- The Convention on Biological Diversity;
- The United Nations Framework Convention on Climate Change;
- The Convention on Marine Pollution: MARPOL 73/78;
- The United Nations Convention on the Law of the Sea (UNCLOS);
- The Convention on International Trade in Endangered Species (CITES);
- The Convention on Desertification;
- The Montreal Protocol; and
- The Convention on Persistent Organic Pollutants.

The Angkor Temples have been declared a World Heritage Site and there are proposals to declare two further sites: an area of the Tonle Sap Lake and an area of the Cardamom Mountain Range.

In the field of climate change, as a Non-Annex 1 party to the UNFCCC Cambodia has been actively participated in the global efforts to response to climate change. The Royal Government of Cambodia has taken a firm stance to support the promulgation of the Kyoto Protocol to achieve the ultimate goal of the UNFCCC. In this context, the Royal Government of Cambodia signed Instrument of Accession to the Kyoto Protocol on 04 July 2002, indicating its commitments to the global efforts in addressing climate change issues. In addition, many government activities and measures also contribute to the global efforts to achieve the objectives of the UNFCCC such as creation and management of 23 protected areas, the current forest protection efforts, air pollution control measures, promotion of renewable energy development and cleaner technology, etc.

Research and Systematic Observation

The recording of systematic observations and development of research programs has been greatly hindered by the thirty years of civil war, which ended in the late 1990s. However recent data relating to meteorology, hydrology, land use, forest cover and population figures are available. The international lending institutions, the donor community, international organizations and non-governmental organizations have played an important role in collating information on natural resources and the environment, collecting data, implementing small research projects and in developing research capacity during the last decade.

Education, Training and Public Awareness

Education and training specifically relating to climate change is limited to the work of the GEF-supported Climate Change Enabling Activity Project. However, there have been a number of environmental education, training and awareness projects and activities, which have included climate change in their curricula.

Since 1993, environmental education and awareness programmes have been introduced and integrated into formal education curricula at all levels. A number of international organizations, local and international NGOs have implemented non-formal environment education activities with monks and local communities as part of sustainable agriculture and community/rural development programs.

In recent years, environmental and sustainable development issues have become popular and frequent topics for mass media in Cambodia. The Ministry of Environment, a number of NGOs and local media have been organizing various programmes to promote better understanding among the general public and policy makers about these issues, which also include climate change.

Financial Resources and Technology Transfer

Financial Resources

As a least developed country, Cambodia has limited financial capacity to implement its development programmes as well as to fulfil its commitments under international conventions. Foreign currency earnings mainly come from the garment and tourism sectors, which are the main sources of employment and income growth for the country. Government revenue is generated from taxes and non-tax sources. By far the largest taxes are the Value Added Tax (VAT) and the customs duties. In 2000, 73% of all tax revenues were from imports and the consolidated budget deficit was 5.7% of the GDP and entirely financed by donors, through concessionary lending and grant support. The GDP is 3,093 million US$ and the GDP per capita is US$256 for the same year.

Donor Support to Climate Change Activities

The UNDP/GEF-funded CCEAP is the only project on climate change in Cambodia so far. Cambodia has submitted an add-on proposal for interim financing on first National Communication (Phase 2) to UNDP/GEF. Cambodia is currently participating in a UNITAR-executed project entitled "Building Human and Institutional Capacities to Address Climate Change Issues in Least-Developed Countries". The ADB's Promotion of Renewable Energy, Energy Efficiency and GHG Abatement (PREGA) project is still on the initial stage. There are other projects, which although not classified as climate change projects, can actually reduce GHG emissions, once implemented. Some of these projects are the WB/MIME "Cambodia Renewable Energy Promotion Project", JICA's "Transport Master Plan Of Phnom Penh" and DANIDA's "Natural Resource and Environment Programme", among others. Several project proposals are underway, to be submitted for funding to some potential donors. NEDO of Japan and WWF have also expressed interest in climate change projects in Cambodia.

Technology Transfer

In the SEDP-II, 2001-2005, Cambodia has emphasized technology transfer. Although the initiative is not specific to climate change, most of the technology transfer can reduce GHG emissions.

Cambodia is still in the process of applying for projects under the UNDP/GEF, ADB and other grants that its neighboring ASEAN countries (like Thailand & Vietnam) have already implemented.

Domestic barriers to technology transfer. Cambodia's institutional setting and the domestic political environment are generally supportive of activities that will contribute positively to addressing climate change issues as reflected in the SEDP-II and other policies of the

government. However, there is insufficient coordination and sharing of information between government agencies. Also, the recent world economic crisis partially caused by the September attacks in the U.S. is among the potential barriers to technology transfer in Cambodia. Information regarding the benefits of GHG emission reduction projects is not yet widely disseminated to the government institutions, private sector and the banks.

External barriers to technology transfer. Advanced technologies are manufactured outside Cambodia and are usually expensive. There is a need for an agency in Cambodia to certify that these technologies are safe and not rejects of other countries.

Capacity Building

The CCEAP has assisted Cambodia in formally developing its technical capacity in the field of climate change for the first time. To enable Cambodia to fully and actively participate in the implementation of climate change convention, additional technical and institutional capacity building programmes are very important. The staff involved in climate change activities should always be up to date with recent developments. In addition, the country needs to strengthen its institutional capacity to ensure better implementation of all climate change-related activities.

Cooperation and exchange of information between government institutions, with countries in the region, as well as international organizations, are crucial.

I. INTRODUCTION

Cambodia ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 18 December 1995. The Convention entered into force for Cambodia on 17 March 1996, thus making the country eligible under the financial mechanism of the UNFCCC. In August 1998, the Government of Cambodia and the United Nations Development Programme (UNDP)/Global Environment Facility (GEF) signed the document of the project *Enabling Cambodia to Prepare its First National Communication in response to the UNFCCC* (Cambodia's Climate Change Enabling Activity Project: CCEAP). This 3-year project started in January 1999 with the objective of preparing the First National communication to the UNFCCC. This is seen as the first step taken by the government in the actual implementation of the UNFCCC in Cambodia.

Preparation of this First National Communication was a big challenge for Cambodia, a country that managed to end its three-decade internal turmoil only a few years ago. This Communication is a result of the collective efforts and enthusiasm of the National Technical Committee with strong support from concerned agencies and individuals.

The First National Communication describes how Cambodia, as a Non-Annex 1 Party to the Convention, is meeting its commitments under the UNFCCC. The report contains eight chapters in addition to this introductory chapter. Chapter 2 provides information on the national circumstances of Cambodia for 1994. Chapter 3 summarizes the results of the National GHG Inventory for 1994, the first-ever GHG inventory in the country. The results of the GHG projections and mitigation options, as well as a summary of the vulnerability and adaptation assessment conducted by CCEAP, are presented in Chapter 4 and Chapter 5, respectively. Chapter 6 describes the Cambodian Government plans, policies and measures for working towards sustainable development. Chapter 7 reports on initiatives for recording systematic observations and development of research programs. Chapter 8 describes environmental education, training and awareness projects and activities, some of which have included climate change in their curricula. And finally, Chapter 9 addresses the issues of financial resources, technology transfer and capacity building in relation to climate change.

II. NATIONAL CIRCUMSTANCES FOR 1994

II.1 Geography

Cambodia is located in Southeast Asia between latitudes 10º and 15ºN and longitudes 102º and 108ºE, with a mainland area of 181,035 km^2 extending approximately 580 km from east to west and 450 km from north to south. Cambodia shares its border with Thailand in the west and north, with Laos in the north, and with Vietnam in the east and south/southeast and has a coastline in the south/southwest, in the Gulf of Thailand (Figure 2.1).

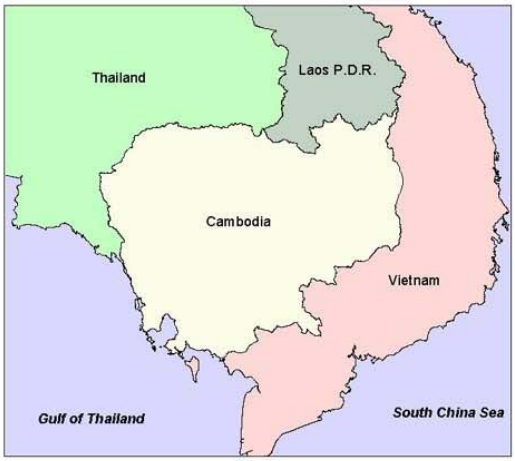
The country is comprised of the central alluvial plains of the Mekong River and Tonle Sap Basin and mountains and highland areas, which surround the central plains. The Cardamom mountain range separates the coastal areas from the central plains in the southwest. The Dangrek mountain range, which forms part of the Cambodian-Thai border in the northwest, is a continuation of the Korat plateau and the northeast plateaus are a continuation of the Kontum massif, which forms the central highlands of Vietnam. The highest point in the country is Phnom Aural (1,813 m).

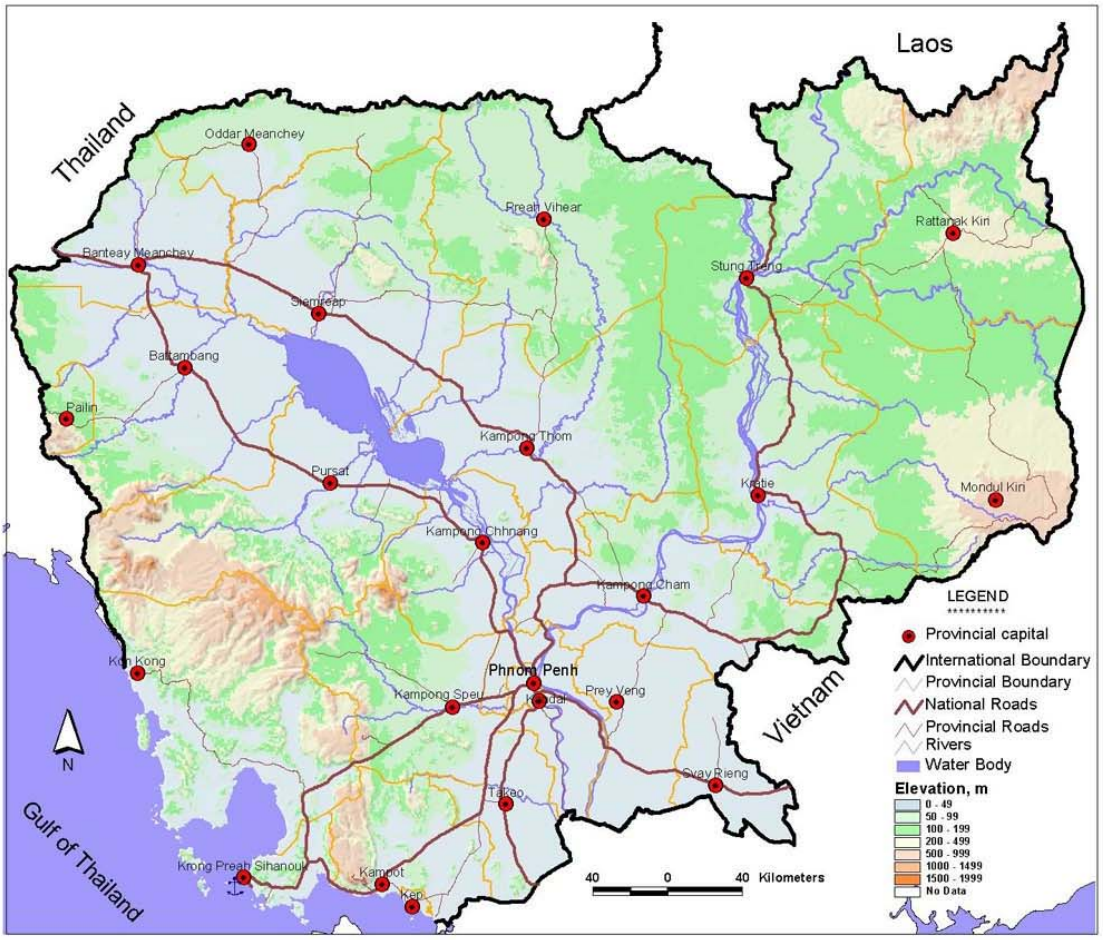
Cambodia's coastal zone, which is located in the Southwest of the country, has a total length of approximately 435 km. The coastal watershed has an area of approximately 18,300 km^2 and covers two provinces, Koh Kong and Kampot, and two municipalities, Sihanoukville and Kep, which lie outside the Mekong River Basin. Cambodia's claimed Economic Exclusive Zone in the Gulf of Thailand is estimated to be 42,000 km^2. The coastal zone plays a significant role in agriculture, fishery, tourism, and marine transport. The population of Cambodia's coastal zone is relatively low. In 1995, the total population of the coastal provinces and municipalities was estimated to be 6.5 % (675,000 population) of the total national population with the population density varying from 7.07 people/km^2 in Kampot province to 138 people/km^2 in Sihanoukville.

Table 2.1: General information on National Circumstances

Criteria	1994
Area (km^2)	181,035
Population (million)	9.87
Urban population	15 % (1,524,000)
Population in absolute poverty (%)	39
Life expectancy (years)	M. 52, F. 54
Literacy rate (%)	68.7
Estimate share of informal sector in GDP	7.3 %
Share of industry in GDP (%)	18.3
Share of services in GDP (%)	36.5
Share of agriculture in GDP (%)	45.2
Land area under agricultural purposes (ha)	4,079,500
Livestock:	
- Non-dairy cattle "cow" (head)	2,621,900
- Buffalo (head)	814,200
- Horses (head)	21,000
- Swine (head)	2,002,300
- Poultry (head)	10,094,400
Forest area (ha)	10,804,300 (60 % of the total country's land area)

Figure 2.1: Map of Cambodia





II.2 Climate

Cambodia's climate is governed by monsoon and characterized by two major seasons: from May to early October, strong prevailing winds from the southwest bring heavy rains and high humidity and from November to April, winds and humidity are low. The average annual rainfall is 1,400 mm in the central low regions and may reach 5,000 mm in certain coastal zones. The annual average temperature is 28^{o}C, with a maximum average of 38^{o}C in April, and a minimum average of 17^{o}C in January.

Cambodia rarely suffers from extreme weather events such as typhoons or even severe storms because it is protected by the surrounding mountain ranges. Storms occur most frequently during the period from August to November, with the highest frequency in October.

The country frequently experiences floods which result from heavy rains that fall locally and upstream in the Mekong Basin between May and October. Widespread drought occurred throughout the country in 1986/87 and 1997/98. Both floods and droughts have caused considerable economic losses and social and environmental impacts.

II.3 Population

In 1990 and in 1994, the population of Cambodia was 8.60 and 9.87 million, respectively. The 1998 official census recorded a population of 11,437,656 with an annual growth rate of 2.49%. In recent years, the urban population has increased dramatically, due to economic migration of the rural population. In 1994, the urban population was 1,524,000 but by the 1998 census this number had increased to 1,795,575, 15.7% of the total population (Figure 2.2). According to the 1962 census, the urban population contributed 10.3 percent of the total population of Cambodia. The 1998 census recorded an average population density of 64 people per km^2, ranging from 3,448 people per km^2 in Phnom Penh to 2 people per km^2 in the remote northeastern provinces, with eighty five percent of inhabitants living in rural areas.

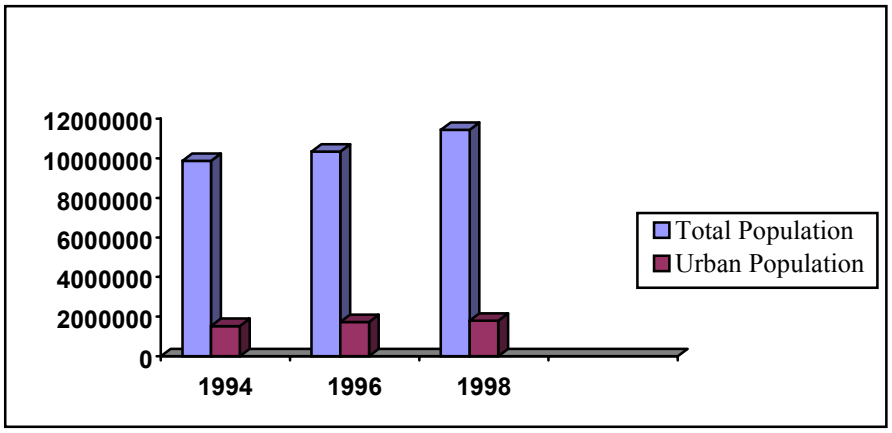


Figure 2.2: Trend in Population Growth from 1994 to 1998

Poverty is a serious social problem in Cambodia. Approximately 40%, 39% and 36% of the population, respectively in 1990, 1994 and 1998, lived below the poverty line. In 1998, the incidence of poverty was lowest in the capital (11%) followed by other urban areas (30%) and rural areas (40%).

Cambodia has a very young demographic profile as a result of the combination of the heavy death toll of the 1975-78 Khmer Rouge's period and the baby boom of the early 80's. About

42.8% of the population is between 0-14 years of age; and the female population accounts for 52% of the total, the highest among the 10 countries of the region.

Khmer constitute the principal ethnic group, with non-Khmer ethnic groups, e.g. Vietnamese, Chinese, Cham (Cambodian Muslims) and 12 minority tribes, constituting the remainder of the population.

II.4 Human Health

Since Cambodia is tropical, the direct impact of the climate on human health is significant. Malaria and dengue fever are the two most important mosquito-borne diseases, which are found in Cambodia. Malaria remains one of the most serious health problems in the country with 500,000 estimated cases and 5,000 to 10,000 estimated deaths per year. Most of the malaria occurs in non-immune patients in remote areas, especially in forest fringes and forested areas. Dengue fever has become an increasingly important cause of childhood morbidity and mortality. In 1990, more than 7,000 cases and 340 deaths from dengue fever were recorded.

II.5 Political and Decision-Making Structure

The end of the Cold War allowed the Peace Accords to take place in Paris in October 1991, putting an end to over three decades of fighting. Cambodia was temporarily placed under the control of the United Nations Transitional Authority for Cambodia (UNTAC), with the mission of preparing and organizing a fair and free election in 1993. After this election, Cambodia adopted a new constitution. The monarchy was re-introduced and Cambodia became a constitutional monarchy (the King is the Head of State who reigns but does not govern). The country has a democratic multi-party system. After the election, the National Assembly proposes the candidate for nomination for the post of Prime Minister (PM) to the King. The PM is the head of the government.

Up to 1998, the parliament was composed of a National Assembly, whose members were elected through the election process, using the proportional representation system at provincial and city levels. After the 1998 election, Cambodia adopted a *two-house system*, with the National Assembly as the Lower House, and the newly established Senate as the Upper House.

II.6 Natural Resources

Cambodia's natural resources wealth lies in the rivers and lakes, the terrestrial and inundated forests, the inland and coastal fisheries, pockets of volcanic soils and gem stones. The latter, the sapphire-ruby-zircon gems of Pailin, are being heavily exploited. There are also deposits of fossil fuels (coal and offshore gas and oil) but further studies are needed to evaluate reserves worth developing. Raw materials for construction, e.g. basalt, granites, limestone, dolomite, and quartzites, are available in Cambodia. The country also has phosphate deposits suitable for the production of phosphate fertilizer.

II.7 Water Resources

Cambodia is rich in water resources, with the Mekong River and the Tonle Sap system dominating the hydrology. The Mekong, which is the twelfth longest river in the world, flows from the Tibetan Plateau in China through Myanmar, Thailand and Laos, south through east and southeastern Cambodia into Vietnam where it flows into the South China Sea. Three tributaries,

the Sesan, Sekong and Srepok, join the Mekong soon after it enters northeastern Cambodia and contribute 10-20% of the total annual flow of the Mekong. At Phnom Penh, the river divides into three branches, the Tonle Sap River, the Bassac River and Lower Mekong River. The Tonle Sap River connects the Mekong to the Tonle Sap Lake, the largest permanent freshwater lake in Southeast Asia.

The Tonle Sap-Mekong river system has a unique hydrological feature. Each year during the wet season the Tonle Sap river reverses its course allowing the floodwaters of the Mekong to flow into the lake. The lake surface is reported to range from 2,700 km^2 during the dry season to approximately 16,000 km^2 at the maximum level of flooding. The Tonle Sap Lake is rich in fish and other aquatic life. The flood waters of the Tonle Sap, the Mekong and tributaries provide irrigation for farming and create the moist land that is needed for growing rice and other crops. Water transport is extremely important for the movement of people and freight.

In the rural areas of Cambodia, people traditionally use rivers, lakes, ponds and shallow dug wells for their domestic water needs. In the rainy season, people mainly use rainwater for drinking and cooking. Access to clean water supply for drinking water varies significantly throughout the country. In 1997, it was reported that across all the regions of the country, about 5.7 million people in rural areas lack access to clean water. In urban areas, water is also taken from surface sources. For example, in Phnom Penh city, water is taken from the Mekong, the Bassac and the Tonle Sap rivers and is treated by three water treatment plants, which have a production capacity of 75,000 m^3/day.

II.8 Forests

Forests make up a major part of the country's natural resource base. Hill evergreen, tropical rain and dry land evergreen forests are found in the humid coastal ranges, humid northeastern uplands, and the very humid to sub-humid low altitude areas. The dry *Dipterocarp* forests are widespread east of the Mekong River and North of the Great Lake at altitudes below 500 meters. Mangrove forests are found along the coasts of Kampot and Koh Kong provinces. Freshwater inundated forests are found in the Tonle Sap Lake and in areas of the Mekong.

Kirirom National Park, one of 23 protected areas in Cambodia

In 1960 Cambodia's forests covered 73% of the total land area of the country. According to the World Bank report dated January 8, 1999, the forest cover, for the year 1997/98, had decreased to 58% of the total land area. The reduction has been attributed mainly to commercial logging and agricultural encroachment. The annual deforestation rate between 1993-97 is estimated at 140,000-175,000 ha. The 1994 production of logs was estimated at 1.5 million m^3. The annual fuelwood extraction is estimated at 6 million m^3 of which 50% are from forests.

The Royal Government of Cambodia has made considerable efforts to protect and use the country's forest resources in a sustainable manner and to maintain the stability of forest biodiversity. Of the total forestland, 31% lies within protected areas, 60% has been allocated as forest concessions, and 9% is unallocated. A new Forest Law is currently under development.

II.9 Biodiversity

Cambodia has a rich biodiversity. The forests, wetlands and other habitats support many species of flora and fauna, including 130 species of mammals, more than 600 species of birds, more than 2,300 vascular plants and an unknown number of reptiles and amphibians.

The forest ecosystems are biologically rich. The World Conservation Monitoring Centre estimates that 15,000 different species of plants, nine percent of which are endemic, exist in Cambodia. Tree species include *Dipterocarpacaeae, Leguminosae, Lythraceae,* and *Fagaceae* families. The Tonle Sap lake and its floodplain support a rich diversity of plants and animals that have adapted to seasonal fluctuations. As many as 850 species of fish have been recorded in the Tonle Sap lake and Mekong river. The marine waters contain coral reefs, sea-grass beds, 435 species of fish and marine mammals such as dolphins. The coastal wetlands are also a diverse ecosystem and are reported to contain at least 74 tree species.

Species of mammals, which were present in Cambodia in the past, but are now believed to be extinct or critically endangered, include the Kouprey (*Bos sauveli*) and Asian rhinoceros. Other mammals, which are vulnerable or rare now, are the Banteng, brown-antlered deer, Gaur, pygmy loris and sunbear. Birds that are now endangered include the greater adjutant stork and the sarus crane.

An Angkor Wat wall carving depicting the rich biodiversity of Tonle Sap lake

II.10 Agriculture

The agriculture sector provides direct employment to approximately 80% of the labor force. Eighty five percent of the population depends directly on agriculture and the related sub-sectors of fisheries and forestry. Cambodia's land area used for agricultural purposes increased from 3,785,000 ha in 1990 to 4,079,464 in 1994 and continues to increase as more forest is converted for agriculture and land formerly inaccessible from the war is de-mined. Of this total, more than 50% was covered by cropland. The cultivated areas are concentrated in the lowlands around the Tonle Sap Lake and the Mekong River, and in the southern region of the country.

Rice field in Kampong Cham province

Rice, the staple food of the population, accounts for the majority of the cropping area. The total land for rice production in 1990 was approximately 1.9 million hectares. Rain-fed lowland rice production accounts for approximately 86% of the total rice area, divided between short, medium and long duration varieties. Economically, maize, soybeans, mungbeans, sweet potato, cassava, and sesame have been the most important non-rice crops in the 1990s. Livestock production is also an important agricultural activity with cattle comprising 85% of agricultural draft power. Most rural families raise pigs and poultry.

II.11 Energy

According to the World Development Index (World Bank, 1998), Cambodia uses relatively little commercial energy per person: 44 kg of oil equivalent per capita for 1994. Cambodia imports 100% of the required petroleum products from countries in the region. Petroleum products are the main source of commercial energy for power generation, industry, transport, and the residential and commercial sectors. Petroleum products imported into Cambodia for 1994 were estimated to be 415.67 kt, of which 2.5% was lubricant. The main petroleum products used in the country are LPG, gasoline, diesel oil, fuel oil, kerosene and jet fuel. The consumption of petroleum products for each sector are: 107.6 kt for power generation (27%), 2.12 kt for industry, 262.25 kt for transport (65%), 26.2 kt for residential sector, 8.56 kt for commercial sector, and 8.89 kt for other non-energy use.

Woodfuel and other biomass are the major energy sources for cooking for Cambodian people, especially in rural areas. It was estimated that, in 1994, indigenous and renewable biomass energy covered over 85% of the total national energy supply. Cambodian biomass includes firewood and charcoal. Table 2.2 below shows the trend of energy demand from 1994 to 2010.

Woodfuel is the major source of energy for cooking in Cambodia

There is one small hydropower plant, O Chum II, in Ratanakiri province with a capacity of 1 MW. The generation data were given as 1,145 MWh in 1994 and 1,450 MWh in 1995. Cambodia has a high hydropower potential for electricity generation and/or for irrigation. As of this date, due to decades of war, electricity from hydropower sources is still very insignificant.

Table 2.2: National Energy Demand from 1994 to 2010 (TJ)

Type of Fuel	1994	2000	2005	2010
Wood	77,721	89,616	103,552	106,344
Charcoal	1,097	1,213	1,367	1,357
Other biomass	1,754	1,600	1,559	1,351
LPG	103	421	729	1,050
Gasoline	6,006	10,765	15,288	20,284
Kerosene	1,323	1,678	2,081	2,430
Jet fuel	725	881	1,125	1,435
Diesel oil	4,580	7,521	10,539	14,783
Fuel oil	65	102	158	249
Electricity	777	1,308	2,066	2,962
Total	**94,151**	**115,105**	**138,464**	**152,245**

Source: Asian Development Bank TA 2241-CAM, October 1996, *Strengthening the Institutional and Legal Framework for the Energy and Minerals Sectors Project*. Final Report.

Solar energy for decentralized utilization in remote rural zones has been developing over the last few years. However, its development remains limited due to high investment costs.

II.12 Economy

Cambodia, a developing country, began its conversion to a free market economy in 1989. The per capita income increased from US$130 in 1990 to US$241 in 1994. The Gross Domestic Product (GDP) in 1990 was US$1,115 million and US$2,385 million in 1994. Between 1991 and 1995, Cambodia recorded an average growth rate of 6 % per annum.

The country's economy is strongly dependent on natural resources and agriculture for generating employment, income and foreign exchange. Thanks to its rich historical sites, such as the prestigious Angkor complex, Cambodia has a high potential for the development of a tourist

industry. The dominant sectors and their contribution to GDP in 1990 and 1994 are shown in Table 2.3.

Table 2.3: Shares of GDP by Origin, at 1989 Constant Prices (%)

Sector	1990 (%)	1994 (%)
1. Agriculture	***51.5***	***45.2***
Crops and rubber:		23.4
- Rice		12.7
- Other crops and rubber		10.7
Livestock		13.0
Fishery		3.9
Forestry		4.9
2. Industry	***11.6***	***18.3***
Mining and quarrying		1.2
Manufacturing		7.3
Water and electricity		0.2
Construction		9.6
3. Services	***36.9***	***36.5***
Transportation/communication		3.2
Wholesale and retail trade		14.7
Tourism and hotel/restaurant		0.6
Government/administration/education and health		4.1
Home ownership		6.7
Other services (*or informal services*)		7.3
Gross Domestic Product	100.0	100.0

The country also has many opportunities for expanding the production of rubber, its prime cash and export crop, as well as subsidiary food and commercial crops (principally maize, soybean, green bean, groundnut, jute and cotton).

II.13 Trade

Since the 1993 UNTAC sponsored election, Cambodia has increased trade with Asian and European countries as well as with the United States of America. Cambodia qualifies for the World Trade Organization (WTO) Generalized System of Preferences (GSP) and has been granted GSP by many countries, including the European Union, North America, Japan, Scandinavia, Australia and New Zealand. Despite its very small base, Cambodian domestic exports (mainly timber, garments, rubber, corn, soybean, fish) grew by a commendable 56% in 1995, although it fell short of the 66% growth achieved in 1994. Main imports are oil products, vehicles, construction materials and equipment, fabrics, etc. In 1994, exported goods were 12.4% of GDP and imported goods were 22.3% of GDP.

III. NATIONAL GREENHOUSE GAS INVENTORY FOR 1994

III.1 Introduction

As a signatory to the UNFCCC, Cambodia is obliged to undertake its national GHG inventory in accordance with Article 4.1.a of the Convention. The GHG inventory is one of three major components of the project; the other two being GHG abatement analysis and vulnerability and adaptation assessment components. This is the first-ever GHG inventory in Cambodia and covers five sectors: (i) energy, (ii) industry, (iii) agriculture, (iv) waste, and (v) land use change and forestry (LUCF). The inventory was carried out by the National Technical Committee (NTC), members of which are representatives from the Ministry of Environment; Ministry of Agriculture, Forestry and Fisheries; Ministry of Public Works and Transport; Ministry of Water Resources and Meteorology; Ministry of Industry, Mines and Energy; and Royal University of Phnom Penh.

The objectives of the inventory are: (i) to quantify anthropogenic emissions by sources and removal by sinks of major GHGs, and (ii) to build national capacity to fulfill the country's commitments under the UNFCCC. This inventory allows Cambodia not only to better estimate the various emissions but also to focus on a more climate sensitive development programme, which entails the formulation of mitigation and vulnerability and adaptation policies.

III.2 Methodology

For Cambodia, as a developing country (a Non-Annex I party to the UNFCCC), it is mandatory that the national GHG inventory covers three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). However, in this first national GHG inventory, other gases such as carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and non-methane volatile organic compound (NMVOC) were also considered whenever data were available. Following the recommendation of UNFCCC Secretariat, the Cambodian National GHG inventory was developed using the 1996 revised IPCC methodology with the base year of 1994. Each of the GHGs has different contributions to the total greenhouse effect, which can be expressed as global warming potential (GWP). The GWP is expressed in tonnes (or units) of CO_2 equivalent (CO_2-eqv.) emissions per tonne (or unit) of GHG emissions. Methane (CH_4) has 21 tonnes of CO_2-eqv. per tonne of methane emitted. Nitrous oxide (N_2O) has 310 tonnes of CO_2-eqv. per tonne of N_2O emitted. The methane and nitrous oxide emissions were converted to tonnes of CO_2-eqv. by multiplying the methane emissions by 21 and the tonnes of nitrous oxide emission by 310.

The basic approach for calculating emissions of a particular gas from a particular sector is based on the following equation:

Emission = Activity Data x Emission Factor

In some cases, activity data needed for developing the inventory for a certain sector were not available. In such cases, the data were estimated from related available data by using several assumptions and these are referred to in this study. In other cases, some activity data were available in the reporting format of the concerned governmental institutions and NGOs/IOs, however, some uncertainties still exist due to the current weak data management in most line ministries. Local emission factors were also not available. In most cases, the emission factors used for the analysis were IPCC default values or emission factors developed by regional

countries such as Thailand, Philippines or Indonesia. The Philippines[3] Reference Manual for National GHG Inventory was also adapted for use in Cambodia.

III.3 Emissions of Greenhouse Gases

In 1994, Cambodia emitted approximately 46,536 Gg of CO_2, 445 Gg of CH_4, 12 Gg of N_2O, 38 Gg of NO_x, 1,207 Gg of CO, 58 Gg of NMVOC and 26 Gg of SO_2, and removed approximately 64,850 Gg of CO_2 (Table 3.1). Therefore, in 1994 Cambodia was a net sink country. The overall assessment of Cambodia's contribution to greenhouse gas emissions using Global Warming Potential showed that Cambodia could offset approximately 5,142 Gg of CO_2-eqv. of global GHG emissions (Table 3.1).

Emissions and removals of CO_2 in Cambodia are primarily from land use change and forestry sector. Of the 46,536 Gg of CO_2 emitted from all sectors, approximately 97% were emitted by the LUCF sector. Most of the CH_4 and N_2O emissions were from the agriculture sector (Table 3.1). CO_2 accounted for 74% of all the GHGs emitted in 1994, while methane and nitrous oxide contributed approximately 18 and 8%, respectively (Figure 3.1a). By sector, LUCF was responsible for approximately 79% of the GHG emissions, while agriculture and energy contributed to approximately 18 and 3%, respectively (Figure 3.1b).

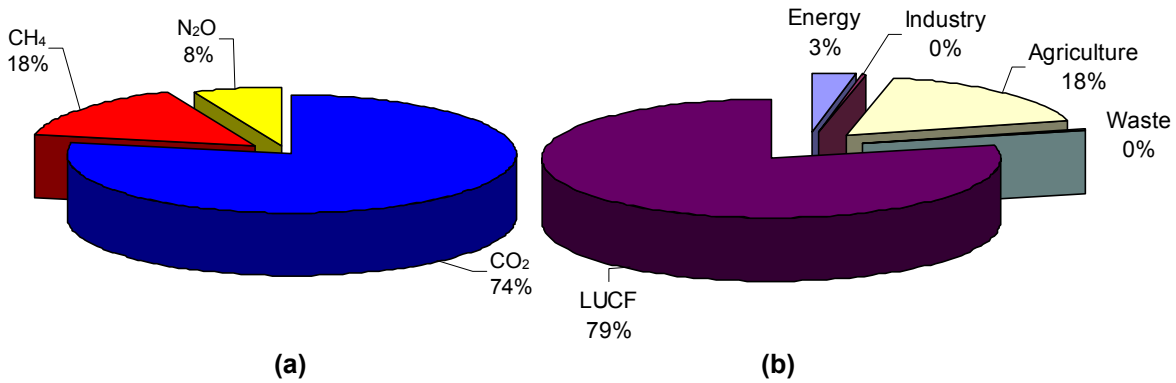


Figure 3.1: (a) 1994 Percentage Share of the Three Main GHGs and (b) Total CO_2 Equivalent Emissions by Sectors

[3] In the process of GHG calculation, Cambodia adapted the Philippines software as it has already been simplified from the IPCC methodology.

Table 3.1: Summary of 1994 Greenhouse Gas Inventory of Cambodia (Gg)

Sector and Source Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
I. ENERGY							
A. Fuel Combustion Activities							25.63
1. Energy industries	331.31	0.02	0.00	0.91	0.07	0.02	
2. Manufacturing industries	6.53	0.00	0.00	0.02	0.00	0.00	
3. Transport	825.25	0.14	0.01	7.55	52.54	9.93	
4. Commercial/service	26.50	0.00	0.00	0.04	0.01	0.00	
5. Residential	82.49	0.01	0.00	0.12	0.02	0.01	
B. Biomass emissions*	7,773.54	23.96	0.32	8.06	403.91	47.58	
SUB TOTAL (A+B)	1,272.08	24.13	0.33	16.69	456.56	57.54	25.63
CO_2 EQUIVALENT	1,272.08	506.82	102.44				
TOTAL CO_2 EQUIVALENT	**1,881.35**						
II. INDUSTRY							
A. Cement	49.85						0.03
B. Food and beverages						0.02	
C. Pulp and paper				0.01	0.03	0.22	0.03
SUB TOTAL (A+B+C)	49.85	0.00	0.00	0.01	0.03	0.24	0.06
CO_2 EQUIVALENT	49.85	0.00	0.00				
TOTAL CO_2 EQUIVALENT	**49.85**						
III. AGRICULTURE							
A. Domestic livestock		184.79	3,88				
B. Rice cultivation		150.40					
C. Grassland burning		1.98	0.02	0.88	51.90		
D. Agricultural residue burning		2.09	0.05	1.81	43.86		
E. Agricultural soils			7.13				
SUB TOTAL (A+B+C+D+E)		339.25	11.08	2.70	95.76		
CO_2 EQUIVALENT		7,124.26	3435.89				
TOTAL CO_2 EQUIVALENT	**10,560.15**						
IV. WASTE							
A. Solid wastes		5.90					
B. Domestic/commercial Wastewater		0.66					
C. Industrial wastewater		0.21					
D. Human sewage			0.42				
SUB TOTAL (A+B+C+D)		6.77	0.42				
CO_2 EQUIVALENT		142.23	131.16				
TOTAL CO_2 EQUIVALENT	**273.39**						
V. LAND USE CHANGE AND FORESTRY							
A. Change in forest/woody biomass	-64,850.23						
B. Forest/land use change	45,214.27	74.77	0.51	18.58	654.20		
SUB TOTAL (A+B)	-19,635.96	74.77	0.51	18.58	654.20		
CO_2 EQUIVALENT	-19,635.96	1,570.08	159.34				
TOTAL CO_2 EQUIVALENT	**-17,906.54**						
TOTAL NAT'L GHG EMISSIONS	**-18,314.03**	444.92	12.35	37.97	1,206.54	57.78	25.69
EQUIVALENT CO_2	**-18,314.03**	9,343.39	3,828.85				
TOTAL NAT'L CO_2-eqv. UPTAKE	**-5,141.79**						

*CO_2 emissions from biomass are not included in the total (IPCC).

The inventory of greenhouse gases has been categorized according to source and sinks in the following sectors: 1) energy; 2) industrial processes; 3) agriculture; 4) waste, and 5) land use change and forestry.

The methods and results of the inventory relating to each sector and its associated sub-sectors are discussed in the section below.

III.4 Energy

In general, fuel combustion and production activities involving oil, natural gas and coal are the major sources of GHG emissions from the energy sector. CO_2 is produced when carbon-based fuels are burned. The GHGs emitted from fossil fuel production activities such as coal mining, production and processing of oil and gas products are minimal in comparison with fuel combustion activities and are considered as fugitive emissions. In the case of Cambodia, the major source of GHG emissions in the energy sector are from fuel combustion, as there are no oil production activities and all oil products are imported.

III.4.1 Fuel Combustion Activities

In 1994, Cambodia used 2,352 ktoe of energy. Of this value, biomass accounts for 82% and the balance came from petroleum fuels. Cambodia does not have fossil fuel production or processing activities. Therefore, the fugitive emissions are very minimal and not accounted for in this GHG calculation.

In 1994, GHG emissions from fuel combustion activities were estimated at 1,881 Gg of CO_2 equivalent (Table 3.2). The biggest share of GHG emissions from the energy sector was emitted by the transport sub-sector, which accounted for 44%. The residential sub-sector accounted for 36% of energy sector emissions, mainly due to CH_4 emissions from fuel wood combustion, and the energy industries accounted for 18%. Manufacturing and commercial sub-sectors accounted for approximately 2% of the total emissions from this sector. By gases, CO_2 is the dominant gas emitted in combustion activities, followed by carbon monoxide, NMVOC, CH_4, NO_x, N_2O, and SO_2 (Table 3.3).

Table 3.2: Total CO_2-Equivalent Emissions from Fuel Combustion Activities (Gg)

Sub-Sector	Total Emissions	Percent Share
Energy industries	332	17.7
Residential	683	36.3
Manufacturing industries	7	0.4
Transport	831	44.1
Commercial	28	1.5
Total	**1,881**	**100**

Table 3.3: GHG Emissions from Fuel Combustion Activities (Gg)

Greenhouse Gas Source Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Energy	**1,272.08**	**24.13**	**0.33**	**16.69**	**456.56**	**57.54**	**25.63**
A. Fuel combustion activities (sectoral approach)							
1. *Energy industries*	**331.31**	**0.01**	**0.00**	**0.91**	**0.07**	**0.02**	**0.00**
a. Public Electricity and heat production	331.31	0.01	0.00	0.91	0.07	0.02	
2. *Manufacturing industries and construction*	**6.53**	**0.01**	**0.00**	**0.06**	**0.79**	**0.02**	
3. *Transport*	**825.25**	**0.14**	**0.01**	**7.55**	**52.54**	**9.93**	**0.00**
a. Civil aviation	51.32	0.00	0.00	0.22	0.07	0.04	
b. Road transportation	727.59	0.14	0.01	6.95	52.21	9.84	
c. Railways	2.85	0.00	0.00	0.05	0.04	0.01	
d. Navigation	16.16	0.00	0.00	0.33	0.22	0.04	
e. Others	27.34						
4. *Other sectors*	**108.99**	**23.96**	**0.32**	**8.17**	**403.15**	**47.57**	**25.63**
a. Commercial	26.50	0.04	0.00	0.06	1.17	0.02	
b. Residential	82.49	23.92	0.32	8.12	401.99	47.55	

Note: There is a discrepancy between the "official" and "unofficial" figures for fossil fuels consumption. According to the press report from the interviews with an international oil company in Phnom Penh, it is estimated that around 100,000 metric tonnes of petroleum fuels are uncontrollably imported into Cambodia each year. This would imply an under-estimation of the CO_2 emissions of the order of 20 to 25%.

III.4.2 Traditional Biomass Fuels

Biomass fuels are the main source of energy for over 90% of Cambodian households. Cambodia's biomass fuels are divided into firewood, charcoal, dung, and other biomass (including agricultural residue). Biomass is the cheapest and most accessible source of energy used for cooking. According to the IPCC guidelines, CO_2 emissions from biomass used as fuels are excluded from the total CO_2 emission figure. This is true as long as there is a good biomass resource management, because biomass growth reabsorbs CO_2. It is therefore assumed that any CO_2 emissions from burning biomass are reabsorbed during plant growth. However, in order to assess the direction of the "net flux" of CO_2 emissions (a balance between emission and absorption), CO_2 emissions from biomass is included in the land-use change and forestry section. Non-CO_2 emissions (such as CH_4 and N_2O) are included since they are not reabsorbed by plant growth. This study indicated that carbon monoxide was the main gas emitted from traditional biomass burning activities (Table 3.4).

Table 3.4: Non-CO_2 Emissions from Biomass Burning (Gg)

Biomass	CH_4	N_2O	NOx	CO
Wood/wood waste	23.22	0.31	7.77	387.50
Charcoal	0.22	0.00	0.00	7.64
Other biomass	0.53	0.01	0.01	0.53
Total	**23.97**	**0.32**	**7.78**	**395.67**

III.5 Industrial Processes

Industrial emissions arise directly from industrial processes associated with manufacturing cement and food processing and are not due to the fuel consumption of these industries, which are already accounted for in the energy sector. The amount of CO_2 emitted from industrial processes is estimated to be approximately 50 Gg and all comes from the Cambodia's only

cement factory (Table 3.5). Up to 1994 there were very few factories in Cambodia and as a result the only industries taken into account for the calculation of GHG emissions were food processing and the cement factory.

Data used in the assessment was obtained from the records of the Ministry of Industry, Mines and Energy and from selected factories. For example, for the cement factory, the emissions were determined using balanced chemical equations of the resources transformation process.

III.5.1 Cement Manufacturing

Carbon dioxide is produced during the production of clinker, an intermediate product from which cement is made. However, clinker statistics were not available in Cambodia and, as a result, cement production statistics were used. This does not compromise the accuracy of the emission estimates since there is a direct relationship between cement production and clinker production. Studies in most countries have indicated that the difference in emission estimates using clinker or cement data is very small.

III.5.2 Sugar Manufacturing and Beer Brewing

In Cambodia, sugar is produced from sugar palm juice at a household level. The process involves evaporating water by burning wood fuel. The energy consumption in this process is reported in the energy sector. GHG emissions are also produced during the microbial fermentation process in the production of beer, wines and spirits. However, these activities are assumed to give zero net CO_2 emissions since the CO_2 emitted is assumed to be reabsorbed during crop growth.

Table 3.5: GHG Emissions from Industrial Processes (Gg)

Greenhouse Gas Source	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
A. Mineral products	**49.85**			**0.00**	**0.00**	**0.00**	**0.03**
1. Cement production	49.85						0.03
B. Other production	**0.00**			**0.01**	**0.03**	**0.24**	**0.03**
1. Pulp and paper				0.01	0.03	0.02	0.03
2. Food and drink						0.22	
Total industrial processes	**49.85**	**0.00**	**0.00**	**0.01**	**0.03**	**0.24**	**0.06**

III.6 Agriculture

Agriculture is the most important sector of the Cambodian economy in terms of national GDP contribution and livelihood dependency. The GHG emissions from this sector come from various sub-sectors such as domestic livestock, rice cultivation, agricultural soil, etc. The net CO_2 is assumed to be zero since it will be reabsorbed in the next growing season.

Three classes of animals are covered in this section, i.e. ruminants, pseudo-ruminant animals and mono-gastric animals. Horses are pseudo-ruminants and swine are mono-gastric animals. For the GHG inventory, the IPCC 1996 recommends the use of three-year average data centered on the inventory year, if available. This minimizes whatever biases may arise in case the inventory year is an exceptional year not representative of the country's normal agricultural activity level.

The estimation of GHG emissions from prescribed burning of savannas is included in the Agriculture Sector of the Revised 1996 IPCC Guidelines. The term ***savanna*** refers to tropical and subtropical vegetative formations with grass coverage occasionally interrupted by some

shrubs and small trees. Savanna, however, does not appear on the Cambodian inventory of vegetative coverage, primarily because the term is not widely used by local foresters. Statistics on savanna land area - and the fraction burnt annually- therefore are not readily available. For this reason, we adopt the Philippines definition: ***Cambodian grassland***, which more or less resembles a typical savanna in terms of vegetative cover.

There is, however, no established method of estimating emissions from grassland burning; so the original working equation for savanna burning has been retained and adopted. To avoid double counting of emissions, grassland burning is reported here in the agricultural sector and not under the LUCF sector.

Burning has become a common agricultural practice especially in developing countries. Most farmers resort to burning as a means of disposing of agricultural waste such as crop residues. Among all the agricultural activities, it is perhaps the most obvious source of greenhouse gases. The burning of vegetative biomass is not treated by the Revised 1996 IPCC Guidelines as a net source of CO_2 because of the assumption that the CO_2 released from burning will be reabsorbed eventually during the next growing season. It may, however, be a significant source of non-CO_2 trace GHG such as CH_4 and N_2O, and the GHG precursor gases such as CO and NO_x. Emissions of these gases are discussed below.

A nitrogen-to-carbon ratio is applied to estimate total emitted nitrogen. Several ratios of total carbon to total nitrogen are then applied to approximate the release of non-CO_2 trace gases and GHG precursors. Field burning of crop residues is not monitored by any agency in Cambodia. The practice of burning crop residues supposedly varies from region to region and from farmer to farmer. Burning of crop residues for purposes other than the disposal and reduction of the volume of agricultural waste is not covered in this study. Emissions from crop residues removed from fields and burned for fuel are reported in the energy sector.

The GHG contribution from agricultural activities comprises a significant portion of the annual GHG emissions as expected in a country where agriculture is the major livelihood for 85% of the population (Table 3.6). In 1994, excluding the land use change and forestry sector which has a high CO_2 uptake by the forestry sub-sector, Cambodian agriculture was estimated to produce over 80% of the overall national equivalent CO_2 emissions (10,560 Gg of the total 12,764.74 Gg of CO2-eqv.). The contribution of domestic livestock to the total emissions of this sector was 48%, followed by rice cultivation and agricultural soils (Table 3.7). A trace amount of CH_4, N_2O, and precursors are emitted from grassland and agricultural burning.

Table 3.6: GHG Emissions from Agriculture Sector (Gg)

Greenhouse Gas Source Categories	CH_4	N_2O	NO_X	CO	NMVOC
Total Agriculture	**339.25**	**11.08**	**2.70**	**95.76**	**0.00**
A. Enteric fermentation	**162.75**				
1. Non-dairy cattle	116.25				
2. Buffalo	44.11				
3. Horse	0.38				
4. Swine	2.01				
5. Poultry					
B. Manure management	**22.04**	**3.88**			
1. Non-dairy cattle	5.28				
2. Buffalo	2.41				
3. Horse	0.05				
4. Swine	14.08				
5. Poultry	0.23				
6. Solid system and dry lot		3.86			
7. Liquid system		0.02			
C. Rice cultivation	**150.40**	**0.00**			
1. Irrigated	46.73				
2. Rainfed	103.67				
D. Agricultural soils		**7.13**			
E. Grassland burning	**1.98**	**0.02**	**0.88**	**51.90**	
F. Agricultural residue burning	**2.09**	**0.05**	**1.81**	**43.86**	
1. Rice					
2. Sugarcane					
3. Corn					

Table 3.7: Summary of GHG and Precursors Emissions from Agriculture (Gg)

Source	Emission Type				CO_2-eqv.	Percent Share
	CH_4	N_2O	NOx	CO		
Domestic livestock	184.8	3.9			5,084	48.1
Rice cultivation	150.4				3,158	29.9
Grassland burning	2.0	0.0	0.9	51.9	49	0.5
Agricultural residue burning	2.1	0.1	1.8	43.9	59	0.6
Agricultural soil		7.1			2,209	20.9
Total	339.3	11.1	2.7	95.8		
Total CO_2-eqv.					10,560	100.0

III.7 Waste

Since Cambodia is a developing country, which does not yet have adequate statistics, the IPCC Guidelines for the calculations of emissions have also been used for the waste sector. Most data on waste were obtained from the Ministry of Environment, Ministry of Planning, and FAO. The urban population is the basis of computation of GHG emissions from three sub-sectors: solid waste, domestic wastewater, and human sewage. Due to the lack of data on solid waste generation in 1994, it was assumed that there is a relationship between municipal waste generation rate and the Gross Domestic Product (GDP) growth rate. The 1998 waste generation per capita was extrapolated to the 1994 value. 1999 figures concerning the amount of wastewater and the COD load were used for industrial wastewater as there was also a lack of data for 1994.

As a non-industrial country, the emissions from this sub-sector, on a CO_2-eqv. basis, are negligible, i.e. 273 Gg (less than 1% of the total national emissions; see Figure 3.1b). Within this

sector, human sewage and solid waste contributed to more than 90% of the total emissions, while domestic and industrial wastewater only contributed to approximately 7% (Table 3.8).

Table 3.8: Summary of GHG Emissions from Waste by Gases (Gg)

Sub Sector	CH_4	N_2O	CO_2-eqv.	Percent Share
Solid wastes	5.90		123.96	45.3
Domestic wastewater	0.66		13.80	5.1
Industrial wastewater	0.21		4.47	1.6
Human sewage		0.42	131.16	48.0
Total			**273.39**	**100.0**

III.8 Land Use Change and Forestry

Due to the existing problem of data availability, GHG emissions or uptake from biomass re-growth on abandoned lands and from soil carbon are not taken into account in this inventory. Thus, the inventory of GHG sources and sinks for the LUCF sector accounts mainly for the influence of net annual bio-mass growth and of land use/forest conversion practices that usually involve bio-mass burning and decay. The categories do not include other biomass types that have the potential for carbon sequestration such as grasslands, forest plantations, and agro-forestry farms.

The annual loss of above ground biomass is determined by first calculating the amount of land area that was cleared on the inventory year, e.g. 1994. IPCC (1996) however clarifies that the term "inventory year" need not refer to the actual data for a single year.

Determining the final outcome of land conversion requires information on the patterns and causes of deforestation. Logging and the conversion of forest lands into swidden agriculture are the most significant causes of forest conversion. And in the course of conversion of forest to agriculture lands, it is estimated that 80-90% of the above ground biomass is either directly burnt during conversion or is used as firewood.

CO_2 emissions from forests and other types of vegetative matter can be zero if there is a balance between reduction and regeneration. Standing forests act as carbon reservoirs and growing forests as carbon sinks. However, cleared vegetation might be burnt on or off-site, usable logs might be carried out and the remains allowed to decay over time. In the absence of a balance, a net flux of GHG into the atmosphere would occur if biomass burning is more significant than growing. Estimation of emissions from this sector covers both forest/woody biomass and forest/land use. Emissions from abandonment of managed lands were not estimated because of insufficient data.

III.8.1 CO_2 Uptake due to Managed Forests (Biomass Growth)

In Cambodia, the largest changes that occur in forests are in woody biomass stocks. These changes determine their GHG sequestration capacity. Natural forests are carbon reservoirs but commercial forests, re-growing secondary forests and other growing woody biomass constitute a significant carbon sink.

The main components of Cambodia's forests are: forest (evergreen, mixed and coniferous, etc.), plantation, shrub land, grassland and bamboo. The changing woody biomass stocks, which take place in these forests, vary between 0.5 tdm/ha for grassland to 9.0 tdm/ha for plantation (80% is rubber) annually. State forests and national parks under protected areas can be considered to be carbon reservoirs. Estimates of national woody covers were from the Department of Forestry and

Wildlife (DFW) of the MAFF. The IPCC default value concerning the dry matter content (of 0.5) is used to make an estimation of total carbon increment for each woody biomass. These are converted into sinks for CO_2. It is estimated that the biomass growth absorbed 73,122 Gg of CO_2 (Table 3.9) in 1994.

III.8.2 GHG Emissions

Biomass Removals. Biomass removals represent the emissions from commercial harvesting of wood for timber and for other applications (round wood harvests). In this inventory, biomass removal through illegal logging was excluded, since no official data were available for this. It is, however, important to note that if some of the assumptions used in the LUCF sector in particular were changed, the country's GHG emission status may change considerably.

Forest Conversion. Deforestation in the broader sense of the word, including reductions in tree density and cover, has been widespread in Cambodia. The maximum estimation of annual loss of natural forests provided by World Bank (1993-1997) was 140,000-175,000 ha and the minimum 38,000-77,000 ha. Forest loss was mainly due to logging activities, conversion of forest areas for agricultural purposes, etc. MAFF has reported that between 92/93-96/97 approximately 50% of agriculture land was developed on shrub land and therefore shrub land has been considered as one of land categories under forest conversion.

GHG Emissions. GHG emissions from LUCF come from commercial harvesting of wood for timber and for other applications (fuel wood consumption) and forest conversion. CO_2 emissions due to wood harvesting and wood uses (such as firewood and charcoal) amounted to approximately 8,272 Gg, while those from forest conversion were 45,214 Gg (Table 3.9).

Table 3.9: GHG Emissions and CO_2 Removals by LUCF Sector in 1994 (Gg)

Greenhouse Gas Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO
A. Changes in forest and other woody biomass stocks						
1. Biomass growth		-73,122				
2. Roundwood harvest	8,272					
B. Forest/land use change						
1. On-site burning	17,134		74.77	0.51	18.58	654.20
2. Off-site burning	4,283					
3. Biomass decay	23,797					
Total land use change and forestry	**53,486**	**-73,122**	**74.77**	**0.51**	**18.58**	**654.20**

As it was mentioned above, LUCF sector is responsible for most of the carbon emissions and removals in Cambodia. Overall assessment has indicated that LUCF contributed 79% of the total CO_2 equivalent emissions. However, the capacity of LUCF to absorb CO_2 is much higher than the emissions, therefore this sector was able to offset all 1994 GHG emissions from other sectors (energy and agriculture).

III.9 Comparison of Cambodia's GHG Emissions with Selected Countries

The overall assessment of Cambodia's contribution to greenhouse gas emissions using Global Warming Potential showed that Cambodia could offset approximately 5,142 Gg of CO_2-eqv. of global GHG emissions. Table 3.10 shows how Cambodia fared in its offset when compared with some selected countries and the world.

Table 3.10: GHG Emissions of Cambodia and Selected Countries

Countries	Year	GHG Emissions (million tonnes)	Net GHG Emissions (million tonnes)
Cambodia	1994	**67.9**	**-5.14**
Philippines	1994	100.8	100.7
Malaysia	1994	144.0	75.6
Republic of Kazakhstan	1994	219.2	212.6
Thailand	1994	324.9	286.4
Indonesia	1994	902.1	498.3

Source: Initial National Communications. The emissions are expressed in CO_2-equivalent and include three major GHGs: CO_2, CH_4 and N_2O.

IV. GREENHOUSE GAS PROJECTION AND MITIGATION OPTIONS

IV.1 Greenhouse Gas Projection

IV.1.1 Introduction

GHG projection under the CCEAP, which is the only GHG projection study in Cambodia so far, was conducted for four sectors: energy, agriculture, waste and LUCF. Projection of GHG emissions from the industry sector was not performed since the industrial development plan for the period of up to 2020 concerns mainly light industries such as garments, textiles and food processing which do not emit GHGs. A number of assumptions were made based on historical trends in these sectors in the last 10 years. Results from this projection analysis of greenhouse gas emissions and removals by sectors (baseline scenario) indicated that in 2000 Cambodia was already a net emitter of GHGs. The net emissions were approximately 6,244 Gg of CO_2-eqv. In 2020, the net emissions would increase to approximately 43,848 Gg of CO_2-eqv. Among the sectors, LUCF would be the main source of GHG emissions (63.0%), followed by agriculture (27.5%). Energy would only contribute to approximately 9.0% of the total national emissions (Table 4.1).

Table 4.1: Projection of GHG Emissions and Removals by Sectors (Gg)

Source/Sink	1994*		2000		2010		2020	
Emissions		%		%		%		%
Energy	1,881	2.8	2,622	3.6	4,780	5.9	8,761	9.0
Industrial Processes	50	0.1	-		-		-	
Agriculture	10,560	15.5	12,030	16.4	17,789	22.1	26,821	27.5
Waste	273	0.4	331	0.4	425	0.5	523	0.5
LUCF	55,216	81.2	58,379	79.6	57,627	71.5	61,512	63.0
Total Emissions	**67,980**	**100.0**	**73,362**	**100.0**	**80,621**	**100.0**	**97,617**	**100.0**
Removal by LUCF	-73,122		-67,118		-61,090		-53,769	
Net Emissions	**-5,142**		**6,244**		**19,531**		**43,848**	

* 1994 inventory (IPCC methodology).

IV.1.2 Energy

Based on the LEAP 2000 model, CO_2-eqv. emissions from the energy sector were assumed to increase exponentially (Figure 4.1a). The largest contribution to the total emissions was the transport sub-sector followed by households. In 2020, the total CO_2-eqv. emissions would be approximately 8,761 Gg, about four times that of 1994 and the transport sub-sector would contribute to approximately 62% (Table 4.2) of the total. However, it should be noted that households is actually the sub-sector with the highest energy demand, i.e. 86.4% of the country's total energy demand in 1994. Since the primary source of energy for households is fuel wood (82% of total energy demand)[4], the CO_2 emitted is considered as biogenic and it is not included in the GHG inventory, as it is assumed to be re-absorbed by the forestry sector.

CO_2 dominated the emissions of GHGs from the energy sector, followed by CH_4 and N_2O (Figure 4.1b). The percentage contribution of CO_2 to the total GHG emissions will increase while

[4] Data source: MIME.

percentage CH_4 and N_2O will decrease. The main source of CO_2 is the transport sub-sector, while the main sources of CH_4 and N_2O are the households sub-sector (Table 4.3).

Table 4.2: Projection of CO_2-Equivalent Emissions from Energy Sector by Sources (Gg)

Sector	1994		2000		2010		2020		2030	
	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%
Households	685	37.0	775	29.6	980	20.5	1,219	13.9	1,421	8.7
Industry	6	0.3	11	0.4	28	0.6	61	0.7	187	1.1
Service	4	0.2	6	0.2	11	0.2	25	0.3	54	0.3
Transport	789	42.6	1,374	52.4	2,799	58.6	5,444	62.1	10,329	63.0
Transformation	369	19.9	456	17.4	962	20.1	2,012	23.0	4,416	26.9
Total	**1,853**	**100.0**	**2,622**	**100.0**	**4,780**	**100.0**	**8,761**	**100.0**	**16,407**	**100.0**

Table 4.3: Projection of CO_2-Equivalent Emissions from Energy Sector by Gases (Gg)

GHGs	1994		2000		2010		2020		2030	
	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%
CO_2*	1,101	59.4	1,775	67.7	3,713	77.7	7,434	84.8	14,825	90.4
CH_4	634	34.2	712	27.2	892	18.7	1,099	12.6	1,288	7.8
N_2O	118	6.4	135	5.1	175	3.6	228	2.6	294	1.8
Total	**1,853**	**100.0**	**2,622**	**100.0**	**4,780**	**100.0**	**8,761**	**100.0**	**16,407**	**100.0**

* Non-biogenic.

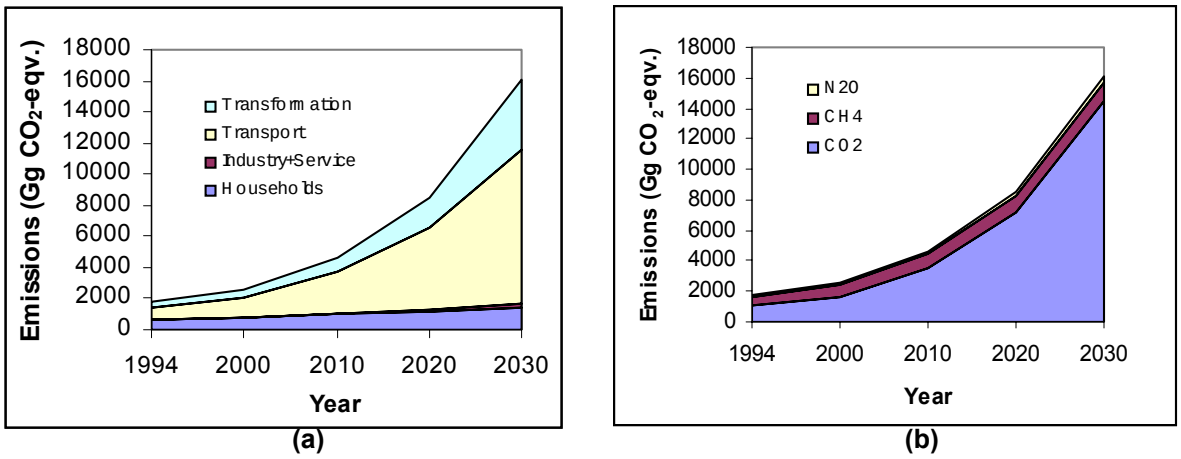


Figure 4.1: Projection of GHG Emissions from Energy by: (a) Sources, and (b) Gases

IV.1.3 Agriculture

The results of the projection showed that GHG emissions from agriculture would increase quite significantly. In 2020, methane emissions will be about three times the 1994 emissions while nitrous oxide will approximately double (Figure 4.2). The rate of increase in methane emissions for livestock would be slightly higher than that from rice paddy (Table 4.4). In total, GHG emissions from agriculture in 2000, 2010 and 2020 would be approximately 12,030; 17,789; and 26,821 Gg of CO_2-equiv., respectively.

Table 4.4: Projection of GHG Emissions from Agriculture Sector (Gg)

Activity	GHGs	1994	2000	2010	2020
Domestic livestock	CH_4	185	195	323	545
	N_2O	4	4	7	13
Rice cultivation	CH_4	150	198	254	303
Grassland burning	CH_4	2	2	2	2
	N_2O	0	0	0	0
Agricultural residue burning	CH_4	2	4	4	5
	N_2O	0	0	0	0
Agricultural soils	N_2O	7	7	10	16
Total CH_4		339	399	584	854
Total N_2O		11	12	18	29
Total CO_2-eqv.		**10,560**	**12,030**	**17,789**	**26,821**

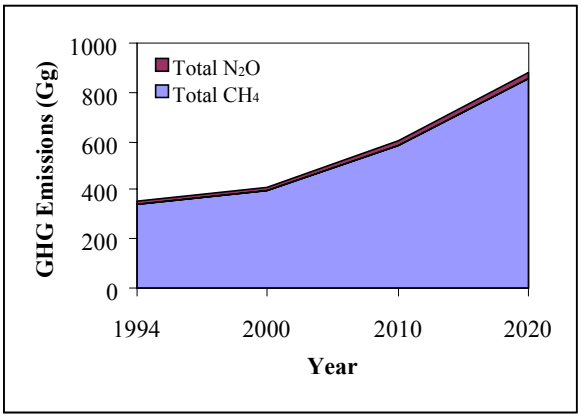


Figure 4.2: Projection of CH_4 and N_2O Emissions from Agriculture Sector

IV.1.4 Waste

Projection of GHG emissions from waste indicated that the rate of the emissions in 2020 would be approximately twice the 1994 emissions. In 1994 the rate of CO_2-eqv. emissions was approximately 273 Gg while in 2020 it would increase to 523 Gg (Figure 4.3). The main sources of GHG emissions would be from solid waste and human sewage (Table 4.5).

Table 4.5: Projection of GHG Emissions from Waste (Gg of CO_2-eqv.)

Waste Sub Sector	1994	2000	2010	2020
Solid waste	123.96	156.66	199.71	246.75
Domestic/commercial wastewater	18.27	15.96	20.37	24.99
Human sewage	131.16	158.10	204.60	251.10
Total	**273.39**	**330.72**	**424.68**	**522.84**

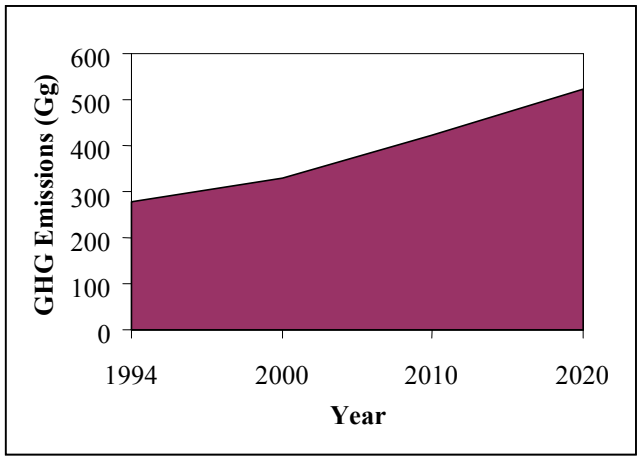


Figure 4.3: Projection of GHG Emissions from Waste (Gg of CO_2-eqv.)

IV.1.5 Land Use Change and Forestry

The projection showed that the total CO_2-eqv. emissions from LUCF for the years 2000, 2010, and 2020 would be approximately 58,379; 57,627; and 61,512 Gg, respectively. During these years forests would absorb approximately 67,118; 61,090; and 53,769 Gg of CO_2-eqv., respectively. Thus, by 2020, the status of Cambodia's forests would have changed from a net sink to a net emitter (Figure 4.4). Net emissions of CO_2-eqv. in 1994 were approximately -17,907 Gg and in 2020 would increase to approximately 7,744 Gg (Table 4.6).

Table 4.6: Projection of GHG Emissions and Removals in LUCF (Gg)

Activity		GHGs	1994	2000	2010	2020
Changes in forest and other woody biomass stocks	Emissions	CO_2	8,272	9,270	13,031	16,916
	Uptake	CO_2	73,122	67,118	61,090	53,769
Forest/land use change	Emissions	CO_2	45,214	47,300	42,954	42,954
		CH_4	75	78	71	71
		CO	654	684	621	621
		N_2O	1	1	0	0
		NO_x	19	19	18	18
Total CO_2 -eqv. emissions			55,216	58,379	57,627	61,512
Total CO_2-eqv. uptake			73,122	67,118	61,090	53,769
Total CO_2 -eqv. net emissions (+)/uptake (-)			**-17,907**	**-8,739**	**-3,462**	**7,744**

Note: CO and NO_x are excluded from the CO_2 equivalent emissions/removals.

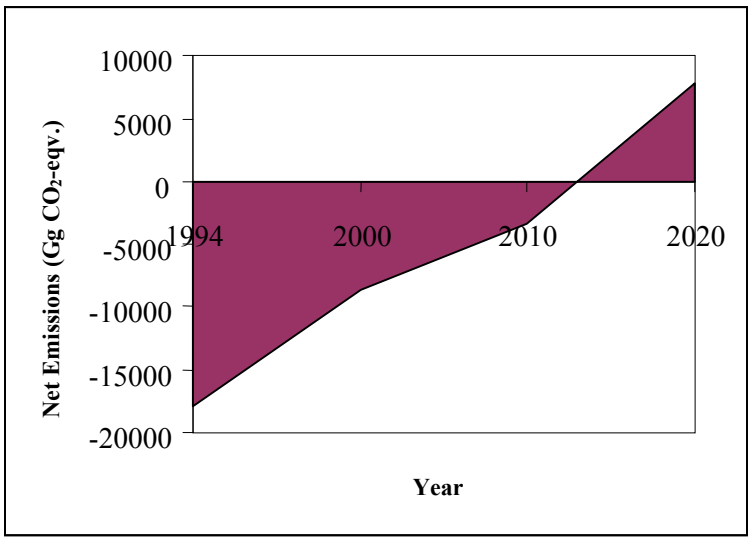


Figure 4.4: Projection of GHG Emissions from LUCF (Gg of CO_2-eqv.)

IV.2 Greenhouse Gas Mitigation Options

IV.2.1 Introduction

In Cambodia, the first attempt to evaluate GHG mitigation options in the energy, agriculture and forestry sectors was done under the CCEAP in 2000. The evaluation covered the period up to 2020.

As a developing country (non-Annex I) Party to the UNFCCC, Cambodia has no obligation to reduce its GHG emissions. While climate change has not been a specific focus for the government, many government activities and measures also contribute to the global effort to limit GHG emissions and develop GHG sinks. These include creation and management of 23 protected areas covering approximately 18% of the country's land area; establishment of various legal instruments related to forest management, waste management and air pollution; promotion of energy efficiency and development of renewable energy; and current efforts to eliminate illegal logging.

Renewable energy and energy efficiency are at very early stages of development in Cambodia

IV.2.2 Energy

Cambodia uses relatively little commercial energy per person, about 50 kgoe. The energy sector is only the third largest source of GHG emissions accounting for 2.8% of the country's total emissions, based on the 1994 baseline scenario for Cambodia.

The baseline scenario does not reflect yet the vigorous economic plans stated in the SEDP-II (2001-2005). There is a need to update the energy data of the MIME, which was done in 1996, to incorporate the SEDP-II. One example of the sub-sector that needs to be updated is the railroad. In the baseline scenario, the energy demand for the railroad is negligible, while at present, the government has plans to upgrade the railroad system through grants and loans from foreign countries.

The government has plans and projects, which although not identified as GHG mitigation projects, will actually reduce GHG emissions once implemented. Demand-side management (DSM) projects are handled by the Energy Department of the MIME. On the supply side, the EDC has plans to switch to the use of a cleaner fuel, natural gas, through its plan to build a Combined Cycle Gas Turbine (CCGT) power plant and has studies on hydropower plants. Energy efficiency will be promoted through various projects such as JICA's "Transport Master Plan for Phnom Penh", which is envisioned to improve roads, acquire efficient mass transit, discipline drivers and educate commuters. Road improvements in various parts of the country are also being financed by foreign donors and international financing institutions. The use of renewable energy will be enhanced through additional World Bank and ADB projects.

IV.2.2.1 GHG Mitigation Options

Four scenarios were evaluated in the energy sector: (i) the Reference scenario, (ii) the Government Plans scenario, (iii) the GHG Mitigation Options scenario and (iv) the High scenario.

- *The Baseline or Reference Scenario*

The baseline or reference scenario was obtained from the final report of the MIME Department of Energy[5]. This scenario projects energy use and emissions reflecting the assumed development of the national economy and energy systems if no steps are taken to reduce emissions.

- *The Government Plans Scenario*

The Royal Government of Cambodia, together with major donors and NGOs have developed energy policies and energy supply projects such as high voltage power transmission lines, hydropower development, improvement of mass transit, improved cook stoves, etc. These policies and projects were not identified as GHG mitigation projects, but if implemented will actually reduce the GHG emissions of the country.

- *The GHG Mitigation Options Scenario*

The GHG Mitigation Options scenario lists all other options aside from the projection already identified by the government under the "Government Plans" scenario. The projections in this scenario have reduced the GHG emission by 10% from the reference case.

- *The High Scenario*

The High scenario is composed of the "Government Plans scenario" plus the "GHG Mitigation Options scenario". This scenario reflects the assumption that policies and programs will be

[5] TA 2241 CAM: "Strengthening the Institutional and Legal Framework for the Energy and Mineral Sectors", financed by the Asian Development Bank.

implemented to encourage adoption of measures that will reduce GHG emissions or enhance carbon sinks.

Table 4.7 below shows the GWP reduction of each mitigation option for the years 2003 to 2030. The reduction in GWP under the High scenario, when summed up amounts to 59,650 Gg of CO_2-eqv. (24% reduction from the Baseline or Reference scenario), accumulated from 2003-2030 (Table 4.8). In the analysis, only the mitigation options with sufficient data were evaluated in the calculations of the GWP emission reduction. The projects which contributed to the reduction in GWP are the Compact Fluorescent Lamp (CFL), the Phnom Penh City Shuttles (Bus), the Improved Cook Stove (ICS), the Hydropower, the 180 to 600 MW Combined Cycle Gas Turbine (CCGT) and the Mass Transit in Rural Areas.

Table 4.7: GWP Reduction of each Mitigation Option

Mitigation Option	GWP Reduction, Gg of CO_2-eqv. (2003-2030)	% Reduction (of Total GWP)
Combined Cycle Gas Turbine*	19,980	33.5
Improved Cook Stove (ICS)	13,060	21.9
Hydropower*	12,390	20.8
Compact Fluorescent Lamp	7,320	12.3
Phnom Penh City Shuttles*	2,300	3.8
Mass Transit (Rural)	4,600	7.7
Total Reduction (24%)	59,650	100.0

* Government Plans scenario.

Table 4.8: GWP Reductions Compared to the Baseline (Gg of CO_2-eqv.)

Scenario	GHG Emissions (2003-2030)
Reference	251,500
High	191,850
Reduction (Reference – High)	59,650

IV.2.2.2 Other GHG Mitigation Options

Several projects or initiatives have potential for reducing GHG emissions, but due to lack of data and time constraints, were not evaluated in the LEAP 2000 programme.

- *Projects Under the Government Plans*

The government has approved the following projects but the data needed to evaluate the GHG emission reduction in the LEAP 2000 programme was unavailable:

a) Institutional, Legal and Regulatory Initiatives (establishment of the Electricity Authority of Cambodia (EAC), the Council for the Development of Cambodia (CDC) and the Law on Environmental Protection and Natural Resources Management;

b) Electricity supply improvement;

c) National transmission system;

d) Electricity trading with neighboring countries;

e) Regulatory reform action - establishment of power sector regulatory framework;

f) Rehabilitation of the electricity system;

g) Provincial and rural electrification;

h) Improvements in the Electricité du Cambodge (EDC);

i) Commercialization of the supply of electricity;

j) Renewable energy projects (the World Bank's "Cambodia Renewable Energy Promotion Project" and the ADB's "Promotion of Renewable Energy, Energy Efficiency and GHG Abatement (PREGA));

k) Improvement in the transport sector (JICA's "Transport Master Plan for Phnom Penh" and ADB, Japanese government and World Bank road rehabilitation and improvement projects).

- *Additional GHG Mitigation Options recommended (not in the Government Plans)*

The following initiatives were identified and recommended for both energy sector development and GHG emission reductions:

a) Policy Reforms:

- Implement a study on the privatization and restructuring of the EDC and power utilities;

- Implement a project to formulate the framework for Integrated Resource Planning (IRP) and Demand-Side Management (DSM) programs;

- Tax relief for renewable energy projects;

- Fund for renewable energy projects;

- Development of mini-hydropower plants (101 kilowatt to 10 MW);

- Energy efficiency building codes;

- Efficiency improvements for existing and new building shells;

- Stimulating building retrofits;

- Passive solar building design;

- Establishment of energy service companies (ESCOs);

- A government programme that encourages utilities and industries to voluntarily reduce GHG emissions;

- Establishment of a "fuel and appliance testing laboratory"; and

- Energy pricing.

b) Enhancing National Capacity:

- Improvement of energy database;

- Develop procedures to ensure consistency of classification of energy data with the economic data;
- Wind energy map;
- Capacity building;
- Training on energy audit;
- Inter-agency cooperation, and
- Fund for salary supplements of national experts.

c) Transport

- Energy-efficient mass transit;
- Infrastructure for road traffic management;
- Enforcement of traffic laws;
- Road improvement in urban areas;
- Driver and pedestrian training and education;
- Energy efficient and pollution control technology; and
- Planting more trees along the roads and preserving existing trees.

IV.2.3 Land Use Change and Forestry

Forests make up a major part of the Cambodian natural resource base. Satellite imagery in 1991 showed that some 73% of the forest cover was intact and a substantial and valuable forest resource remained. At present, the forest areas have reduced to about 60% of the country's area, mainly due to commercial logging and forest conversion to agricultural land use. It was estimated that in the period of 1973-1998, the annual rate of deforestation was approximately 0.6-0.9%.

The Government clearly recognizes the need for a radical forestry reform. Since the mid 90's, a number of initiatives have been implemented to protect forest resources for both economic and environmental benefits. These include a log export moratorium, establishment of a forest crime monitoring unit, forest concession review, establishment of forestry law, creation of protected area system, expansion of community forestry, and reforestation programmes.

The 1993 Royal Decree on the Creation of Protected Areas established 23 protected areas in the Kingdom of Cambodia with a total area of approximately 18% of the country’s surface area, one of the largest percentages in the region. That area is expected to increase up to 25% by 2005 with the establishment of additional forest reserves in the country.

Community forestry is an important forest management alternative to industrial forest concessions, in which the forest management authority is conveyed to local communities. To date, approximately 22 small-scale community forests have been established in order to ensure the long-term security and stability of the livelihood of rural communities that depend on forest products and to increase forest cover. Community forestry has been recognized as an effective strategy for sustainable forest management.

Up to 2000, reforestation activities were limited as priority attention was given to conservation of the remaining forests. From 1985 to 2000 the total area of forest plantation established was 8,701 ha. According to a MAFF assessment, there are 6 million hectares of degraded forestland that need to be rehabilitated from 2001 to 2005 (Second Five-Year Plan for Forestry Sector, 2001-2005). The specific sites and detailed information is now being studied. Under this Second Five-Year Plan, tree planting programs will be implemented in many forms in provinces and towns with the objective of: (i) planting 50,000 ha/year of forest plantations, (ii) planting 120 ha/year on National Arbor Day; and (iii) planting approximately 16,000 ha/yr through public participation and community forestry.

The 1994 GHG inventory indicates that in 1994, Cambodia removed 64,850 Gg and emitted 59,708 Gg of CO_2-eqv. Therefore, in 1994, Cambodia was a net carbon sink country with a net total carbon removal of 5,142 Gg of CO_2-eqv. The main source of carbon dioxide emissions was land use change and forest sector (45,214 Gg or 97%). However, the capacity of the LUCF sector to uptake CO_2 was 43% higher than emissions, thus in total this sector offset all other GHGs emissions from all other sectors.

IV.2.3.1 GHG Mitigation Options

In 2000, a preliminary GHG mitigation analysis in Cambodia's forestry sector was conducted under the CCEAP to evaluate the appropriate GHG mitigation options for the forestry sector in Cambodia. In this study, three mitigation scenarios were proposed namely baseline scenario, potential scenario and mitigation scenario. Five mitigation options were evaluated under each scenario using COMAP (Comprehensive Mitigation Analysis Process model): forest protection (FP), reforestation with short (RSR) and long rotation (RLR), and reforestation without rotation using fast (RFG) and slow growing species (RSG). The option of fossil fuel substitution was not evaluated in this study due to lack of data.

The baseline scenario is a scenario to evaluate mitigation potential of LUCF sector in the future if the rate of tree planting (sink enhancement) on degraded land is assumed to be the same as the historical planting rate and no efforts are made to protect the protection forest from being deforested.

The mitigation scenario is a scenario to evaluate mitigation potential of LUCF sector in the future if the rate of tree planting (sink enhancement) and efforts to protect the forest from deforestation follow government plans.

The potential scenario is a scenario to evaluate mitigation potential of LUCF sector in the future if all degraded land were reforested and efforts to protect the forest from deforestation were maximum.

The results of the analysis indicates that mitigation potential of the five options ranged from 43 to 141 tC/h, investment costs required to implement the five options ranged from 2.5 to 47 US$/ha, while the life cycle cost required for sequestering one tonne of carbon ranged from 0.28 to 1.78 US$. The net present value of benefit of the five options ranged from -0.77 to 4.66 US$/tC. Options that gave positive benefits were RLR and RSR (from harvested wood).

The total areas required to implement the five options under baseline, mitigation and potential scenarios are 16,320; 2,017,391 and 6,070,182 ha, respectively. The total carbon that can be abated under these three scenarios are approximately 1.24; 155.6 and 466.4 million tonnes, respectively. The total investment costs are 0.63, 76.22, and 230.48 million US$ respectively, while life cycle costs are 0.98, 121.30 and 364.67 million US$, respectively, and total benefits are 1.53, 182.77 and 556.23 million US$, respectively.

From the analysis of the five mitigation options, it was found that the highest absorber of CO_2 is reforestation, followed by afforestation, and forest protection. Absorption capacity of carbon depends on the species used in the forest programme. Thus, the proposed initiatives for GHG mitigation in the forestry sector should focus on these three aspects. It is important to note that law enforcement such as monitoring and control of forest management is also critical in implementing these initiatives.

IV.2.4 Agriculture

Greenhouse gas emissions from the agriculture sector include CH_4, NO_x, N_2O and CO. The emissions are produced by several sub-sectors such as livestock, rice fields, agricultural soils and burning of agricultural residues and grassland. Each sub-sector emits different forms and magnitudes of GHGs. In Cambodia, livestock and rice fields are the major source of CH_4 (78% of total CO_2-eqv. emissions), while agricultural soils are the main source of N_2O (21% of total CO_2-eqv. emissions).

Methane emissions from domestic livestock in Cambodia mostly come from enteric fermentation with small amounts from manure management. The 1994 inventory has indicated that domestic livestock emitted 184.79 Gg of CH_4 equivalent to 48.1% of the total CO_2-eqv. emissions from the sector. Economic and population growth leads to an increase of the consumption of meat and eggs, for example an increase of 6.52% in 1998, and hence emissions of methane from livestock are likely to increase.

Rice fields are the second greatest contributor to CH_4 emissions in the country amounting to 150.40 Gg or 29.9% of national CH_4 emissions in 1994. Lowland rainfed rice fields emit the highest rate contributing to 103.70 Gg (68.9%) whereas irrigated rice fields contribute to approximately 31.1% of the total emissions from rice fields. Cambodians use rice as the staple food with consumption of approximately 162 kg/capita/year (white rice). With an average population growth of 2.49%, substantial amounts of rice will be required in the future and this will lead to increases in CH_4 emissions. It is predicted that the increasing rate of CH_4 emissions will be proportional to the increasing rate of rice production.

The results of the projection showed that GHG emissions from agriculture would increase quite significantly. In 2020, methane emissions will be about three times the 1994 emissions while nitrous oxide will approximately double. The rate of increase in methane emissions for livestock would be slightly higher than that from rice paddy. In total, GHG emissions from agriculture in 2000, 2010 and 2020 would be approximately 12,030; 17,789; and 26,821 Gg of CO_2-eqv., respectively.

IV.2.4.1 GHG Mitigation Options

The mitigation options evaluated for the agriculture sector only covered rice paddies. Mitigation options for the livestock sub-sector were not assessed due to insufficient data, even though livestock is the biggest contributor of CH_4 emissions in the agriculture sector. It is also important to note that in Cambodia, animal husbandry is still considered as a family application as there are neither household dairy farming nor investment in this field. The government plan, however, provides for the vigorous development of the livestock industry to meet national consumption.

Evaluation of mitigation options in the agricultural sector was conducted by the CCEAP and was limited to intermittent irrigation applied to dry season rice, direct seeded applied in both dry and wet seasons, organic matter management applied for both seasons, and zero tillage applied in both seasons under two scenarios: the potential scenario (all options be applied to all rice growing areas) and the mitigation scenario (reduce methane emissions from the agriculture sector by approximately 10% from the baseline).

The results of the analysis showed that reduction of emissions which would result from the mitigation options ranged from 71 to 304 kg CH_4 per ha per season (Table 6.1). Using mitigation potential provided by studies conducted in Indonesia (Pawitan et al., 1999), it was found that all options evaluated in this study gave positive benefits with a range of 10 to 71 US$/ha. In terms of methane reduction, the incremental benefit ranged between 116 to 774 US$/t CH_4. Based on profitability, yield, mitigation potential, applicability and acceptability of the options, it was found that options with low barrier are dry season intermittent and organic matter management, options with medium barrier are direct seeding and wet season zero tillage, while that with high barrier is dry season zero tillage.

To reduce methane emissions from the agriculture sector by approximately 10% of the 1994 total emissions (approximately 40 thousand tonnes of CH_4), the area that should be allocated for implementing all the options is approximately 424,000 hectares. By implementing these options it is expected that rice production would increase by approximately 275,865 tonnes. If all rice growing areas used for implementing these options were considered, the production would be expected to increase by approximately 1,460,736 tonnes. However, these efforts may require big investment.

V. VULNERABILITY AND ADAPTATION ASSESSMENT

V.1 Introduction

Many studies have indicated that the atmosphere under elevated CO_2 concentration is warming and may have significant impact on global climate. If the rate of increase of GHG emissions is not reduced, the global climate will change. Therefore, in many countries governments are seeking advice from a wide range of disciplines on the potential impacts of climate change on the environment, society and the economy.

In Cambodia, the first attempt to assess the potential impacts of climate change on the priority sectors and to identify adaptation options to the changing climate was conducted by the National Technical Committee of the UNDP/GEF sponsored Cambodia's Climate Change Enabling Activity Project based in the Ministry of Environment during 2000-2001. Four sectors were selected for the assessment: agriculture, forestry, human health and coastal zone. The impact of climate change on Cambodia's climate was also assessed in this study.

V.2 Impact of Climate Change on Cambodia's Climate

The global warming scenarios used in this study are SRESA2[6] (reference) and SRESB1 (policy). The SRESA2 will lead to higher future GHG emissions while SRESB1 leads to lower future GHG emissions. The impact of climate change on Cambodia's Climate was assessed using two General Circulation Models (GCM), i.e. CCSR and CSIRO. From validation of this study, it was indicated that the two GCM models used in this analysis were not very suitable for use in Cambodia since the two models were developed for use in Japan and Australia which are very different geographical regions. The deviation of GCM models from the observed rainfall data was very significant. The deviation of monthly wet season rainfall could reach 794 mm, especially during the rainy season. Therefore, correction factors were developed and used in the subsequent analysis.

V.2.1 Temperature

The two GCM models suggested that temperature in Cambodia would increase due to the increase in CO_2 concentrations. However the increase in temperature projected by the two models differed. Under scenario SRESA2, the CCSR model suggested that the mean annual temperature would increase by about 0.60^{o}C in 2025 and further increase by about 1.00^{o}C and 2.50^{o}C in 2050 and 2100, respectively. The CSIRO model suggested that the increase in temperature from the current year's temperature in 2025, 2050 and 2100 would be about 0.30, 0.70 and 2.00^{o}C, respectively. Similarly under the SRESB1 scenario, the increase in mean annual temperature from the current temperature in 2025, 2050 and 2100 using CCSR would be about 0.60, 0.90 and 1.60^{o}C respectively and using CSIRO would be about 0.45, 0.75 and 1.35^{o}C, respectively.

V.2.2 Rainfall

Similar to temperature, the changes in rainfall predicted under the two emission scenarios estimated by CCSR differ from those estimated by CSIRO. Using CCSR under SRESA2, annual rainfall in Cambodia would increase by up to 6% of the current rainfall with the magnitude of change varying with time and location. In 2025, the increase in rainfall in the lowland areas would

[6] Special Report on Emissions Scenario, A2 family. The SRES scenarios has four qualitative story lines that yield four sets of scenarios called "families": A1, A2, B1 and B2. Reference: Emissions Scenarios, IPCC 2000.

be higher than that in the high land and coastal areas. Percentage increase in rainfall for the lowland areas is likely to be between 4 and 8% while in the high land and coastal areas -- between 0 and 4%. In 2050, the predicted percentage changes in rainfall for the low land, high land and coastal areas are higher than those occurring in 2025. In the low land areas the change in rainfall would be between 8 and 12% while in the high land and coastal areas -- between 2 and 6%. In 2100, the change in rainfall would be lower than that would occur in 2025 and 2050. The CCSR model suggests that under elevated CO_2, Cambodia's rainfall would increase from the baseline up to the year 2050 and then decrease again in 2100. Using CSIRO, rainfall would continuously increase from baseline until 2100. The increase in rainfall from baseline for 2025, 2050 and 2100 would be between 5 and 15%, 5 and 23% and 3 and 35%, respectively. Similar patterns were also observed for SRESB1, however, the magnitude of changes was smaller than those of SRESA2.

Destructive floods have become frequent in recent years

V.3 Agriculture

Agriculture, especially rice production, is and will remain a major contributor to the Cambodian economy for years to come. Land under agricultural production increased from 3,785,000 ha in 1990 to 4,079,464 in 1994 and continues to increase as more forest is converted to agricultural land and land formerly inaccessible from the war is de-mined.

Rice production has been steadily increasing since 1980 at a rate of 4.5% per year (total of 105,000 tonnes per year) as a result of increased productivity and a 2.3% increase in harvested areas per year (about 382,000 ha/year). Wet season rice production predominates with dry season rice (irrigated rice) accounting for about 10% of the total. However, the rate of increase in production in wet season rice (1.9%) is lower than that of dry season rice (2.8%).

V.3.1 Potential Impact on Rice

The assessment of the impact of climate change on agricultural production was carried out for rice production in the four major rice-producing provinces. The assessment was done using a stochastic approach rather than a deterministic approach since the former approach requires less data inputs.

Variability of rice production in Cambodia is significantly correlated with climate variability, primarily due to the occurrence of floods and drought. Data from the past five years showed that production losses were mainly due to flooding (more than 70% losses), followed by drought (nearly 20% losses). Production loss due to pests and diseases was insignificant (Figure 5.1) in

comparison. Based on previous studies, it was found that the frequency and intensity of floods may increase with changing climate conditions. Increased flooding will in turn cause serious damage to rice crops. Therefore under changing climate, farmers may be exposed to greater risk, in particular those producing wet season rice, thus research on developing varieties resistant to flood would be very important.

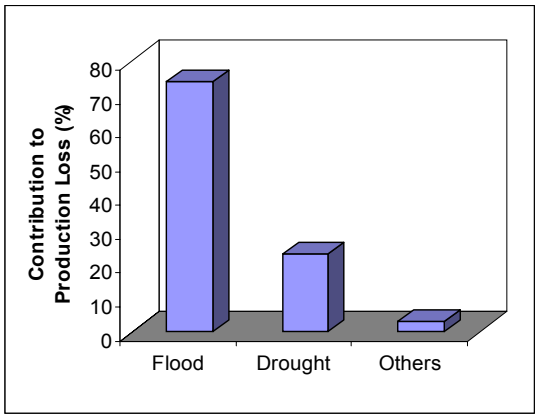


Figure 5.1: Contribution of Natural Hazard to Rice Production Loss in Cambodia

The assessment has indicated that under changing climate the yield of wet season rice would increase while that of dry season rice would remain the same or decrease. Under changing climate, rice production in the four provinces would exceed demand if rice productivity could be increased by about 1 t/ha every 25 years from the current productivity. By 2025, rice production from these provinces would meet 56% of the national demand and in 2050 it would have increased to 67% under SRESA2 scenario and 65% under SRESB1 scenario. In 2100, under SRESA2 the contribution of these four provinces to the total national demand would be almost the same as in 2050 while under SRESB1 it would be lower. Nevertheless, as this study used statistical modeling some of the determinant factors in crop growth and development were not taken into account. Further studies for verification are therefore recommended. The use of deterministic modeling approach will be able to capture more factors that contribute to variability of yield.

V.3.2 Government Plan for Increasing Rice Production

The main purpose of agriculture, forestry and fisheries development in Cambodia is to ensure food security, to conserve national resources and to maintain the share of these sectors of national GDP at 45-50%. Therefore the growth in this sector needs to be maintained at a rate of about 5% per annum.

In terms of increasing rice production, the Royal Government of Cambodia has launched programs and policies as follows:

- Continuing the implementation of irrigated-water policies;
- Expanding irrigated areas from 16-20% of the total cultivated area;
- Expanding the rice cultivated area up to 2,500,000 ha in year 2010;
- Increasing yield and production of rice at a rate of 2.7% per annum and improving the quality of agricultural products;
- Improving technology application and other infrastructures for reducing dependency on the nature;

- Promoting agricultural diversification; and
- Increasing planting indexes through crop rotation or inter-cropping.

Based on the above programs, a projection of rice growing areas, yield, demand and supply has been developed. It is expected that by 2020 Cambodia might be in a position to export as much as 2 million tonnes of rice per year if all programs are successfully implemented.

V.3.3 Adaptation Options

The impact of climate change on rice production in Cambodia would not be substantial if the Government could meet the agriculture development plan. Projections on rice production in the four provinces indicated that from 2025 to 2100, rice production would exceed demand, if the rice productivity could be increased by about 1t/ha every 25 years from the current productivity.

The contribution of these four provinces to internal demands also tends to increase. Programs that can be implemented to increase the rice productivity include:

- Development of new high yielding varieties;
- Improvement of crop management and cultural practices;
- Development of capacity to adapt to current extreme climate conditions such as development of early warning system for extreme climatic events, development of maps showing the rice-growing provinces prone to flood and drought;
- Development of irrigation facilities in low land areas;
- Increasing planting index in suitable areas; and
- Diversification of foods.

V.4 Forestry

Cambodia retains a forest cover of approximately 58 percent. During the last two decades forest resources and forestlands were significantly depleted and degraded due to unsustainable levels of exploitation and forest conversion. Since the forest sector plays a significant role in the Cambodian economy, analysis of the impacts of climate change on this sector is very important.

V.4.1 Potential Impact on Forest

The GCM models used for the assessment of potential impacts of climate change in the forestry sector are CCSR and CSIRO with two emission scenarios, i.e. SRESA2 and SRESB1. The main aspect being investigated was the impact of climate change on Cambodia's forest type, while its impact on forest productivity was not included due to a lack of data for the analysis. Distribution of land cover of Cambodia based on the Holdridge Life Zone Classification Model (US-CS, 1994) was employed. According to this classification, the forest type in Cambodia under current conditions could be classified into three categories, namely wet forest (20%), moist forest (20%) and dry forest (60%).

The change in forest type due to climate change depends on the type of GCM models and emission scenarios used in the analysis because the change in rainfall and temperature between the two GCM models and the two scenarios are different. Under changing climate, the area of

wet forest would decrease while moist forest would increase and dry forest would remain the same, indicating that forest productivity and biodiversity might also change.

V.4.2 Adaptation Options

In order to reduce the impact of climate change on the forest sector, the available options include:

- *Forest Plantation Establishment*

Promotion of forest plantation establishment is important to relieve pressure on the natural forest. The optimal use of unproductive land for forest plantation establishment should be encouraged. Tree species used in the designated areas should match with socio-economic and biophysical conditions of the areas as well as global market. Therefore, maps of land quality index for tree plantations should be verified or established.

- *Conservation of Protected Areas*

Appropriate legal and policy frameworks, protected area management plans, and an effective monitoring system for the conservation of protected areas should be established. Strengthening law enforcement, and community participation in protected area management are also critical. Programmes for protecting critical wildlife habitats and for the expansion of species and forest communities, should also be enhanced in particular in the likely affected areas. Programmes to rehabilitate the protected forests also need to be promoted through enhanced natural regeneration techniques using native and exotic tree species.

- *Improvement of Forest Resource Management*

The common goal of forest management is to achieve sustainable management. Sustainable use of forest resources can be achieved through the promotion of improved silvicultural systems and techniques (such as reduced impact logging techniques) to forest concession holders.

V.5 Human Health

Climate change directly and indirectly affects human health. Since Cambodia is a tropical country, the direct impact of the climate on human health is significant. Malaria and dengue fever are the two most important mosquito-borne diseases, which are found in Cambodia. Cambodia has the highest death rate from malaria in the region and the number of malaria cases contributes highest among the infectious diseases that are associated with changing climate variables. The Royal Government of Cambodia (RGC), specifically the Ministry of Health has treated this as one of the priority issues. The National Center for Parasitology, Entomology and Malaria Control was established with the main roles to prevent and provide better treatment in such a way as to diminish the death rate from malaria as well as the number of malaria patients.

V.5.1 Potential Impact on Human Health

The impact of climate change on malaria incidence has been assessed by CCEAP as it is the most serious vector-borne disease in Cambodia (Table 5.1). The evaluation was done using two GCM models, CCSR and CSIRO and two emission scenarios, SRESA2 and SRESB1. A model that explained variability of malaria cases between months, years and provinces was developed using regression techniques where wet season rainfall (WSR), dry season rainfall (DSR), annual mean temperature (AMT) and socio-economic condition of the province were used as independent variables. Of the socio-economic parameter of provinces, only percent literate was taken into account.

Table 5.1: Percentage Infectious Diseases for all Inpatients

Year	Malaria	Dengue	Diarrhea	Dysentery
1995	11.00	4.00	7.00	2.00
1996	13.00	1.00	6.00	2.00
1997	13.71	2.43	3.52	1.38
1998	13.00	3.03	3.98	1.32
1999	13.55	0.60	4.44	1.16

Sources: Ministry of Health (1995-1999).

The study showed that in the last four years the number of malaria cases was negatively correlated with dry season rainfall (6%), mean annual temperature (19%) and percent literate (46%), and positively correlated with wet season rainfall (29%).

V.5.2 Adaptation Options

Adaptation options recommended include: (i) introducing and expanding control measures to reduce malaria cases through early diagnosis and treatment of the diseases; (ii) distribution of pyrethroid-treated mosquito nets to communities living in high-risk areas to control the vectors; (iii) strengthening programme management and supervisory practices and creation of funds for the provision of mosquito nets and insecticide; and (iv) health education programmes with a focus on low cost preventive measures such as improvement of personal hygiene, use of bed nets and destroying the insect breeding sites.

V.6 Coastal Zone

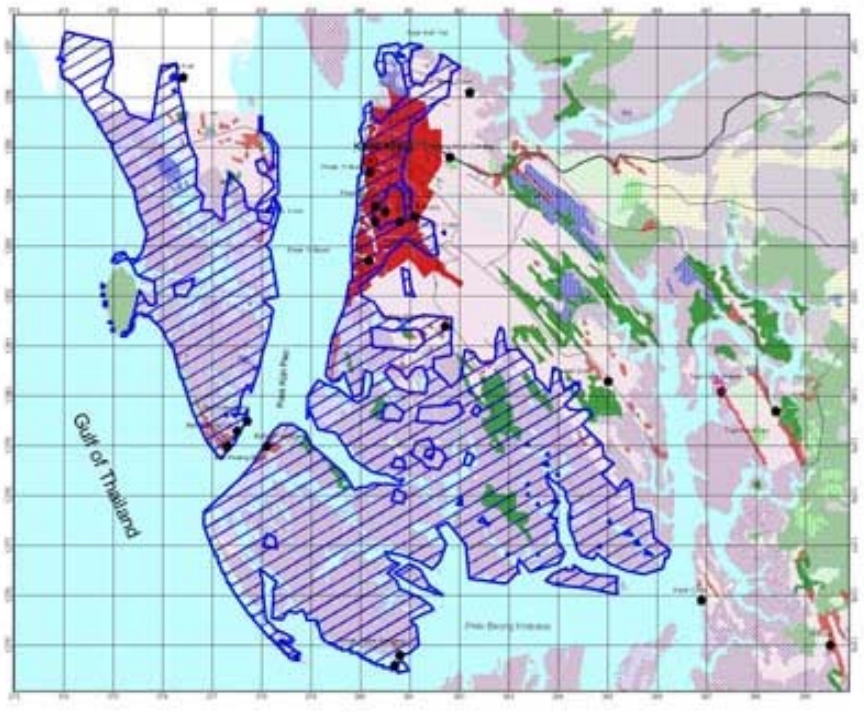
The coastline of Cambodia extends for about 435 km along the northeastern shore of the shallow Gulf of Thailand between the Thai and Vietnamese borders. Cambodia's coastal zone consists of estuaries, bays, and some 64 islands of various dimensions, including three offshore islands. The two provinces and two municipalities lie along the coast with a total population of 675,000 inhabitants in 1995. This figure increased to 845,000 in 1998 (26%) implying an annual average growth rate of 5.7%. Cambodia's coastal zone is important for socio-economic activities. It is prone to several types of coastal disasters, such as typhoon, storm surge, and beach erosion. Sea level rise (SLR) resulting from global warming will have a serious impact on Cambodia's coastal zone, in particular on the low-lying areas such as Koh Kong town.

A pristine beach at Ream National Park

V.6.1 Potential Impact on Coastal Zone

A desk study on potential impacts of climate change on Cambodia's coastal zone, which was conducted by the CCEAP in 2000-2001, states that a 1 m rise in sea level will have significant and profound effects on the economy and on the living conditions of the population in the coastal zone. Furthermore, sea level rise will also threaten seaports, beach resorts, coastal fisheries and coastal land use.

A case study of the potential impact of a 1 meter sea level rise on the low-lying part of Koh Kong province was conducted in order to analyze the area of land to be lost due to inundation and the effect of change on river flows. Geographical Information System (GIS) techniques, which have been used to assess the vulnerability of Cambodia's coastal zone to climate change are effective in identifying the areas that will be affected or could be inundated by a 1 meter sea level rise (Figure 5.1). It was found that 56% of the Koh Kong town area would be inundated when there is a 1 meter sea level rise. Further analysis showed that if the sea level rises by 1m, the total area that will be under the sea water permanently would be about 44 km^2 (0.4% of Koh Kong Province). A number of habitats located along the coastline are also potentially threatened by the sea level rise. Mangrove was considered to be one of the ecosystems that would be most affected by the sea level rise. Of the 44 km^2 affected, about 70% would be mangrove forest. Other land use types that would be flooded quite severely due to sea level rise were shrimp farms (7.7%), grassland (6.8%), city/town (6.3%), and forest (4.1%).



Potential impacts of 1 m sea level rise in Koh Kong province

The salt farms in the coastal zone will be also severely damaged by sea level rise as they all are located in low-land areas, leading to a serious decline in salt production, which consequently will have negative impacts on employment, and other socio-economic conditions in the province.

The identified impacts are quite significant, which indicates that Cambodia's coastal zone is vulnerable to sea level rise and climate change. The results also give a basis for the consideration of some adaptation options, which include development of a national response

strategy, further studies on the potential impacts of sea level rise under different scenarios, public awareness programme, etc.

V.6.2 Adaptation Options

Considering that the possible impacts of sea level rise on coastal zone would be very significant to the country, the study has recommended that the following options be considered:

- Develop a national strategic response to sea level rise for the coastal areas;
- Investigate further potential impacts of sea level rise on biogeophysical, socio-economy, marine resources, freshwater, infrastructure, human settlements, and agricultural production;
- Formulate a comprehensive adjustment and mitigation policy for sea level rise in the context of integrated coastal zone management;
- Develop computer-based information systems covering the results of surveys, assessments and observations in order to minimize the impact of sea level rise resulting from climate change;
- Increase public awareness on the effect of sea level rise on Cambodia's coast;
- Identify potential donors, either multilateral or bilateral sources to assist the country in adaptation to sea level rise; and
- Establish cooperation frameworks, training, technology transfer, surveillance of climate change in case of sea level rise, and the sharing of experiences to assist the government in establishing preparedness response to climate change.

VI. GOVERNMENT PLANS, POLICIES AND MEASURES

In 1992, when world leaders met in Rio de Janeiro to discuss sustainable development issues and produce Agenda 21, Cambodia was still addressing national reconciliation efforts to end the protracted civil war. The UN-sponsored election in 1993 resulted in the establishment of a coalition government in the country. Since then, Cambodia has made considerable efforts in rehabilitating the country, reducing poverty and establishing comprehensive legal, policy, and institutional frameworks to ensure that the country will develop in a sustainable manner.

VI.1 Legal and Policy Framework

The new Constitution requires that the state should ensure rational use of natural resources and environmental protection. Legislation to support sustainable development has been established: the Royal Decree on the Creation and Designation of Protected Areas, the Law on Environmental Protection and Natural Resources Management, Land Law, Mineral Law, Pollution Control Sub-decrees, and Sub-decree on Environmental Impact Assessment. Others under preparation are: Forestry Law, Fisheries Law, Wildlife Law, and Law on Protected Area Management.

The first environmental legislation of the RGC in 1993 was a Royal Decree on the Creation and Designation of Protected Areas, which adopted the concepts of protected area management from the World Conservation Union (IUCN). It designated 23 areas of fragile and critical habitats constituting approximately 18% of the total area of Cambodia, one of the largest percentages in the region. The Royal Government intends to increase that area to 25% by 2005 by establishing additional forest reserves in the country.

The Law on Environmental Protection and Natural Resource Management, which was enacted in 1996, prescribes general goals that the Royal Government of Cambodia must achieve and general principles that it must follow in developing legal requirements for environmental protection programs. The Law requires the RGC to prepare national and regional environmental plans and to prepare sub-decrees concerning a wide range of environmental issues, including environmental impact assessment, pollution prevention and control, public participation and access to information.

Sub-decrees on water pollution control, solid waste management, air pollution control and noise disturbance, and environmental impact assessment (EIA) were promulgated recently. A new Land Law was adopted by the National Assembly and enacted on August 31, 2001. Other key pieces of legislation awaiting approval include the Forestry Law, Fisheries Law, Wildlife Law, and Law on Protected Area Management.

The Royal Government is currently implementing radical reforms in key natural resources management sectors of forestry, fisheries, and land. The RGC campaign to prevent illegal logging and uncontrolled deforestation in Cambodia began in 1995. In 1996, a National Steering Committee to manage forest policy within the Department of Forestry and Wildlife was formed to steer the forest reform process. The drafting of the new forest legislation to establish a legal basis for administration, allocation and management of forest resources, which reflects the new RGC forest policy began in 1998 and is on-going. The new legislation will include a new Forestry Law, a sub-decree on Forest Concession Planning, Management and Control, and a Sub-decree on Community Forestry.

Reform in the fisheries sector is currently underway with the introduction and expansion of community-based fisheries management. Land reform, which started recently, will support and protect the poor by providing land titles and strengthening traditional land use rights.

The translation of the legislative framework for environmental management in Cambodia into detailed regulations and guidelines has only started and there are many regulatory gaps, which must be closed before the legislative framework can be fully functional.

VI.2 Institutional Framework

Cambodia has made significant efforts in building institutions to support sustainable development. In 1993, the Government established the Ministry of Environment and gave it a broad mandate to promote environmental protection and conservation of natural resources throughout the country. New ministries with direct mandates to support rational use of natural resources were created after the 1998 election: Ministry of Water Resources and Meteorology and Ministry of Land Use Management, Urban Planning and Construction. To ensure effective and successful implementation of sustainable development related programmes, the Royal Government has established a number of cross-sectoral National Committees for: Biodiversity, Protected Areas, Coastal and Marine Management, Management of the Tonle Sap Biosphere Reserve, etc.

The Ministry of Environment operates in accordance with the principles to which the Cambodian Government commits itself. These principles include: (i) the recognition of the links between poverty and environmental degradation; (ii) commitment to a participatory approach to deal with environmental issues; (iii) acceptance of the need for an integrated approach to most environmental problems; and (iv) the importance of strengthening relevant institutions and to awareness building. The Ministry of Environment is responsible for promoting environmental protection and conservation of natural resources throughout the Kingdom, thus contributing to improving environmental quality, public welfare, national culture and the economy. It facilitates the development and implementation of policies, plans and legal instruments to promote and ensure the rational use and management of the country's natural resources. Simultaneously, the Ministry has the role of motivating and supporting public participation in decision-making to resolve environmental and natural resource use issues.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has a significant role to play in sustainable development in Cambodia since its mandate covers the management of forest and fisheries resources. The Mission Statement of MAFF is to: "Support the economic growth of Cambodia by providing high quality services which result in a secure food supply, increased agricultural output and add value on a sustainable and cost effective basis to the agricultural, fishing and forest based sectors".

VI.3 Programmes/Plans Related to Sustainable Development

Although Cambodia does not have its national sustainable development programme or Agenda 21, a number of programmes/plans have been initiated to support the Government strategy for sustainable development.

National Programme to Rehabilitate and Develop Cambodia

The overall mission of the Royal Government of Cambodia is stated in the 1994-95 National Programme to Rehabilitate and Develop Cambodia (NPRD). Among the major concerns of the NPRD were the sustainable use of natural resources, macro-economic stability, administrative and judicial reform and other development objectives.

First Five Year Socio-Economic Plan 1996 –2000

The development objectives of the RGC were developed in more detail in the "First Five Year Socio-Economic Plan 1996 –2000" which established the framework for the medium-term

development of the country, in terms of both the broad macro-economic objectives and the specific sectoral strategies and policies. The plan was called the “First Socioeconomic Development Plan” because it was the first five year plan to be prepared after the formation of the Royal Government following the 1993 elections and within the context of a market-oriented economy.

According to the First Socioeconomic Development Plan, the RGC believes that environmental considerations are critical if the country is to prevent destruction of the natural environment and that it is important to “manage, conserve and protect Cambodia’s environment and natural resources in an ecologically sustainable manner to assist in alleviating poverty”. Six medium-term objectives were identified: (i) build the environmental planning and monitoring capacity of core institutions; (ii) improve forest concession management; (iii) strengthen protected area management; (iv) improve the management of the Tonle Sap ecosystem; (v) manage coastal zones; and (vi) reduce urban and industrial pollution.

Second Five Year Socio-Economic Plan 2001–2005

The “Second Five Year Socio-Economic Plan 2001–2005” has three development objectives: (i) promote broad-based, sustainable economic growth, (ii) promote social and cultural development, and (iii) ensure the sustainable management and use of natural resources and the environment. The Plan stresses that "A balance must be achieved between economic, cultural and environmental objectives, and between economic efficiency of resource use and equity". The proposed strategies for achieving the third objective of the Plan include: (i) prevention of environmental and resource degradation caused by policy distortions and market failures; (ii) establishing and implementing the legal frameworks for natural resource management; (iii) enhancing the human resources capacity for natural resource management; and (iv) designing and implementing a land management framework that makes adequate provision for the poor, including local community access to common property resources.

Interim Poverty Reduction Strategy Paper

The Royal Government envisions that sustainable development, including the sustainable use of natural resources can not be achieved without addressing poverty issues, the most serious social issue of present day Cambodia. In this respect, in late 2000, the Royal Government prepared a poverty reduction strategy paper, which serves as an important political platform to combat poverty. The Paper proposes a strategy for addressing poverty in four ways: (i) promoting opportunity, (ii) strengthening capability, (iii) facilitating empowerment, and (iv) enhancing security.

National Environmental Action Plan (NEAP)

The first, 1998-2002, National Environmental Action Plan was prepared to guide the integration of environmental concerns into national and local development policies, economic decision making, and investment planning and focused on selected key areas such as forestry, fisheries, agriculture, conservation, energy development, and waste management.

Preparation of a National Biodiversity Strategy and Action Plan is at the final stage. The goal of the plan is "to use, protect and manage biodiversity for sustainable development in Cambodia". Cambodia has prepared a National Action Plan on Climate Change with a goal of supporting development priorities of the country and at the same time contributing to global efforts to address climate change concerns.

VI.4 International Conventions

Cambodia has ratified a number of International Conventions related to the environment. These include:

- The Convention on Wetlands of International Importance (the Ramsar Convention);
- The Convention on Biological Diversity;
- The United Nations Framework Convention on Climate Change;
- The Convention on Marine Pollution: MARPOL 73/78;
- The United Nations Convention on the Law of the Sea (UNCLOS);
- The Convention on International Trade in Endangered Species (CITES);
- The Convention on Desertification;
- The Montreal Protocol; and
- The Convention on Persistent Organic Pollutants.

VI.5 World Heritage Sites

The Angkor Temples have been declared a World Heritage Site and there are proposals to declare two further sites: an area of the Tonle Sap Lake and an area of the Cardamom Mountain Range. The Cardamom Mountains were described by the conservation organization Flora and Fauna International as follows: “Cambodia’s Cardamom Mountains form what is arguably the single largest, most diverse and least developed natural region in mainland Southeast Asia, and represent one of the last wild places of wholly- or near-intact tropical Asian fauna and flora”.

Angkor Wat temple in Siem Reap province

VI.6 Climate Change Policy

Cambodia signed the UNFCCC in 1995, just two years after the establishment of the first and free-elected government. In 1999, the country started implementation of the UNDP/GEF-sponsored Climate Change Enabling Activity Project, which is the first-ever climate change project in Cambodia. The project is seen as the first step in actual implementation of the UNFCCC in Cambodia. Two inter-agency bodies were established to ensure successful implementation of the project: the Project Steering Committee, which is the policy-making body and chaired by the Ministry of Environment, and the National Technical Committee, which is responsible for the technical implementation of the project.

Although climate change has not been a specific focus of the Government, many government activities and measures also contribute to the global efforts to achieve the objectives of the UNFCCC. Such efforts include policy and project activities in the forestry and energy, such as creation and management of 23 protected areas covering about 18% of the country's land area; establishment of various legal instruments related to forest management, waste management, air pollution control; current efforts to eliminate illegal logging and wildlife trade; and government efforts in promoting renewable energy development and cleaner and efficient energy technology (combined cycle gas turbine, hydropower, etc.).

The Royal Government of Cambodia has taken a firm stance to support the promulgation of the Kyoto Protocol, a valid international instrument that will lay the first foundation to achieve the ultimate goal of the UNFCCC. In this context, the Royal Government of Cambodia signed Instrument of Accession to the Kyoto Protocol on 04 July 2002, indicating its commitments to the global efforts in addressing climate change issues. Cambodia has suggested that the role of forests should be considered in the broader context, not just as a carbon sink but also in mitigating climate change impacts such as flood and storm mitigation. In addition, the use of forests as carbon sinks may also contribute to their protection for the many environmental benefits and services. Nevertheless, resource allocation to be used for enhancing sinks should not compromise the emission reduction efforts through promotion of renewable energy use, energy efficiency, and technology transfer to poor countries. Cambodia considers that for developing countries any mitigation measure should be seen as an opportunity to address their development objectives.

Dr. Mok Mareth, Cambodian Minister for the Environment, at CoP-6

The process of integrating climate change concerns into economic and social development policies and plans is still in an embryonic stage. The first national action plan on climate change has identified a number of existing or proposed government plans in agriculture, forestry, energy and transport, health, and coastal zone, into which climate change objectives can be integrated. In addition, several new climate change initiatives have been proposed which focus on improving local data, technical and institutional capacity, cleaner energy technology, awareness raising and vulnerability and adaptation assessment.

VII. RESEARCH AND SYSTEMATIC OBSERVATION

The recording of systematic observations and development of research programs has been greatly hindered by the thirty years of civil war, which ended in the mid 1990s. However recent data relating to meteorology, hydrology, land use, forest cover and population figures are available.

VII.1 Data Collection and Monitoring

VII.1.1 Meteorology and Hydrology

Systematic observation involving the recording of hydrological and meteorological data is the responsibility of the Ministry of Water Resources and Meteorology (MWRM). From the 1910s until the early 1970s data for hydrological and meteorological stations were recorded daily at 50 hydrological stations on the Mekong, the Tonle Sap and the tributaries.

Only about twenty hydrological stations have been repaired since the mid-eighties. The water quality database from the years 1985 to 1997 has data relating to the stations, the chemical data of each sample and the river discharge and temperature value of each sample. Cambodia now has 13 stations for recording data related to water quality.

The Department of Meteorology (DoM) of the MWRM has 38 meteorological stations that record rainfall, 23 that record evaporation, and 14 stations that record wind speed. As is the situation with the hydrological stations, the meteorological stations were destroyed during the war. LWS, an international NGO, assisted with the repair of the stations in the early nineties but instrumentation is very limited, data is recorded manually and sent to Phnom Penh periodically for inclusion in the database. A proposal has been developed for the rehabilitation and modernization of these stations.

In Cambodia meteorological data collection is still poor. The number of rainfall stations should be increased. In the DoM, for data processing purpose, stations send data to the provincial center once a month by post or messenger. Provincial centers send collected data from stations to DoM monthly in the same manner. For forecasting purposes, key stations send data (weather forecast) daily to DoM by radio and TV all the year round. Rainfall, air temperature, wind speed, wind direction and relative humidity are observed by only two main stations (Pochentong and Sihanoukville).

VII.1.2 Land Use and Forest Cover Data

The first-ever Cambodia Land Cover Atlas 1985/87-1992/93 was prepared by the Mekong Secretariat in cooperation with the Ministry of Agriculture, Forestry and Fisheries with financial support of UNDP and FAO. Two sets of LANDSAT-MSS images and one set of LANDSAT-TM images false color composite obtained during the dry season at a scale of 1:250,000 were used to prepare maps of the atlas. Topographic maps at a scale of 1:50,000 and at a scale of 1:250,000 covering Cambodia were used as references during interpretation of images and digitizing of the interpretation results. Panchromatic aerial photographs at a scale of 1:25,000 to 1:27,000 taken during the 92/93 dry season were used as references and as “ground truth data” for development of the interpretation keys and checking of the interpretation. The classification of 27 land cover types was mainly based on existing classification of vegetation types in tropical Asia.

The Department of Geography of the MLMUC is officially responsible for photo/image interpretation, land use/land cover mapping. However RS/GIS units have been established in several ministries mainly under technical assistance of donor projects.

VII.1.3 Agricultural Data

The most detailed data relating to agriculture in Cambodia have been recorded by the Ministry of Agriculture, Forestry and Fisheries in cooperation with FAO, WFP and the Cambodian Agricultural Research and Development Institute (CARDI).

FAO/WFP made an estimate of 1995/96 production of wet and dry season rice and cereals in 1996 undertaking a survey of communes and by reviewing data from various sources. In 1998/99 MAFF in collaboration with WFP made a more detailed assessment by surveying wet-season paddy production in 1,312 communes in 15 provinces (out of a total of 23), which accounts for over 97 percent of the country's rice production. Information collected included planted area, harvested area, damaged area, the nature of the damage and yields.

FAO supported a study of wood energy consumption in 1996 which found that an estimated 0.6 cubic meters/person/year) or 6 million m^3 of fuelwood is used per year.

VII.1.4 Census Data

With the support of UNFPA, the National Institute of Statistics carried out the national census in 1998. The census information which was compiled and is available to the public in both hard and digital copies, is the only comprehensive data available on Cambodia and one of the advantages of the database is that the geographic codes used are compatible with existing GIS data, therefore allowing the extraction of useful census information for data analysis on natural resource and environmental management.

VII.2 Research

Research activities in Cambodia are very limited. A number of research/surveys, most of which are of socio-economic nature, have been conducted mainly under donor projects or by international NGOs. Cambodia's universities are still in the process of rehabilitation from the loss and damages caused by more than two-decades of civil war and as a result have contributed little to research activities to date.

VII.2.1 Climate Research

In Cambodia climate change-related research is limited by some activities conducted by the CCEAP from 1999. This includes the 1994 GHG inventory, GHG mitigation analysis and vulnerability and adaptation assessment in selected priority sectors. Current activities of the Department of Meteorology of the MWRM include only the recording of meteorological data in selected provinces.

Cambodia does not have its own General Circulation Model (GCM). Climate change scenarios used in national studies are derived from GCMs of other countries (Japan and Australia). The GCM outputs simulated by these GCMs were consistently higher than the observed. This is probably because the two models were developed for use in Japan and Australia, which are very different geographical region.

Strengthening technical and institutional capacity for long-term systematic observations at national level is crucial for the monitoring of climate and its changes. In addition, Cambodia

needs to promote regional cooperation in the field of climate research to serve as a cost-effective means for information sharing and consultations.

Training Workshop on GHG mitigation analysis for the National Technical Committee

VII.2.2 Donor Support to Environment and Natural Resource Research

The international lending institutions, the donor community, international organizations and non-governmental organizations have played an important role in collating information on natural resources and the environment, collecting data, implementing small research projects and in developing research capacity during the last decade. These include ADB, WB, UNDP, FAO, DANIDA, Belgian Government, German Government, and the European Union.

VII.2.3 NGO Support to Research in the Environment Sector

The major international NGOs involved in research and capacity development in the conservation, environment and natural resource sectors in Cambodia include Concern Worldwide, OXFAM, Worldwide Fund for Nature (WWF), World Conservation Union (IUCN), Wildlife Conservation Society (WCS), Fauna and Flora International, Conservation International, Wetlands International and International Development Research Centre. A significant number of local NGOs have developed in recent years that are becoming involved in natural resource management through community development activities.

VIII. EDUCATION, TRAINING AND PUBLIC PARTICIPATION

Education and training specifically relating to climate change is limited to the work of the UNDP/GEF-supported Climate Change Enabling Activity Project. However, there have been a number of environmental education, training and awareness projects and activities, which have included climate change in their curricula.

Since 1993, environmental education and awareness programmes have been introduced and integrated into formal education curricula at all levels. The Research Institute of the Ministry of Education, Youth and Sports which is responsible for the development of high school text books has incorporated environmental topics into high school text books for the science subjects (Earth Science, Biology, Chemistry, etc.) using resource materials that have been developed by the MoE, UNDP, a number of NGOs, and resource materials from other regional countries.

At the Royal University of Phnom Penh (RUPP), the Department of Environment is involved in environmental awareness building and educating/training students to work in the environment sector. The unit developed a curriculum, materials and course book for an environmental awareness course for students. The topic relating to climate change which is titled: "air pollution & climate change issues" contains three relevant headings: global warming, ozone layer depletion, and acid rain. In 2000 RUPP enrolled the first students for the four year Environment Degree course. The curriculum for the course has been prepared and includes classes on climate change.

Royal University of Phnom Penh

The Royal University of Agriculture, which has five faculties providing courses in agriculture and natural resources, introduces the subject of climate change in a meteorology course, which is offered in the introductory course for all faculties. The meteorology course focuses on the effect of climate on agriculture. The post secondary agricultural college Prek Leap, also introduces the subject of climate change in the meteorology course. In addition, environmental education has been integrated into agricultural education at all levels: sustainable forestry, environmental economics, sustainable agriculture, integrated pest management, sustainable aquaculture, watershed management, and agro-forestry.

In 2000, the Royal School of Administration (ERA) of the Royal Government of Cambodia, which is in charge of providing in-service training to senior and medium government staff, introduced a

comprehensive environmental programme into its curriculum. The programme covers major environmental themes such as general environmental concepts; environmental policy; culture and environment; environmental pollution; environmental issues and agriculture, forestry and fisheries; environmental management tools, and international cooperation in the field of environment. A number of short environmental courses were also organized for the staff of the MoE.

A number of international organizations, local and international NGOs, in collaboration with the MoE and the Ministry of Cults and Religion, have implemented non-formal environment education activities with monks and local communities as part of sustainable agriculture and community/rural development programs. Buddhism concepts have been derived for environmental awareness raising purpose to protect forest, wildlife, and to promote clean environment.

In recent years, environmental and sustainable development issues have become popular and frequent topics for mass media in Cambodia. The Ministry of Environment, a number of NGOs and local media have been organizing various programmes to promote better understanding among the general public and policy makers about these issues, which also include climate change.

Environmental NGOs in Cambodia, both local and international, have played an increasing role in advocating environmental protection, community-based resource management, and integrating environmental concerns into development plans and policies.

IX. FINANCIAL RESOURCES, TECHNOLOGY TRANSFER AND CAPACITY BUILDING

IX.1 Financial Resources

Cambodia is a post-conflict country where many of the foundations for growth and development - physical, social, human and economic - have been shattered and need to be put back in place (World Bank[7], 2000). Weak revenues and low private investment make Cambodia reliant on external assistance to finance its development programme (ADB[8], 2000).

Foreign currency earnings are projected to come from the garment (12.4% of GDP) and tourism sector, which are main sources of employment and income growth of the country. Government revenue is generated from taxes and non-tax sources. By far the largest taxes are the Value Added Tax (VAT) and the customs duties. In practice, VAT and other excise taxes are largely collected on imports. In 2000, 73% of all tax revenues were from imports.

In 2000, the RGC continued its conservative fiscal stance and was able to increase revenues and maintain a current surplus of 1.6% of the GDP. In the same year, the consolidated budget deficit was 5.7% of the GDP and it was entirely financed by donors, through concessionary lending and grant support. The GDP is 3,093 million US$ and the GDP per capita is US$256.

Foreign aid financed about 75% of the US$100 million of fiscal capital expenditures in 1998 as well as a large programme of Technical Assistance (TA), budgetary support and emergency relief. For 2001, major donors pledged a total of around US$645 million to Cambodia. Several major aid agencies are involved in Cambodian development. Japan, the largest donor, mainly supports construction of bridges, roads and ports; power and health. ADB, The World Bank, the United Nations agencies, the European Commission, Sweden, France, Australia, DANIDA, and about 400 non-government organizations are working in Cambodia.

The Public Investment Programme[9] shows that the largest allocation is to transport, with close to three-quarters going on (entirely donor-funded) road projects. Health is allocated almost 20 percent of programmed investment: a project for strengthening of health services accounts for almost 40 percent of this figure. Agriculture's allocation is 13 percent, with de-mining, fisheries, and research and extension absorbing 75 percent of the funds. Education will receive nearly 12 percent, with over half allocated to basic education. Water resources is allocated 11 percent, with the largest planned projects being for flood protection and drainage improvement, and community irrigation rehabilitation. The 5.7 percent share to administration is largely for technical assistance in running the 2002 commune elections, reform of judicial administration, restoration of the provincial tax and customs services, and preparation of census administration maps. Communications' allocation of 4.3 percent is mostly for fiber optic links and broadcasting for the development of rural areas.

Environment and **conservation** receives an allocation of 3.6 percent split roughly equally between investment projects (notably construction of a new sanitary landfill for Phnom Penh and sustainable development of coastal wetlands) and technical assistance projects for capacity building in **environmental management**. The **energy sector's** allocation is virtually entirely for investment projects: expansion of the power system; power rehabilitation in provincial towns; rural electrification and solar power development; power system upgrading; and hydropower. Social and community services are allocated just under 3 percent.

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7 The World Bank, Cambodia Country Assistance Strategy, February 2000.

8 Asian Development Bank, Cambodia Country Operational Strategy, Enabling a Socioeconomic Renaissance, July 2000.

9 Second Socioeconomic Development Plan, 2001-2005 (SEDPII).

It was projected that there will be a strong growth in industrial value added, estimated on the basis of rapid expansion in garment exports, primarily to the U.S (ADB[10], April 2001). However, after the September 2001 attacks in the U.S., it is reported that, "*the slowing world economy introduces new risks to Cambodia, which has a relatively open economy and much recent growth has been due to growth in the textile and tourism sub-sectors. Tourism will definitely decline over the next 12 months as visitors are reluctant to leave their home countries due to security concerns and because of the slowing world economy. For the textile sub-sector, Cambodia produces relatively low value garments that should not be too adversely affected by the slowdown in demand in high income countries* (ADB[11], October 2001)". On a positive note, the recent strengthening of the Euro against the dollar should help improve Cambodia's competitiveness with its exports to Europe, which may partially compensate for the loss of tourism due to security concerns[12].

The generation of additional revenue is essential if increased funding is to be provided for economic and social infrastructure development. It is projected that revenue will rise as a percentage of GDP from 11.8 in 2000 to 13.7 in 2005, largely through a rise in taxation revenue from 8.6 percent of GDP to 10.5 percent. The latter involves a rise in VAT proceeds, and a substitution of excise taxes for customs duties (as tariff reform continues), and will demand further improvements in tax and customs administration. The 2001 budget accordingly makes provision for strengthening revenue administration, as well as introducing additional revenue-raising measures.

IX.2 Donor Support to Climate Change Activities

The UNDP/GEF-funded CCEAP is the only project on climate change in Cambodia so far. Cambodia has submitted to UNDP/GEF an add-on proposal for interim financing on first National Communication (Phase 2), which was approved in early 2002. As a least developed country, Cambodia participated in a UNITAR-executed project entitled "Building Human and Institutional Capacities to Address Climate Change Issues in Least-Developed Countries". This project was complementary to information technology capacity building activities that were initiated by the CCEAP. The ADB's Promotion of Renewable Energy, Energy Efficiency and GHG Abatement (PREGA) project is still on the initial stage.

There are other projects, which although not classified as climate change projects, can actually reduce GHG emissions, once implemented. Some of these projects are the WB/MIME "Cambodia Renewable Energy Promotion Project", JICA's "Transport Master Plan Of Phnom Penh" and DANIDA's "Natural Resource and Environment Programme", among others. Preparation of several climate change-related project proposals is underway and will be submitted to potential donors for funding.

The Japanese New Energy and Industrial Technology Development Organization (NEDO) has expressed interest in climate change projects under the Clean Development Mechanism (CDM). The Worldwide Fund for Nature (WWF) will possibly initiate its climate change programme in Cambodia with a focus on the linkage between climate change impacts and biodiversity in the Mekong drainage basin.

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10 Asian Development Bank, Asian Development Outlook 2001, April 2001.

11 Asian Development Bank, Economic Update: Kingdom of Cambodia, October 2001.

12 Since the Riel is essentially fixed to the US Dollar, it has been effectively appreciating against the Euro, the Thai Baht, and the Vietnamese Dong, which has led to a loss of competitiveness of Cambodian exports in these key markets (ADB, October 2001).

IX.3 Technology Transfer

Technology transfer in climate change refers to the communication of knowledge, skills and practices to deal with climate change issues, namely GHG inventory and mitigation, and vulnerability and adaptation (V&A).

In the final draft of the SEDP-II, 2001-2005, the government has plans that will promote technology transfer in various sectors.

As the CCEAP is the first climate change project in Cambodia, the members of the NTC were able to work with international consultants and gained knowledge on research and methodologies used to determine GHG inventory, mitigation and V&A. However, Cambodia is still in the process of applying for projects under the UNDP/GEF, ADB and other grants that its neighboring ASEAN countries (like Thailand & Vietnam) have already implemented.

Barriers to Technology Transfer

- *Domestic Barriers*

Cambodia's institutional setting and the domestic political environment are generally supportive of activities that will contribute positively to addressing climate change issues. This is reflected in the final draft of the SEDPII and in other policies of the government.

In spite of the government's general support for climate change related projects, one domestic barrier on technology transfer is the weak coordination and sharing of information between government agencies. There is a need to set up a government body that will "enforce" the submission of all activities, projects and other information related to climate change and be made available to the public. To cope up with modern technology and be "connected" to the rest of the world, a website of this government agency will help Cambodia be recognized as a modern developing country and erase the negative image of Cambodia as portrayed in a number of websites.

The recent world economic crisis partially caused by the September attacks in the U.S. is among the potential barriers to technology transfer in Cambodia. The economic crisis will put a strain on the budget of public agencies, constraining their proposed development programs.

Information regarding the benefits of GHG emission reduction projects is not yet disseminated to the private sector and the banks. The private companies, which are profit-driven, are usually reluctant to implement projects, which will reduce GHG emission, mainly because most of these companies are not aware of the "no-regrets" projects. The banks should also be equally informed, to help the possible project proponents obtain loans for GHG emission reduction projects.

- *External Barriers*

Advanced technologies are manufactured outside Cambodia and that means the costs are in US dollars. Most of the equipment is expensive. There is also a need for an agency in Cambodia that will certify that these technologies are safe and not rejects of other countries. This would require capacity building to train experts in order to check the environmental soundness of the equipment. Once the experts are trained, the next measure is how to keep these experts in their jobs through proper incentives, job security and motivation.

IX.4 Capacity Building

The CCEAP has assisted Cambodia in formally developing its technical capacity in the field of climate change for the first time. To enable Cambodia to fully and actively participate in the implementation of climate change convention, additional technical and institutional capacity building programmes are very important. The staff involved in climate change activities should always be up to date with recent developments. The following training activities are required to enhance the capacity of the members of the National Technical Committee:

- Training on basic environment concepts and economics of climate change projects;
- In-depth technical trainings on GHG mitigation analysis and vulnerability and adaptation assessment;
- Energy data development (demand analysis, forecasting);
- Advanced English language training, and training on negotiation skills.

Members of the National Technical Committee representing future Cambodian capacity in the field of climate change

Because of the importance of land use change and forestry and agriculture sectors, in terms of economic development and GHG emission/removal, priority should be given to improving activity data and emission factors of these sectors. In addition, future climate change initiatives should be made in the following priority areas: renewable energy development and other cross-sectoral initiatives such as assessment of climate change impacts on biodiversity, assessment of climate change impacts on the Tonle Sap ecosystem, climate change and conservation, climate change and water resource, etc. Climate change awareness raising programme and technology transfer should also receive due attention.

Cambodia needs also to strengthen its institutional capacity in the field of climate change. A permanent, cross-sectoral agency that will involve all concerned stakeholders should be established to serve as a policy-making body and to oversee all climate change-related activities.

Cooperation and exchange of information between government institutions, with countries in the region, as well as international organizations, are crucial.

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