Climate Change Mitigation in Asia and Financing Mechanisms

Proceedings of a Regional Conference
Goa, India, 4-6 May 1998

Edited by P.R. Shukla and Pramod Deo

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

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EDITORS' INTRODUCTION

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EDITORS' INTRODUCTION

P.R. Shukla and Pramod Deo

Aims and Structure of the Workshop

The pertinence of the conference theme "Climate Change Mitigation in Asia and Financing Mechanisms" is self-evident from the rapidity with which the climate change negotiations have progressed. The negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) culminated in the Kyoto Protocol in December 1997. The UNFCCC objectives require the mitigation of greenhouse gas (GHG) emissions to be achieved cost effectively. The implementation therefore requires using the instruments and mechanisms that lead to global cost effectiveness. Financing mechanisms have a vital role in this regard. Following the Earth Summit, the Global Environment Facility (GEF) was designated on an interim basis for financing the incremental cost for mitigation projects in developing countries. The UNFCCC also established a pilot Activities Implemented Jointly (AIJ) mechanism for bilateral implementation of mitigation measures. The Kyoto Protocol has proposed a new mechanism - Clean Development Mechanism (CDM) - for co-operative mitigation between the developing nations who have no binding emissions/ limitations/ commitments and the industrialised nations who have binding commitments under the Protocol. While the international community operationalises the CDM, the World Bank is seeking feedback on the Prototype Carbon Fund (PCF) as one of the potentially many ways for operational entities to function under the CDM.

The three primary objectives of the conference, which was organized by the UNEP Collaborating Centre on Energy and Environment (UCCEE) in conjunction with the Environment Department of the World Bank, at Goa in India from May 4 to 6, 1998, were - i) to share the GHG mitigation experiences from Asian developing countries, ii) to disseminate the standard methodological approach for mitigation analysis developed by UNEP and its applications in different countries, and iii) assess the role and efficacy of financial mechanisms and to, specifically, seek feedback on the Prototype Carbon Fund proposed by the World Bank. Following these objectives, the

workshop presentations and discussions were structured in three parts. In the first part, participants from eleven Asian developing countries made presentations that were followed by discussions. The second part included the presentations by the experts from UCCEE, UNFCCC and other invited experts who presented the mitigation methodology and the issues and experiences relating to various co-operative implementation mechanisms. The third part included the presentations by the World Bank representatives on the Prototype Carbon Fund and the discussions on financial mechanisms.

Keeping in view the workshop structure the proceedings of the workshop are organized in three sections: Section I include country papers and presentations provided by participants from eleven Asian countries. Section II includes the papers and presentations from UCCEE, UNFCCC and invited experts. Section III includes the documents and presentations on PCF provided by the World Bank.

UNEP Studies and UNEP/GEF Project

An important background to the conference has been the UNEP Greenhouse Gas Abatement Costing Studies initiated in 1991 by the UNEP and the "UNEP/GEF Greenhouse Gas Limitation Project" initiated in 1996 by UCCEE and financed by GEF through UNEP. The Costing Studies, coordinated by UCCEE, started the work of developing the methodological framework and testing of the framework through practical application in ten countries. The results of the Phase II studies were published in 1994. The results of Phase III studies, which included applications in two countries and extended the coverage to include more gases and sectors, were published in 1995.

These experiences led to launching of the "UNEP/GEF Greenhouse Gas Limitation Project" in 1996. The project was initiated by UCCEE and is financed by GEF through UNEP. The UCCEE worked in collaboration with Lawrence Berkeley National Laboratory (LBNL) for developing methodological framework for national mitigation analysis. Country teams in eight countries carried out mitigation studies. The study teams included national organisations and government agencies. The participant countries, chosen from among number of national requests, covered the developing countries from Africa, Asia and Latin America as well as transition

economies from Eastern Europe. In some countries, the mitigation studies have been completed, while in others they are nearing completion.

Alongside the UNEP/GEF project, a number of studies were initiated by UCCEE with DANIDA assistance and UCCEE was actively involved in UNDP/ GEF capacity building projects. In all the studies have covered fifteen countries having diverse mix of economic development, land use pattern, resource endowment etc. The diversity has helped the development and validation of methodological guidelines under varied conditions. This experience provided a rich background for the conference. The papers and presentations in the proceedings by the experts and the representatives from countries that participated in the country studies programme reflect this experience.

Section I: Country Papers and Presentations

The country papers and presentations, received from all the eleven participating countries, represent the experience with mitigation analysis in these countries. Most country papers report the GHG inventory assessment, besides providing an analysis and prioritisation of mitigation options. This information makes the proceedings a very rich source of inventory data and a compendium of mitigation analysis and implementation experience.

Bangladesh

The paper from Bangladesh contains important discussion of the climate change related concerns of a developing nation that faces severe impacts. It also lists the previous studies related to climate change analysis conducted in Bangladesh. Very useful information about the sources and quantum of carbon dioxide and methane emissions is provided. The highlight of the paper however is the discussion on mitigation strategy which shows that major options for Bangladesh are increased use of natural gas, energy efficiency, energy pricing reforms and enhanced funding by adopting active policy related to AIJ.

China

The contribution from China is a brief summary paper that highlights main points of the presentation by Chinese delegation attending the workshop. The paper provides useful demographic, economic and resource endowment related information. The paper provides insightful summary of China's contribution and efforts for climate change mitigation. In this context, the mitigation options are identified in the paper are : family planning and population control, energy conservation, increased use of renewable energy and afforestation.

India

The paper from India presents the results of the mitigation study carried out for India under the Asia Least-Cost Greenhouse Gas Abatement Strategies (ALGAS). The analysis uses a bottom-up energy systems model - MARKAL and Analytical Hierarchical Process (AHP). The discussion on construction of the baseline scenario contains useful information for model users. Comparing the results of mitigation scenarios with the base line scenario identifies mitigation options. The paper contains rich information about the energy and emissions trajectories for India till the year 2020. The CERI (Cost of Emissions Reduction Initiative) provided in the paper furnish important policy relevant information on incremental mitigation costs for India. The prioritisation of the mitigation options is done with AHP using four criteria : CO_2 abatement potential, feasibility, secondary benefits and consonance with national development priorities. The highlight of the paper is a ranked list of mitigation technology options in power sector. The best options from abatement cost criteria among the conventional power technologies are the Cogeneration and Combined Cycle and among renewable power technologies are the Small Hydro and Biomass. The sensitivity to the variability of AHP procedure are well discussed by considering two different expert assessments. The paper finally provides a list of barriers to the selection and implementation of the options.

Indonesia

The Indonesian paper discusses mitigation options in the forestry sector. The MARKAL model is selected for the analysis. Paper lists the forestry options considered in Java and Sumatra and presents the mitigation related input data for the forestry sector. Since the model is still under development, the paper does not provide the results of the mitigation analysis.

Lebanon

Paper from Lebanon provides an executive summary of a country report on GHG inventories. The GHG inventory for seven gases is provided for 1994. The emissions data are provided at disaggregated sector levels, which include energy, industry, agriculture, and land-use changes and forestry sectors. Emissions from other sectors such as urban waste are also assessed. The paper provides an analysis of the global warming potential of GHG emissions from Lebanon.

Malaysia

The paper from Malaysia discusses the activities initiated that have implications for GHG mitigation and institutional as well as capacity building tasks undertaken in the country. The energy sector, which is identified as a major contributor to the GHG emissions, the main options identified is the substitution of oil by hydro and gas and the use of more efficient combined cycle gas technologies. In the forestry sector, the major options include the rehabilitation of logged-over area to permanent forest. The air quality regulation, in force since 1974 and amended in 1985, has also contributed to mitigation of GHG emissions. The measures for air quality improvement, such as use of natural gas in public service vehicles also have secondary benefits of GHG mitigation. The paper argues that formation of National Climate Committee in 1994 is a major institutional development for effective implementation of climate change commitments. The paper provides very useful information about the on going enabling activities as well as awareness and capacity building actions undertaken at the initiative of Malaysian government.

Pakistan

The proceedings contain a paper and a presentation from Pakistan. The paper includes results of the mitigation studies from Pakistan. Some very useful information available in the paper include: i) national inventory of sources and sinks of CO_2, CH_4 and N_2O for Pakistan for the year 1989-90, ii) baseline projections for GHG emissions till year 2020, iii) identification of mitigation options and opportunities, iv) a detailed

abatement scenario for the year 2020 which includes least cost actions in energy, forestry and agriculture sector, and v) a list of five GHG abatement projects which can be undertaken on priority basis. The presentation from Pakistan includes various tables and charts which quantifies the GHG inventories, future emissions, mitigation supply curve, incremental costs and mitigation potential for different options and implications of mitigation actions for Pakistan's future energy scenario. The conclusions identify a need for institutional reforms such as development of a Climate Change Cell in the Ministry of Environment and a Climate Change Committee. The recommended policy reforms include removal of cross subsidies in energy prices and the restructuring of public utilities. The paper concludes with the recommendation of shifting towards sustainable development policies as the best and lasting solution to the climate change problem.

Philippines

The paper from Philippines provides some results from the country study project. The paper provides a detailed and informative table on National GHG Inventory in 1990 for five greenhouse gases, five major sectors and twenty-seven sub-sectors. The emissions scenario till 2020 is specified together with sectoral details. The paper contains very interesting discussion of policies and measures in the energy sector proposed under the Philippine National Action Plan. Besides, energy sector, mitigation policies and measures are identified also for agriculture sector. The merit of the analysis includes identification of mitigation actions in different time frames and mitigation costs.

Sri Lanka

The paper is based on Sri Lanka country report for the mitigation study sponsored by the Asian Development Bank (ADB). Interestingly, the analysis suggests that methane from agriculture is the largest contributor to GHG emissions and contributes 38 percent to GWP in 1990. The analysis covered includes energy, industry and agriculture sectors. Analysis, spanning from 1990 to 2005, uses the MARKAL-Macro model. The energy sector analysis is performed at disaggregated sectoral levels - for power, transport, residential and industry sectors. Major mitigation options recommended include DSM in electricity sector and improvement of appliance efficiencies in other sectors, using compressed natural gas as fuel in road vehicles,

reducing materials used in industrial processes and improvement of cultivar for rice paddy to mitigate methane emissions.

Thailand

The proceedings include a presentation from Thailand that provides useful data and insights into mitigation analysis. The detailed GHG inventories provided for the year 1990 show that the energy and land use change (including forestry) sectors contribute 35 percent each and agriculture 24 percent of CO_2 equivalent emissions. The contribution of different GHGs to the GWP in 1990 is: CO_2 - 73%, CH_4 - 25% and N_20 - 2%. The projections made till the year 2020 suggests a very rapid increase in emissions under a business-as-usual scenario (BAU). Under the BAU, the power plants and industry are expected to contribute to over 60 percent emissions in 2020. Priority mitigation options are therefore suggested for the power sector which include switching to natural gas for power generation and promotion of microhydro electricity generation projects. Other prominent mitigation options suggested are in the forestry sector which include improved forest management and participation of private sector in reforestation.

Vietnam

The Vietnam paper is a comprehensive national report on GHG limitations. The report lists climate change related studies carried out in Vietnam. The GHG inventory reported for the year 1993 suggests that agriculture, energy and forestry are the largest emitters in that order. The mitigation analysis is carried out by making projections till year 2030. Energy sector mitigation analysis uses EFOM-ENV model. For forestry sector analysis COMAP (Comprehensive Mitigation Analysis Process) model is used. Baseline and abatement scenarios are reported for agriculture, energy and forestry sectors. Prominent mitigation options identified in these sectors include: energy efficiency improvement on the demand side, fuel switching and wind power in power sector, reforestation and water management and improved nutrition in agriculture and feed management for livestock. CERI curves which are provided for each sector provide very useful and insightful information. The highlight of the report is the detailed GHG mitigation strategy plan which enumerates the mitigation options and

discusses for each option the aspects of finance, government policy and institutions that are vital for implementation of the mitigation strategy plan.

Section II : Contributions from UNEP, UNFCCC and Invited Experts

The papers and presentations in this section contain methodological and conceptual inputs contributed by experts. These inputs provide excellent information and guidelines for the countries to develop and implement mitigation portfolio. Following is the summary of the four contributions included in this section.

Contributions from UCCEE

The presentation and a paper from UNEP Collaborating Centre on Energy and Environment dwells on the important theme of economics of GHG limitations. These documents provide comprehensive and systematic guidelines for assessing the climate change mitigation projects. The guidelines deal with description of national social and economic framework, baseline scenario, mitigation scenarios and projects, assessment of macroeconomic impacts of climate change strategies and implementation issues. An important contribution of the paper is the pithy and trenchant description of cost concepts and cost assessment approaches. Another valuable contribution in the paper is a framework for integrating quantitative and qualitative assessment of impacts. The paper contains very useful methodological information on multi-attribute analysis, sectoral and macroeconomic assessment and policy formulation and implementation. The UCCEE documents included in these proceedings have immense value for national and global policy analysts, policy makers, project developers and financial institutions.

UNFCCC Documents

The UNFCCC documents contain a paper and a presentation that discusses issues related to three co-operative instruments in the context of the Kyoto Protocol. Two of these - Joint Implementation: JI (Article 6) and International Emissions Trading: IET (Article 17) are for co-operative transactions of emissions among parties in Annex B of the Protocol. The third instrument - Clean Development Mechanism (CDM) - extends the scope for transactions with rest of the countries. The paper discusses the

mandates of these instruments and the issues concerning the mandates and the design of the mechanisms. The paper discusses differences in issues originating from project based nature of JI and CDM and inventory based character of IET. An important contribution of the paper is a discussion of cross-cutting issues which are critical to equalise the marginal value of mitigation across the instruments. The proposed work programme for COP4 contains a valuable agenda for the policy makers and negotiators.

Contribution by Invited Expert Dr. Anil Markandya

This paper provides an excellent introduction to assessment of indirect costs and benefits of GHG limitations. The vital contribution of the paper is the framework for comprehensive assessment of all impacts of GHG limitation projects. The discussion on the quantification of indirect impacts contain very valuable information for analysts. The brief discussion on case studies concludes with an important observation about the wide difference between financial and economic cost assessment. The paper drives home a very important point that the indirect costs of GHG projects are often more important than the direct costs.

Contribution by Invited Expert Dr. Jayant Sathaye

This paper deals with the emissions mitigation in energy sector. A brief description of the mitigation studies methodology is highly readable and informative. The most important contribution of the paper is the key findings from energy sector mitigation studies in several developing countries from Africa, Asia and Latin America. The analysis shows wide diversity of mitigation potential and options across the countries. The paper provides useful caveat on definition of baseline and resulting anomalies. The section on implementation of mitigation options in developing countries contains important information and suggestions for removal of barriers for realising a cost effective mitigation strategy.

Section III : Documents and Presentations from the World Bank

The World Bank documents and presentations provide comprehensive information about the Prototype Carbon Fund (PCF) proposed by the Bank as one of the many ways that operational entities can operate under the clean development mechanism

(CDM) for developing countries and joint implementation for Annex I countries of the UNFCCC. As a financial instrument, PCF intends to achieve the mitigation of GHGs listed in the Kyoto Protocol while supporting long-term efforts to create a carbon trading market through project based offsets and promoting sustainable development in developing countries.

The World Bank documents contain comprehensive information about the mission, objectives, purpose and operational details of PCF. The material in these documents provides cogent information about development of the carbon offset market in the context of the Kyoto Protocol. The documents are also a rich source of information for national policy makers, planners and project developers, who can find useful guidelines for evaluation of project and opportunities for participating in future carbon offset market that the implementation of the Kyoto Protocol will create.

An important agenda of the workshop had been the discussion and feedback on PCF by the participants from potential host countries. The presentations by the World Bank team provided a comprehensive coverage of PCF which enabled the participants to provide important feedback to the World Bank team. The summary document prepared by the World Bank team at the conclusion of the workshop is included in the proceedings. The summary contains a description of the basic features of PCF which were presented at the workshop and the response of the World Bank team on the issues raised by the participants during the discussions in the workshop.

Final Comments

These proceedings contain very useful material that can be of considerable use to policy makers, analysts, national planners and other stakeholders in GHG mitigation. The country studies (Section I) contains very rich empirical data and analysis of potential least cost mitigation actions in eleven developing countries in Asia. The country papers are also a valuable source of information for identification of projects by governments, NGOs and the private companies interested in GHG emissions mitigation projects. The papers from UN organizations and experts (Section II) contain excellent conceptual materials on mitigation cost assessment, guidelines for the countries to develop mitigation portfolio and information about the financial

mechanisms under the Kyoto Protocol and issues thereof. The World Bank documents (Section III), besides containing comprehensive information about the proposed Prototype Carbon Fund, also include very useful conceptual and practical discussion related to development of project based carbon offsets generation and trading and financing of mitigation projects. Thanks to the excellent contribution by the authors and the participants of the workshop, we believe that the wealth of information contained in these proceedings, will be a source for cost-effective decisions on GHG mitigation and also contribute to achieving the ultimate objective of the UNFCCC.

P.R. Shukla and Pramod Deo
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SECTION I

COUNTRY PAPERS

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COUNTRY PAPER

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Climate Change Mitigation in Asia and Financing Mechanisms
(contributions from Bangladesh)

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At present the whole world is beset with grave environmental problems resulting in ecological imbalance caused by greenhouse effect, climate change, depletion of ozone layer, desertification, global change and sea level rise etc. All of the factors mentioned above are threatened the very existence of living beings on earth. Due to shortage of time I would like to place a short discussion on "Climate change mitigation in Asia and Financing Mechanisms". Climate change is a major Global problem it is a problem which can never be solved unless all nations and peoples tackle it with the same idea and enthusiasm regardless of their races and nationalities. We need a powerful worldwide collaboration setup to solve all sort of problem excluding natural problem. Greenhouse effect plays an important role to change Global climate. Now question may arise what is greenhouse effect and how it may effect of climate change?

2.1 Greenhouse effect: The Science

The temperature of greenhouse is raised by using a shield through which solar radiation is allowed to enter but the consequential heat is prevented from escaping. In a roughly analogous manner, certain trace gases in the atmosphere notably carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapour, ozone (O_3) and the chlorofluorocarbon (CFs) are transparent to high energy solar radiation having short-wave length, but absorb long-wave terrestrial radiation, thus trapping heat in the lower atmosphere. The global atmospheric concentrations of these trace gases have been increasing, largely due to human activities, and likely to increase substantially in the future. The result in theory, warming of the Earth's surface and lower atmosphere.

2.2 The phenomenon has become known as the "Greenhouse Effect" in popular terminology, and its consequential effect is known as "Global Warming". The gases responsible for this are known as Greenhouse Gases (GHGs). The magnitude of this warming would depend on the rate of increase in the concentration of greenhouse gases involved and the complex feed-back processes in the earth-atmosphere system.

2.3 There exists a delicate balance between the earth's hot equatorial climate, cold polar regions, wind and rainfall patterns. With an increased load of GHGs into the atmosphere and its consequential effect, a new pattern of temperature, wind and rainfall distribution would result. It is believed that the new climate patterns would be significantly different compared to that being observed in different parts of the world.

3.1 GHGs and Their Global Emissions

The concentrations of GHGs in the atmosphere are believed to have changed naturally on ice-age time scales, and have been increasing since pre-industrial times due to anthropogenic activities. The abundance of the GHGs were relatively constant for over a thousand years prior to the industrial revolution. However, with increasing population atmospheric GHG concentrations increased significantly. Evidences from air trapped in Antarctic and Greenland ice shows that there have been major increases in the concentrations of radiatively active gases since the beginning of the industrial revolution.

3.2 The important issue in the emission of GHGs is the large gap between the developed and the developing countries. Both the developed and the developing countries are emitting GHGs and contributing to the GHG load in the atmosphere. The rich developed countries are emitting GHGs as a result of their wasteful consumption pattern and reckless lifestyle. On the other hand activities vast population living in poor developing countries also contributing to the GHG load. The per capita GHG emission by industrialised countries is about 6 times the world average emissions, while GHG emissions from USA alone accounts for 20% of the total global emissions.

3.3 Countries like Bangladesh are not big GHG emitters. Unfortunately, as predicted by the national and international communities involved in climate change impact assessments, poor countries such as Bangladesh would be the worst victims of climate change and sea level rise.

4.1 The Global Concern and IPCC

In response to growing international concern about the threat of climate change, in 1988 the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) jointly established the Intergovernmental Panel on Climate Change (IPCC). The IPCC drew together hundreds of world's leading scientists and policy makers, from both developed and developing countries. In 1990, IPCC published its First Assessment Report.

4.2 According to the second assessment report of IPCC, published in 1995, the scientists believe that the basic understanding of climate change and the human role therein, as expressed in the earlier 1990 report, carbon dioxide remains the most important contributor to anthropogenic forcing of climate change. In a short period future mean temperature change and sea level rise will alter the earth's climate to an extent unprecedented in human history. Many important aspects of climate change are effectively irreversible.

4.3 The second assessment report said that if carbon dioxide emissions were maintained at near current (1994) levels, they would lead to a nearly constant rate of increase in atmospheric concentrations for at least the next two centuries, reaching about 500 ppmv by the end of the 21st century. It is, by comparison, twice the pre-industrial level concentration of 280 ppmv.

4.4 The 1995 IPCC assessment report reveals that the recent years have been among the warmest since 1860, the period of instrumental record, despite the cooling effect of the 1991 Mount pinatubo volcanic eruption. The global sea level rose between 10 to 25 cm in the last 100 years mainly due to an increase in global mean temperature by 0.3 to 0.6 degree Celcius.

5.1 Sea Level Rise

One of the most important consequences of an increase in mean global temperatures will be a possible rise in the sea level around the planet. The reasons for this rise in sea level include:

- The expansion of the ocean's volume when water temperatures increase. Although small, such thermal expansion can translate to a considerable rise in mean sea levels.
- Mountain glacier melt will also contribute a sizeable amount of water to the oceans, which will also contribute to sea level rise. It should be noted that such mountain glacier melt will not only contribute to sea level rise once the water reaches the sea, but will also contribute to increased flooding in floodplains.
- Meltwater from the land is expected to be the third component.

5.2 In addition to the rice in sea level due to increased temperatures, as described above, the land surface of the planet is also undergoing changes in elevation due to a number of factors, including tectonic changes, sedimentation etc. The actual amount of sea level rise at any given point along a coast will always depend on the movement of the land surface and be felt as relative sea level rise.

5.3 The report said that the average sea level would continue to rise as a result of thermal expansion of the oceans and melting of glaciers and ice sheets. The report examined different possible scenarios of greenhouse gas emission, corresponding rise in global mean temperature and came to the conclusion that over the 2100 A.D. sea level could rise at a similar rate in future centuries beyond 2100, even if concentrations of GHGs were established by that time, and would continue to do so even beyond the time of stabilisation of global mean temperature. Regional sea level changes may differ from the global mean value owing to land movement and ocean current change.

6.1 Climate Change and Concern of Bangladesh

Bangladesh one of the most densely populated countries in the world with over 755 people per square Km has a per capita income only about US$ 235. Over 40% of the population live in poverty. With its high population density, low level of development, and low lying deltaic mass, Bangladesh has already been facing a number of natural and man made problems. Natural hazards like cyclones, floods, droughts and socio-economic problems such as poverty, low literacy, poor health delivery systems, high unemployment are some of them. In the future Bangladesh may also have to face adverse impact of development across its border - which among other things, are expected to have reduced availability of water during the dry season and has to deal with impacts of climate change and sea level rise. To better prepare the country for dealing with these impacts pragmatic planning is needed based on authentic data and analysis from scientific studies.

7.1 Previous Studies in Bangladesh

There has been a number of studies conducted on climate change issues in Bangladesh. The first major study on effect of climate change and sea level rise on

Bangladesh was conducted in 1989 (Mahtab, F., 1989). Subsequently various other studies were carried out in the early nineties. The latest and up-to-date amongst those studies are (i) Country Study on Bangladesh under Technical Assistance from the Asian Development Bank (BDB, 1994), (ii) The Study on Greenhouse Effect and Climate Change in Bangladesh, undertaken jointly by Bangladesh, Unnayan parishad, Centre for Environmental and Resource Studies, New Zealand and Climate Research Unit, U.K., and (iii) Assessment of Vulnerability of Bangladesh of Climate Change and Sea Level Rise: A Pilot Study, jointly conducted by Bangladesh Centre for Advanced Studies, Resource Analysis, The Netherlands and Approtech Consultants Ltd. All these studies were based on secondary data. The findings indicate that detectable changes may be underway and Bangladesh would be hard hit by the impacts of climate change and sea level rise. As a consequence its agriculture, forestry, infrastructure, communication, and different other sectors of economy would be severely affected. The country would be more vulnerable due to increased inundation, drought, cyclone and high tides.

8.1 Study Background and Objectives

The Department of Environment (DOE), Ministry of Environment and Forest, Government of the People's Republic of Bangladesh made a request for a grant to the U.S. Government for studying various aspects of climate change and its implications for Bangladesh. Upon its subsequent approval, a country Study on Climate Change (Bangladesh Climate Change study) was launched in October 1994 to address the following major issues:

- Preparation of a country-specific inventory of greenhouse gases (GHGs).
- Assessment of vulnerability of the country, with special respect to climate change.
- Assessment of mitigation options to develop appropriate strategies and policies for reducing GHG emission into the atmosphere.
- Recommendations for an appropriate awareness and dissemination programme based on findings of the above components.

8.2 The Government formed a study team drawing upon expertise from various organization, government agencies, public and non-government research bodies and the universities for conducting the country study. The Director General of the DOE has been nominated as the national coordinator for the study while a senior level researcher from a public research organization has been appointed as the over-all technical team leader. Each of the four components of the study also had a specific study team again formed on the same basic principle of drawing expertise from various sources.

8.3 At the apex level, two committees were formed. One of these, the National Advisory Committee, headed by a reputed senior scientist and drawing upon personnel from various concerned agencies and ministries of the Government provided professional advice to the study teams in their investigation and analysis. The National Steering Committee, again drawing upon concerned

ministries and their subordinate agencies, but this time headed by the Secretary of the Ministry of Environment and Forest, exercised the final administrative jurisdiction over the course of the study and the approval of the findings before their submission to the US country studies Management Team, the administrative arm of the sponsor, for its final approval.

8.4 The greenhouse gases which effect the climate change are carbon dioxide, methane, nitrous oxide, water vapour, ozone and the chlorofluorocarbons. In respect of five greenhouse gases Bangladesh only emitting carbon dioxide and methane. Commercial or fossil fuel (natural gas petroleum, coal and hydropower) is the main source of carbon dioxide emission. Biomass fuel (agriculture residue, tree residue, fuel wood and dung) also play a great role for the emission of carbon dioxide.

9.1 Carbon dioxide emission

The commercial or fossil fuel is supplied from the following sources:

i) Natural gas (indigeneous)
ii) Petroleum
   a) Imported petroleum products
   b) Imported crude oil
   c) Local crude oil from Haripur Oil Field
i) Coal, primarily imported, and
ii) Hydropower.

9.2 Among these, the last one is not used for estimation of any carbon dioxide emission. Several studies carried out on the emission of carbon dioxide from different sources Bangladesh estimate the following:

- The total carbon dioxide released from all primary fossil fuel use in Bangladesh amounted to 13,443 Gg in 1990 (base year).
- The corresponding value of carbon (oxidized) amounted to 3,666 Gg in the base year.
- On a per capita basis the above values of carbon dioxide and carbon emission (1990 population being 109 million) amounted to just about 123.3 and 33.6 Kgs respectively.
- Biomass combustion caused an annual release of 61283.7 Gg of CO_2 in 1990. the emission from agricultural residues contributed to about 59% of total emissions from biomass energy combustion.

10.1 Methane emission

Methane is released in the process of production and distribution of natural gas. This amounted to an annual release of 6.1 Gg. Municipal landfills appears to release 73.6 Gg of methane per year. Emission from waste water is difficult to estimate due to non-availability of data and was not attempted.

10.2 By far one of the largest sources of methane is wet rice cultivation. Because of various uncertainties regarding the relevant parameters, only a range has been

estimated- The emission of CH_4 is estimated to range from 257 Gg to 622 Gg with a median value of 468 Gg. Livestocks emit CH_4 as a result of enteric fermentation and manure management. Here again there are large uncertainties. Enteric fermentation is estimated to contribure 446.8 Gg and manure management another 73.07 Gg of CH_4 making it a total of 519.67 Gg from livestock.

10.3 Land-use changes indicate a net sink effect of 6859 Gg of carbon (or 21,551 Gg carbon doxide).

10.4 Collecting all the results together and converting the release of various gases into a common unit of global warming potential, it is found that Bangladesh released 44,541 Gg of CO_2 equivalent in 1990, of this roughly 30% was due to the emission of carbon dioxide from fossil fuels. Practically the whole of the rest was from CH_4 with livestock and rice fields as major contributors. the forestry sector acts as a net sink of carbon.

11.1 Mitigation strategy for climate change

Principles of mitigation: Mitigation implies a set of actions which prevent an outcome. One of the major causes of greenhouse gas emission is inefficiency in fossil fuel and energy production, distribution and consumption.

11.2 The findings of the mitigation analysis indicate the following: Of the fossil fuels, Bangladesh has a fair reserve only of natural gas and other fossil fuels like coal and petroleum products are practically all imported.

11.3 Electricity generation depends mainly on relatively inefficient technologies while the most efficient combined cycle is used in only one plant.

11.4 Energy intensity (energy use per unit of sectoral GDP) is the highest in case of industry followed by transport sectors owing to very large degrees of inefficiencies.

11.5 The top-down and bottom-up data for energy consumption do not match. The mismatch is the highest in case of industry. Such mismatches occur in all other sectors.

11.6 In future the demand for all fossil fuels and electricity may increase. While gas reserve may dwindle the pressure on the national exchequer for foreign exchange to buy fuel from abroad for transport, electricity generation and other purpose will increase. One general way to ease the pressure is to increase efficiency in energy production, distribution and use in all sectors.

11.7 On a priority basis, generation of power, industrial and residential use of energy and energy use in transport should be the main areas of focus for mitigation. In industry major savings potential exists in boiler maintenance, use of efficient motors and also in house keeping. In the domestic sector, major efficiencies lie in lighting.

11.8 In evaluating and operationalising a mitigation strategy, with emphasis on energy efficiency, attention has to be given to the following: i) pricing energy on the basis of economic cost of its supply, and ii) technology and its cost.

11.9 There is also the international aspect of mitigation. Particularly the government should, urgently focus on generation of funds for mitigation activities through an active policy on activities implemented jointly ie nationally, regionally and globally.

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

GOA, India, 4 to 6 May 1998

COUNTRY PAPER

CHINA

Mitigating Climate Change: China's Condition and Efforts

(Main points of presentation by Chinese delegation at the Climate Change Mitigation in Asia and Financing Mechanisms, at Taj Holiday Village, Goa, India, 4 to 6 May 1998)

I. China is a developing country, although it has achieved a great success in economic development and social affairs since 1978.

A. China has the largest population in the world, or 1.224 billion at the end of 1996. That is 22 percent of world population. Although it has been experiencing a quick urbanization process, China's major portion of population are still living in rural areas. The percentage of rural population in the whole population was 81 percent in 1980, 74 percent in 1990, and 71 percent in 1996.

B. The per capita natural resources of China, i.e. fresh water, farmland, forest, and grassland, are below one third of the world average.

C. China's economic development level is both low and uneven across regions. According to UN's report in 1997, China's per capita GDP in 1996 was only 664 US dollars (for comparison, Japan 36066, US 27033, EU 20048), which tells that China is a low-income country. Per capita income of rural residents is only 340 US dollars. To the end of 1996, China still has 58 million people stricken by poverty, by the standard of per capita net income of 100 US dollars.

D. Coal dominates China's energy supply. It covered 75 per cent in 1996. The total amount of energy consumed by every Chinese equals 1.13 ton of standard coal in 1996, which is 1/11 of US, 1/6 of Japan, 1/5 of UK, or 1/2 of world average. Per capita electricity consumption of China is 863 KWh, in which daily life uses only 80 KWh. In exploiting and using energy, old technologies are still employed, and the comprehensive technical level is at least 10 to 15 years behind that of developed countries. The energy industry is checked by pressures both from the supply side and from the environmental protection.

II. China's contribution and effort to mitigate the climate change

A. Family planning and population control

- The population growth rate in China has been reduced. The birth rate was reduce from 2.106 percent in 1990 to 1.698 percent in 1996, while the natural growth rate was reduced from 1.439 percent to 1.042 percent.

B. Saving energy by improving efficiency in using energy

- The essence of China's energy policy is saving energy through technical improvement and energy efficiency upgrading. From early 1980's, a series of economic and technical policies have been adopted to save energy. The 1990-1995 period has seen a reduction of 1/4 in terms of energy consumption per unit GDP, that is equal to saving 358 million tons of standard coal. Many industrial products tell the same trend in this period. For example, in iron and steel industry the unit consumption of energy reduced 10 percent; in electric power industry, 3.5 percent; in the non-ferrous industry, 16 percent. Last year, China made the Saving Energy Law, which will put the work to a further step.

C. Make a better structure of energy supply through developing new forms of energy and renewable energy

- The government have been intensifying the development of hydraulic power, petroleum, natural gas, and coal bed gas by means of policy incentives and capital investment. The government also encourage the development of large scale nuclear power projects in the coastal areas where energy supply can not meet the economic development. The development of new forms of energy and renewable energy in rural and remote areas are also encouraged.

- To the end of 1995, the use of new and renewable energy has reached 300 million tons of standard coal annually; the scale of methane generation system has been further enlarged to 1.5 billion cubic meter, and there are 5.7 million household methane generating pits; wind power capacity has reached 30 MW.

- The major limitation to the development of renewable energy in China is the lack of money and technology.

D. Planting trees

- Forest coverage in China is only 130 million hectares, or 0.11 hectare per person, which is 11.7 percent of world average.

- The government has successfully finished five major ecological forestry projects, along coast, major rivers and mountains, around farmlands, and combating desert in Northern China. In contrast to the global trend of forest decreasing, China's forest coverage and livestock is rising. In fact, China has the largest area of artificial forest in the world. The government has set the target of forest coverage rate at the year 2010 as 17 percent.

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

GOA, India, 4 to 6 May 1998

COUNTRY PAPER

INDIA

Asia Least-cost Greenhouse Gas Abatement Strategy Identification and Assessment of Mitigation Options for the Energy Sector

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UNEP- World Bank Conference on
Climate Change Mitigation in Asia and Financing mechanisms
4-6 May, 1998
Goa, India

The focus of the presentation was on greenhouse gas mitigation options for the energy sector for India. Results from the Asia Least-cost Greenhouse gas Abatement Strategies (ALGAS) project were presented. The presentation comprised of a review of the sources of greenhouse gases, the optimisation model, ie the Markal model, used for determing the least-cost options, discussion of the results from the baseline and the abatement scenarios. The second half of the presentation focussed on a multi-criteria assessment of the abatement options using the Analytical Hierarchical Process (AHP) model.

The emissions of all greenhouse gases, for India, are estimated to be 986.3 Tg of carbon dioxide equivalent for 1990. The energy sector accounted for 58 percent of the total emissions and over 90 percent of the CO2 emissions. Net emissions from land use change and forestry were zero.

The MArket ALlocation (MARKAL) model is an energy sector model based on the end-use approach. The MARKAL is a dynamic, linear optimization model for the energy sector, was used in estimating the baseline and the abatement scenarios for India till 2020. The objective function of the model is to minimize the cost of energy supply and use in the economy. The model solves to determine the least-cost options to meet a given level of useful energy demand. To determine the cost of carbon abatement, imposing a constraint on the total level of carbon emissions in the model gives the least-cost energy mix under stricter or controlled conditions for carbon emissions. The difference in the system costs of carbon-constrained scenarios, and the unconstrained scenario reflects the additional cost of abating carbon for the energy sector.

The model operates by minimizing an objective function (system cost) over a fixed time frame and yields the least cost mix of technologies needed to meet the projected demands. The advantages of such a modeling approach to technology comparison as opposed to other methods is that a more realistic solution can be obtained for the contribution of a technology to the energy system, both in terms of magnitude as well as timing. This is possible since the model makes a time integrated analysis of the energy system rather than a snap shot approach, and because it accommodates feedback and competition between supply and demand side technology options. Moreover, in addition to yielding estimates of the role of specific energy technologies under cost optimal conditions, the model also makes it possible to investigate the change in their potential contribution when more stringent policy constraints like the possible adoption of CO_2 taxes or emissions control are applied. The model can therefore provide a merit ranking or the relative attractiveness of each technology considered. It is important to highlight that such a modelling framework, is useful for scenario analysis rather than for determining the future energy scenario.

In the study for India undertaken by TERI, scenarios are differentiated by varying the energy related parameters and the discount rates. The underlying macroeconomic factors remain unchanged across all scenarios. The most likely scenario has been identified as the *baseline scenario* against which all references are made. The baseline includes some carbon abatement technologies which are likely to be used in the future with or without considerations for reducing carbon emissions. This scenario includes the autonomous energy efficiency improvements which are likely. The scenario with maximum options to abate CO_2, that is, in terms of technological options available,

earlier start dates, efficiency improvements and/or a decline in costs for the low CO_2 options, is defined as the *Comprehensive scenario*. On the other extreme, there is the *Past Trends Continue (PTC) scenario*. This describes the projection of past trends and has limited carbon abatement options. Within the two extremes of the scenario and the Comprehensive scenario lie a number of possible scenarios, including the baseline scenario.

The baseline scenario is used as the basis for comparing other scenarios. The baseline scenario is not just a projection of past trends but consists of technological options which are likely to be included in the normal course of economic growth and were/are not necessarily available in the past or currently. In all scenarios, assumptions regarding the driving forces, that is, the GDP rate of growth, population growth, income class distribution and end-use demands are constant (Table 3.28). In other words, variations in scenario are due to the differences in the energy sector. Average annual GDP growth is 6.1% in 1990-2000, 5.8% in 2000-10 and 5.6% in 2010-20.

There are a number of different cases which have been considered in the analysis. These are the Baseline, Past Trends Continue (PTC) and the Comprehensive (COMPRE) scenarios. For each scenario, there is a base case and different abatement cases where, reductions in cumulative carbon emissions for the time-period 1990 to 2020 of 5, 10, 15 and 20 percent are imposed. For a *particular scenario,* the technological options available are the *same* in the basecase and in the abatement cases. The options available (in terms of availability and the upper bound) *vary across different cases*. For example, the COMPRE scenario, which represents a high policy initiative scenario, more technologies (Options A, B and Cin the table below) are available which are not available in the Baseline case (only Options A and B). Carbon abatement and incremental costs are estimated using the Baseline base case. Within a particular case (for example, the Baseline) the technologies available are the same, however, in the unconstrained base case the low cost, high CO2 option is the least-cost solution (Option A) despite the availability of a low CO2 but high cost option (Option B). Both the options are available in the unconstrained base case and in the abatement scenarios, however, the market penetration of these differ to yield the least-cost solution for each scenario. This implies that a negative cost for carbon abatement is not possible within a particular case. As the Baseline basecase is the reference, the CERI curve for the COMPRE appears as a negative intercept on the incremental cost axis (here more options are available which give a lower energy system cost for the basecase, i.e., *x-a*).

Case	**Baseline**		**COMPRE**	
Scenario	Base	Abatement	Base	Abatement
Energy system cost	x	x+y	x-a	x-a+z
Cumulative CO2 emissions	100	95	98	95
Incremental costs	-	y	-a	-a+z
Abatement of CO2 emissions	-	5	2*	5
Option A low cost, high CO2 Availability Selected				
Option B High cost, low CO2 Availability Selected				
Option C Low cost, low CO2 Availability Selected				

Primary Energy supply

Primary commercial energy supply in the economy increases from 6746 PJ in 1990 to 29717 PJ in 2020. The annual rate of growth decreases for each subsequent decade. Most of the coal is produced indigenously. The growth in oil demand out paces domestic production, resulting in a higher percentage of demand being met by imports. Indigenous reserves of gas are limited and in 2020, 2945 PJ of natural gas is imported, which is approximately 85 percent of the gas used in the Indian economy in that year.

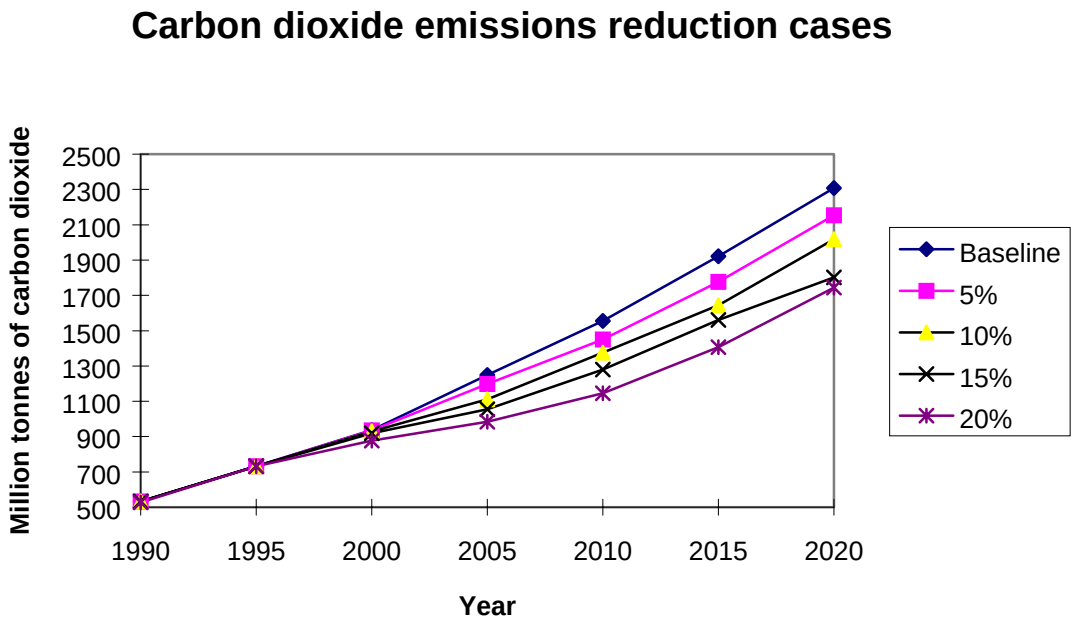
The results indicate that by 2020 India would have achieved a per capita income level of 1000 US$ (1990 prices) compared with the average world per capita GDP of 4200 US$. Per capita emissions for India in 2020 would vary between 460-485 kgC compared with 1991 levels of 2400 kgC for Japan and 5400 kgC for the USA.

Constraints on carbon emissions were imposed on the baseline scenario. Total carbon emissions over the period 1990 to 2020 are reduced by 5 %, 10 %, 15 % and 20 %. The carbon emissions profiles for these cases are shown in the following Figure . An analysis of the results reveals that carbon dioxide abatement is brought about primarily by fuel switching and to some extent by a shift to more expensive but more efficient technologies.

Table 1: Primary energy supply - baseline scenario (PJ)

	1990	**2000**	**2010**	**2020**
Coal Indigenous Imports	3850 3850 -	7145 7145 -	10508 10508 -	15516 15167 349
Oil Indigenous Imports	2416 1410 1006	4245 1592 2653	7533 1774 5759	10723 1955 8768
Gas Indigenous Imports	480 480 -	1002 1000 2	1909 667 1242	3478 533 2945
Hydro *	249	324	625	917
Nuclear	24	31	25	12
Total commercial energy	7019	12747	20600	30646
Crop residue	763	763	763	763
Fuel wood	3134	3134	3134	3134
Animal waste	1314	1227	1113	939
Total traditional energy	5211	5124	5010	4836

Energy in electricity generated

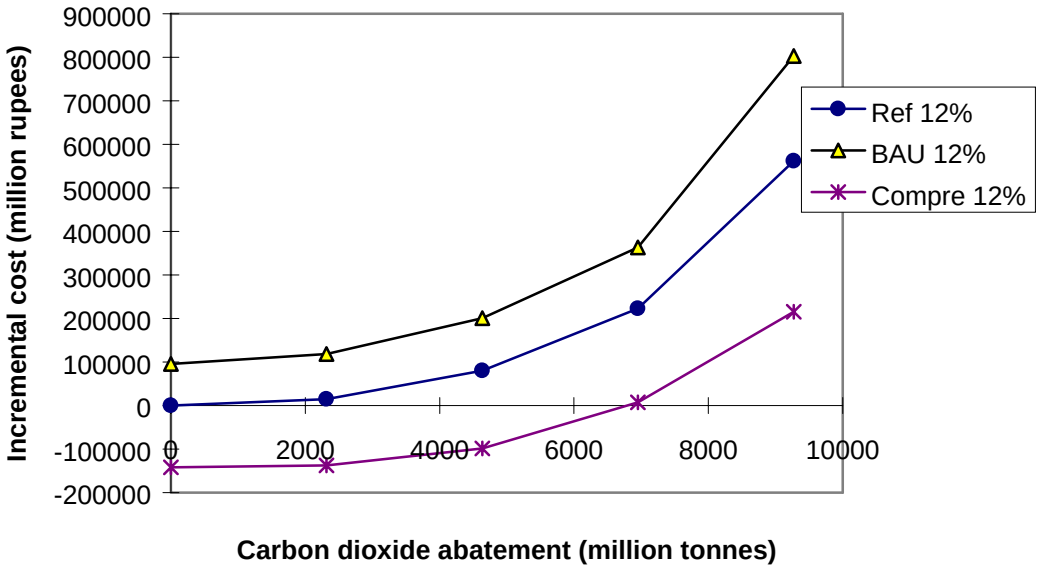


Cost of emissions reduction initiative (CERI) curves for individual carbon abating technologies, are not discussed here. Developing CERI curves for individual technologies would be necessary in an accounting framework type of model where a

ranking of the various abatement technologies is required. In an optimizing framework like the the MARKAL model, cross-sectoral abatement options are selected. Those with the least increase in the energy system costs are selected first followed by the more expensive ones as the carbon reduction requirements are increased. This results in an automatic ranking of the technologies.

In this study, CERI curves are developed for the baseline, the Past-Trends-Continue (PTC) scenario, the comprehensive (COMPRE) scenario. CERI curves for the energy-sector on an economy-wide basis, are constructed by placing a restriction on the cumulative carbon emissions for the period 1990 to 2020. The total carbon emissions are reduced by 5, 10, 15 and 20 percent of the cumulative level in the baseline, which is 46352 million tonnes of carbon dioxide. CERI curves estimated are presented in the figure. It is important to highlight that the carbon emissions in the 12 percent discount rate unconstrained baseline are the basis for comparing reductions in emissions for all cases, whereas, to estimate the incremental costs, the baseline with the corresponding rate of discount are used.

Energy sector CERI curves



The limitations of the model include: it assumes a perfect market (including perfect knowledge) and common investment criteria and behavior across all parts of the energy sector, requires detailed projections of primary energy prices and energy demands in addition to technology data, performs a limited analysis of market barriers and socio-economic factors. The results provide indications of which technologies are more suitable than others, but cannot provide strict quantitative judgements. Moreover, the economic/institutional barriers are not completely captured. The framework does not adequately capture the difference in indivual discount rates, the convenience of using and the reliability of technologies. This necessiates a detailed assessment of attractive mitigation options and others not economically attractive to be present a more realistic picture.

The MARKAL model is a dynamic optimization approach to minimize the cost of energy supply and demand. It enables an integrated assessment of energy sector related abatement options on the supply-side as well as in the end-use sectors, over time. However, technology evaluation is based on purely quantitative criteria.The assessment of abatement options on non-monetary criteria is undertaken using a multi-criteria approach using the AHP model. Although the AHP incorporates qualitative evaluations of abatement technologies, it can not facilitate an inter-sectoral analysis, nor can it capture the long-term implications at the national level. This necessitates an analysis of GHG abatement options using both the frameworks.

The second half of the presentation focused on the analytical hierarchical process for assessment of mitigation options. Although the MARKAL model provides the least cost solution for the economy, and also indicates the preferred technological options, the analysis is based on strictly quantitative assessment. However, for a comprehensive assessment and prioritization of mitigation options there are several extraneous factors, besides quantitative criteria such as CO_2 abatement potential or costs of a particular technological option, that contribute towards actual deployment of the option. These extraneous factors include criteria such as the likely integration/compatibility of an option with the overall developmental priorities of the country, socio-economic thrust of policies. It also includes other non-quantifiable criteria such as perceptions on risks associated with the adoption of the option, non-CO_2 benefits that could accrue, including other environmental benefits.

The analytical hierarchical process (AHP) provides a tool for scoring and weighting of not only quantifiable attributes of a mitigation option/technology, but also integrates “non-monetary” criteria. The process involves a scoping exercise to develop a hierarchy for evaluation. A scoring system also needs to be devised to undertake a comparative assessment. With a clear delineation of the hierarchy and the scoring system, a ranking of technologies is undertaken by analysing the composite scores, as also via sensitivity analyses.

The overall definition of the model is premised on the overriding goal of mitigation. The achievement of this goal is evaluated on the following criteria :

1. CO_2 abatement potential, which is defined as the quantity of CO_2 abated when comparing a mitigation technology with the “baseline”/“current practice” technology.

2. Feasibility of an option, which subsumes sub-criteria costs, existing policy pronouncements and packages to promote and push the option, and risks (perceived or actual) attached to the option.

3. Environmental and other benefits that may accrue.

4. Consonance with the overall development priorities of the country.

The weights for the criteria and sub-criteria are normalized to unity.

A brief mention was made of the options considered in the conventional power sector and for renewables in India. After highlighting the investment costs and abatement costs for options in this sector (Table), a presentation was made of the ranking of options in all the sectors under consideration.

Technology	**Investment cost (Rs/KW)**	**Abatement cost (Rs/kg of CO_2)**
Conventional Power		
Cogen	16234	0.18
Combined cycle	14732	0.98
ISTIG	17045	1.30
PCSCB	21645	6.17
IGCC	28409	6.13
PFBC	34090	9.06
Renewables		
Small hydro	35714	1.59
Wind farm	25297	4.64
PV	107142	9.75
Biomass	12797	1.84
Solar Thermal	67151	10.67

A summary of the priority listing that emerges from the model results is provided below in Table. Two sets of model results were presented, reflecting how the priority ranking for options may vary due to difference in weights assigned to the non-monetary criteria by two different sets of respondents.

Case 1*: AHP model results: In-house View*

As mentioned earlier, the AHP process subsumes both monetary and non-monetary criteria, and perhaps, this is the strength of the exercise. Case B, is a reflection of the scoring scheme assigned by the in-house expert.

***Case 2**: AHP model result: Alternative View*
To examine the variability in valuation of non-monetary criteria, and the impact of subjectivity on ranking, an alternative view was elicited. Only the top two technologies in each sector are reported.

Scenario	Rank	Conv Power	Ren Power	Transport	Ren for agriculture
In-house	1	Cogen	Small hydro	CNG car	Gasifier-agro
	2	Comb cycle	wind	MRTS	Gasifier-wood
Alternative	1	Cogen	Small hydro	MRTS	-
	2	Comb cycle	Biomass	CNG car	-

An exposition of how different criteria can drive the selection of a technology was provided by showing the model result for the renewables sector.

Table Percentage distribution of weights of each criteria

Option	Composite weight	CO_2 abatement	Feasibility	Other environment	Development
Small Hydro	0.290	15%	25%	5%	55%
Wind	0.244	18%	62%	1%	18%
SPV	0.200	69%	14%	6%	11%
Biomass	0.189	24%	29%	2%	45%
Solar Thermal	0.066	68%	17%	1%	0.14

The above clearly highlights that:

a. Small hydro is the preferred option not only from the point of view of tangible and quantifiable criteria of CO_2 abatement, but also from non-numeric criteria as overall development priorities of the country. In fact, bulk of the push for small hydro is ascribable to it due to its relevance in overall development plan of the country.

b. For wind power, however, the push is primarily due to the feasibility of the option. Feasibility here is a composite of costs, policy packages to promote the option and the risk perceived by investor in deploying the option. Although on the cost sub-criterion, wind is second to small hydro, but when judged on the other two sub-criterion it is by far the most preferred option. This clearly reveals that the technology is mature and the government is providing handsome packages to drive the option in the economy.

c. For the biomass powered generation option, the importance of the criteria are more or less balanced. In contrast, SPV which has a slightly higher weight than biomass, much of the thrust is due to the carbon abatement potential.

d. It may also be noted than on quantifiable criteria comparison (Table) the spread between the options is marked. But from the model ranking, it is obvious that although the ranks are similar there is not a wide disparity in the composite weights of the options. This shows the importance of planning and policy makers leanings/thrust for an option, which lend it the "preferred" status.

Finally, the presentation highlighted barriers to the introduction of select options which are provided below:

- Cogeneration: Lack of enforceable power purchase agreements
- Combined cycle power plants: Limited availability of gas
- Small Hydro: Inadequate incentives, lack of local grids near site, management capacity
- Wind Farms: High capital costs, low capacity utilization factors
- Industry: No mandatory standards, lack of Energy Service Companies and utility DSM

The above clearly highlights the relevance of legal and institutional measures in promoting a technology mix, as also the utility of AHP analysis.

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

GOA, India, 4 to 6 May 1998

COUNTRY PAPER

INDONESIA

Integrated Economic Assessment of Energy and Forestry Mitigation Options Using MARKAL

By : Indonesian Team

Introduction

There have been a number of economic assessment of GHG mitigation studies carried out in Indonesia (Sasmojo et al., 1998; Boer et al., 1998; Pawitan et al., 1998). Several alternative mitigation options for energy and non-energy sectors have been described and the economic assessment of the oprions has been done for each sectors. However, most of the economic assessment particularly for non-energy sector, was not to find a least cost option but the lowest cost options. A program called MARKAL developed by a consortium of energy specialists from more than a dozen countries (Fishbone, 1981) in the early 1980s, is a program that can be used for optimization, so that the least cost options could be selected. Indonesia has used this program intensively for energy system analysis. Attemp to use this program for other sector has not been developed as this program was designed for energy sector. Therefore, using MARKAL for other sector, all activities of the other sectors should be treated as energy activities. This study is aimed to use MARKAL for analysing both energy and forestry sector together.

This paper described briefly the methodology of using MARKAL for both energy and forestry sectors. As the activities in energy sector have unique characteristics, thus only forest activities are described in more detail.

Activities in Forestry Sector

In this study, area covered for forestry sector was only Java and Sumatra. In this study, forest activity in Java divided into four activities namely (1) plantation forest, (2) reforestation, (3) afforestation and (4) rehabilitation of critical land. The first three activities are intended for wood production while the last actvities for land conservation (no harvesting). For Sumatra, data were derived from Jambi data. Thus forest activities and species used in each activities in Sumatra is assumed to be the same as those at Jambi. The activities include (1) timber plantation, (2) afforestation, (3) concession forest (HPH) and (4) rehabilitation of critical land. As in Java, the first three activities are intended for wood production.

***Forest Plantation*.** In Java, forest plantation has been started since 1880 using teak and between the two world wars plantation work was continued and the range of species was extended to a number of hardwood species, and more recently also to indigenous and exotic fast growing species (Table 1). The responsibility of managing the timber estate in Java is the State Forest Enterprise (Perum Perhutani). Forest area available for timber production is about 1.97 million ha. Baseline rate of harvesting is still lower than the sustainable rate. In this study, the sustainable rate is assumed to be 70% of maximum rate of harvesting. The maximum rate is calculated as the available land divided by rotation.

Afforestation, Reforestation and Rehabilitation. Any planting activities taking place in non-forest area is defined as afforestation while that in forest area is

reforestation. Most of the two program are carried out in critical lands. Both programs is often called as rehabilitation of critical land. In this study the last term is used as any planting activities taking place in critical land with no harvesting, while for the former two programs are any planting activities taking place in bare land or critical land with harvesting. In Java, it is assumed that 30% of the total critical land in non-forest area is allocated for afforestation while the remaining plus total area of critical land in forest area are allocated for rehabilitation program. In Sumatra, all area of critical land in forest area are allocated for rehabilitation program, and all area of critical land in non forest area for afforestation. Furthermore, unproductive land such as grassland and degraded overlogged forest is allocated for reforestation. The total area available for each activity and tree species used in each activity are presented in Table 1.

Concession Forest. Concession forest is natural forest which is allocated for concession companies. This forest is normally defined as production forest (Table 1).

Table 1. Total area available in Java and Sumatra for forest activities and tree species used in each activities

Activities	Species	Available Land (ha)	Baseline rate of planting and/or harvesting (ha/year)	Mean annual increment (tB/ha/yr)	Rotation (year)
JAVA					
Plantation forest	*Tectona grandis* (Teak)	1,106,189	5,259	3.90	40
	Pinus mercusii (Pine)	597,744	2,517	6.93	35
	Switenia spp (Mahoni)	74,876	28	7.97	40
	Paraserienthes falcataria (Sengon)	6,982	415	19.07	10
	Others (Rimba)	182,018	308	4.30	30
Afforestation [1/]	*Acacia mangium* (Akasia)	516,274	7,818	25.00	7
	Paraserienthes falcataria (Sengon)	516,274	11,727	19.07	10
Rehabilitation of critical land[1/]	*Tectona grandis* (Teak)	1,821,666	4,234	3.90	110
	Acacia mangium (Akasia)	1,821,666	7,524	25.00	10
	Paraserienthes falcataria (Sengon)	1,821,666	7,524	19.07	15
	SUMATRA				
Reforestation[1/]	*Acacia mangium* (Akasia)	1,033,383	13,832	25.00	7
	Paraserienthes falcataria (Sengon)	1,033,383	5,928	19.07	10
Afforestation[1/]	*Pinus mercusii* (Pine)	2,285,690	8,273	6.93	35
	Acacia mangium (Akasia)	2,285,690	116,727	25.00	7
Concession forest	Others (Rimba)	9,105,709	186,471	1.88	30
Rehabilitation Critical land[1/]	*Pinus mercusii* (Pine)	1,022,100	2,250	6.93	35
	Acacia mangium (Akasia)	1,022,100	5,250	25.00	10

[1/] The available area is the total area available for all species. Thus the available area will be shared between species.

Methodology

In this study, energy and forestry sector analyzed together using MARKAL model in term of balancing GHG concentration at the atmosphere. For energy system all activities from mining extraction, processing, energy transport, conversion, up to energy demand were included in the analysis. For forestry sector, the activities included in the analysis is described in Table 1.

The objective function for the model is to minimize total cost of energy supply and forest production or carbon sink. The mathematical formulation of the model can be simplified in the form of objective function as follows :

Subject to:

$$Minimize\ Z = \sum_{ij} c\ E_{ij} + d\ F_{ij}$$

Energy Source (E) $\leq$ Reserve

Forest (F) $\leq$ Forest Availability

CO_2 Emission ($Emission_E + Sink_F$) $\leq$ Emission Target

where:

$c\ E_{ij}$ = Cost of energy supply

$d\ F_{ij}$ = Cost of forest production/carbon uptake

Schematically, link between energy and forestry sector is presented in Fig. 1. The unit activity used in forestry sector is meter cubic of product for forest plantation, afforestation and reforestation, and hectare of land for the rehabilitation.

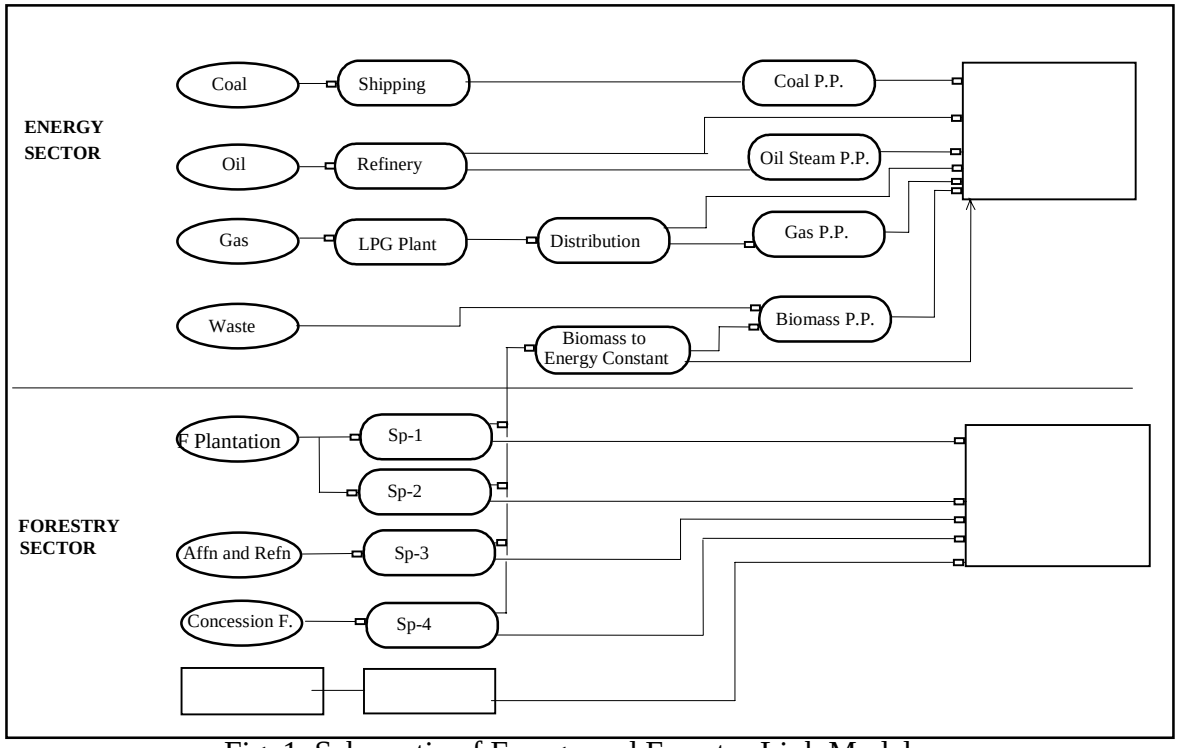

Fig. 1. Schematic of Energy and Forestry Link Model

In the least cost model, activities cost is the main parameter driven the model. Since MARKAL is an energy supply optimization model, all activities of the forestry should be treated as energy activities. In the energy system there are four main different activities, i.e. extraction, processing (i.e. energy-transport, and form changed), conversion (power generation), and demand. Each of these activities has unique characteristic. For the forestry sector model, planting/forest activities was categorized as "extraction" that require total present value of cost of planting and maintenance. Harvesting process that produce timber and biomass for energy is categories as "process" activity. In this "process" detail costing with regard to the activities including their machinery cost and technical characteristic could be introduced, but since no specific data available, this costing capacity was not applied for this project. Lastly for the wood demand and rehabilitation target are categorized as "demand" activities.

Calculation of Present Value of Cost for Forest Activities. In this study, the calculation of NPV of cost for forest activity was carried out using COMAP model developed by LBNL (Sathaye and McYeb, 1995). Cost data was collected from Perum Perhutani, Jambi Forest District Office and Timber Estate Companies in Jambi.

***Calculation of CO_2 emission and Uptake*.** In this study is only carbon dioxide CO_2 considered. Sources of CO_2 emissions are from the "extraction" process of the energy system and from biomass burning. The annual carbon uptake is calculated by multiplying mean annual increment (t B/ha/year; see Table 1) with area of growing forest (ha) and carbon fraction of the biomass (a value of 0.5 was used). In addition, carbon stored in the forest products is also considered as carbon sink. The delayed emission from the forest product through decomposition process is calculated outside the MARKAL model since this model is not able to perform the calculation of the delayed emission.

In this study, forest products were divided into four products namely sawn wood, industrial wood, pulp/paper and residues or waste. The fraction of biomass allocated for log, fuel wood and residues, and the fraction of log allocated for each of product are presented in Table 2.

Table 2. Fraction of biomass allocated for log, fuel wood and waste, and fraction log allocated for sawn timber, industrial wood, pulp/paper, and waste produced from log processing.

Species	Fraction of biomass (%) for			Fraction of log (%) for			
	Log	Fuel wood	Residue	Sawn timber	Industrial wood	Paper/ pulp	Waste
Tectona grandis (Teak)	40.0	49.0	11.0	21.0	45.5	0	33.5
Pinus mercusii (Pine)	34.0	36.0	30.0	24.5	0	45.0	30.5
Switenia spp. (Mahoni)	32.0	28.0	40.0	28.0	39.0	0	33.0
Paraserienthes falcataria (Sengon)	36.0	38.0	26.0	33.6	7.8	43.2	15.4
Others (Rimba)	32.0	28.0	40.0	21.0	32.5	18.0	28.5
Acacia mangium (Akasia)	36.0	38.0	26.0	14.0	0	72.0	14.0

Furthermore, fractions ($year^{-1}$) of in-use wood commodities that decay or burn each years for the sawn wood, pulp/paper, and other industrial wood are assumed to be 0.02, 0.10, and 0.07 respectively (Winjum *et al.*, 1998) while for residue and waste is assumed to be 0.25. Thus all of carbon stored in the sawn wood, pulp/paper, industrial wood and waste will be released to the atmosphere within 50, 10, 14 and 4 years respectively.

In the case of Java, the uptake and emission of CO_2 from plantation forest is assumed to be in balance since the activity has been taking place since long time ago. The emission and uptake of CO_2 are calculated if the rate of harvesting and planting is increased from the baseline year wood demand.

Wood Demand Projection. Wood demand projection was developed based on the relationship between GDP and consumption level reflected in income elasticity (MoF and FAO, 1990). Income elasticity is assumed to decline over time, to reflect the commonly observed fact that they are lower at higher income per capita. The GDP growth rate was assumed to be 5% per annum until year 2000 and by 4% per annum after that year. The wood demand projection for sawn timber, paper/pulp and other industrial wood is presented in Table 3.

Table 3. Wood deman projection for Sumatera and Java

	1990	1995	2000	2005	2010	2015	2020
	Sumatera						
Sawnwood	1.15	1.54	1.93	2.30	2.66	3.03	3.4
Paper/pulp	0.11	0.26	0.41	0.55	0.69	0.83	0.97
Other Industrial wood	2.08	2.85	3.62	4.35	5.08	5.79	6.49
Total Demand	**3.34**	**4.65**	**5.96**	**7.20**	**8.43**	9.65	**10.86**
Java							
Sawnwood	4.87	6.56	8.25	9.80	11.35	12.94	14.52
Paper/pulp	0.5	1.13	1.76	2.36	2.96	3.56	4.16
Other Industrial wood	8.94	12.19	15.44	18.58	21.71	24.71	27.71
Total Demand	**14.31**	**19.88**	**25.45**	**30.74**	**36.02**	**41.21**	**46.39**

Source : MoF and FAO (1990)

Results

The markal model is now being developed. Some constraints have been encountered during the development. The output of the model was unrealistic and therefore no output could be presented at this workshop. A close consultation with the MARKAL developer will be carried out to solve the encountered problems. It is expected that the model will be ready by the mid of June 1998.

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

GOA, India, 4 to 6 May 1998

COUNTRY PAPER

LEBANON

EXECUTIVE SUMMARY

I-INTRODUCTION

The structure of the present greenhouse gas inventory report follows the order established in the "Revised 1996 IPCC Guidelines-Greenhouse Gas Inventory Workbook, Volume 2", which has identified six major economic sectors, as follows:

- Energy
- Industrial processes
- Solvent and other product use
- Agriculture
- Land use change and forestry
- Waste

These guidelines have considered the following greenhouse gases:

- CO_2, carbon dioxide
- CO, carbon monoxide
- No_x, nitrogen oxides
- N_2O, nitrous oxide
- SO_2, sulfur dioxide
- CH_4, methane
- NMVOCs, non methane volatile organic compounds
- HFCs, hydrofluorocarbons
- PFCs, perfluorocarbons
- SF_6, sulfur hexafluoride

It should be noted that the protocol developed for the United Nations Framework Convention on Climate Change, in the Conference Of Parties 3, held in Kyoto on December 10, 1997 has determined six greenhouse gases to be controlled, which are:CH_4, CO_2, N_2O, HFC, PFC, SF_6.

In this report, each sector starts with an introduction presenting the state of each sector in Lebanon, followed by the methodology adopted in order to compute emissions of greenhouse gases by sources and removals by sinks, in accordance with IPCC guidelines, complemented by experts' assumptions in estimating greenhouse gases and finallly accompanied by the IPCC sectoral tables which present the result obtained in each sector. The report ends with an "Appendices " chapter which includes all IPCC Volume 2 worksheets, showing the computations made resulting in emitted or removed greenhouse gas quantities.

This executive summary described in the IPCC summary tables 7A and 7B and table 8A, presents the main results obtained in each sector. In the last paragraph, the global warming potential of the greenhouse gases emitted in Lebanon in 1994is provided for

three calculated time horizons, based on the "1995 IPCC technical summary of working group I" report.

In order to provide a summary picture of all important results obtained by the National Inventory team, this executive summary hereby presents in table1:

- The emitted amount of each greenhouse gas by sector.
- The total emitted amount of all greenhouse gases in a sector.
- The total amount of each greenhouse gas in all sectors.
- The total quantity of greenhouse gases emitted in Lebanon, in gigagrams.

Following the summary table, charts 1-7 have been developed to show:

- The contribution of various sectors to total CO_2 emissions in Lebanon in 1994(Fig.1)
- The contribution of various sectors to total CH_4 emissions in Lebanon in 1994(Fig.2)
- The contribution of various sectors to total N_2O emissions in Lebanon in 1994(Fig.3)
- The contribution of various sectors to total NOx emissions in Lebanon in 1994(Fig.4)
- The contribution of various sectors to total CO emissions in Lebanon in 1994(Fig.5)
- The contribution of various sectors to total NMVOC emissions in Lebanon in 1994(Fig.6)
- The contribution of various sectors to total SO_2 emissions in Lebanon in 1994(Fig.7)

Table 1 Summary of Greenhouse Gas Emission Inventories for Lebanon (1994)

SECTOR	CO_2	CH_4	N_2O	NO_X	CO	NMV0C	SO_2
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Energy	11678.694	1.3794	0.1157	54.0959	473.7119	87.3411	79.6036
Industry	1924.063	N0	NO	0.01112	0.0003	273.888	3.382
Solvents	NE	NE	NE	NE	NE	NE	NE
Agriculture		7.97862	3.0147	0.00146	0.04306		
Land-use Change & Forestry	2335.0968	12.5685	0.0864	3.12305	109.974		
Waste	0	42.804	0	0	0	0	0
Total	**15937.8538**	**64.7305**	**3.2168**	**57.2315**	**583.7296**	**361.2291**	**82.9852**

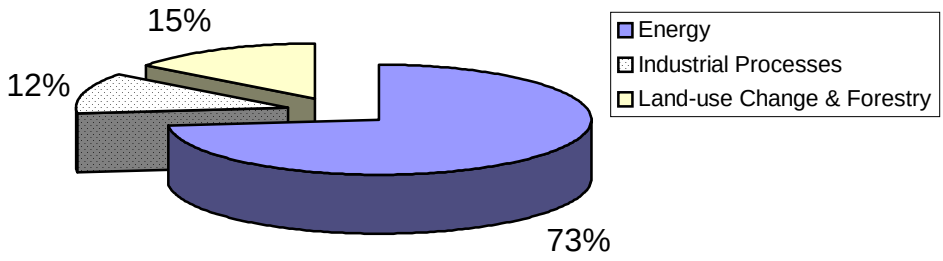

Fig. 1 Contributions of Various Sectors to CO_2 Total Emissions in Lebanon (1994)

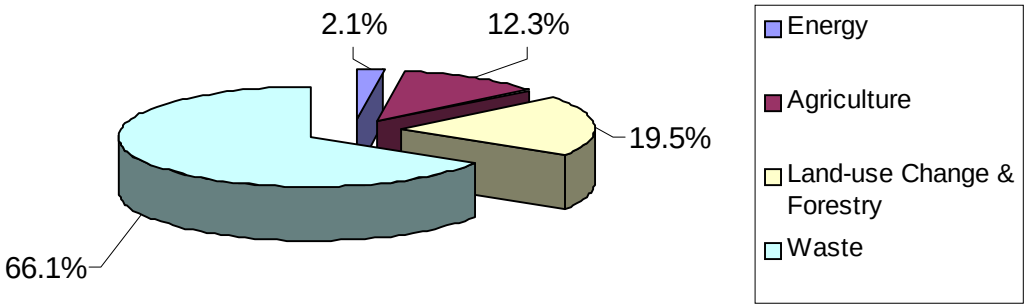

Fig. 2 Contributions of Various Sectors to CH_4 Total Emissions in Lebanon (1994)

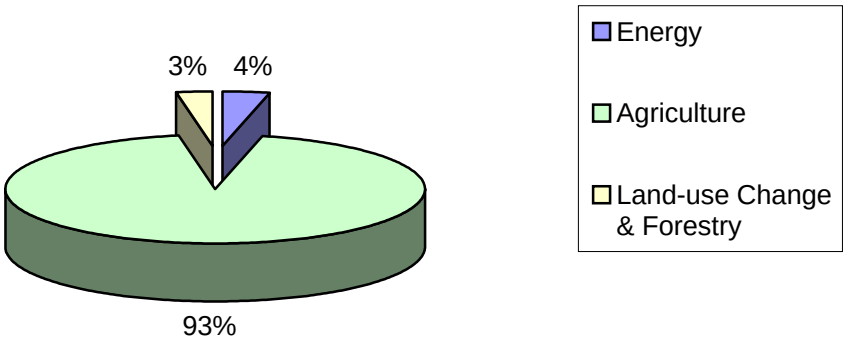

Fig. 3 Contributions of Various Sectors to N_2O Total Emissions in Lebanon (1994)

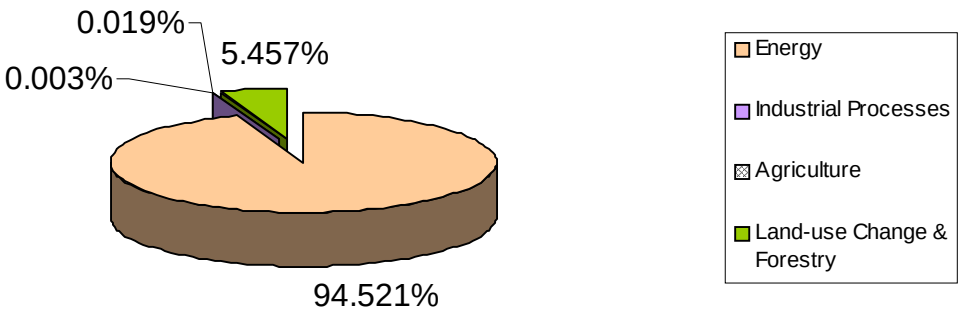

Fig. 4 Contributions of Various Sectors to Total NOx Emissions in Lebanon (1994)

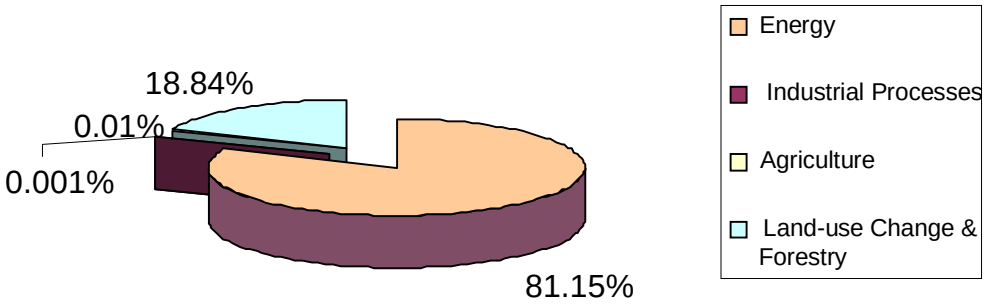

Fig. 5 Contributions of Various Sectors to the Total CO Emissions in Lebanon (1994)

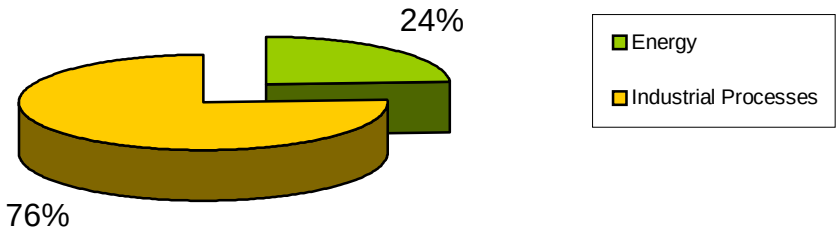

Fig. 6 Contributions of various Sectors to Total NMVOC Emissions in Lebanon (1994)

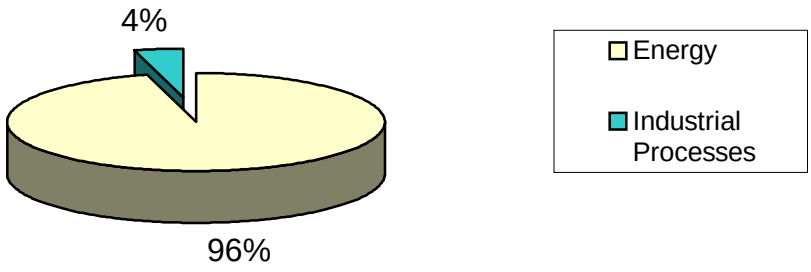

Fig. 7 Contributions of Various Sectors to Total SO_2 Emissions in Lebanon (1994)

In order to convey a concrete picture of the location of the main greenhouse gas sources in Lebanon, maps 1-5 have been built and present the geographical distribution of Lebanon's potential greenhouse gas sources for year 1994:

- Map 1 presents the geographical distribution of the greenhouse gas sources in the Energy sector
- Map 2 presents the geographical distribution of the greenhouse gas sources in the Industrial processes sector
- Map 3 presents the geographical distribution of the greenhouse gas sources in the Land use change and forestry sector
- Map 4 presents the geographical distribution of the greenhouse gas sources in the Agriculture sector
- Map 5 presents the geographical distribution of the greenhouse gas sources in the Waste sector

II-ENERGY SECTOR

The following GHG are of interest in the energy sector: carbon dioxide CO_2, methane CH_4, nitrous oxide N_2O, oxides of nitrogen Nox, carbon monoxide CO, sulfur dioxide SO2 and non-methane volatile organic compounds (NMVOCs). The inventory has focused on the following GHG related sources

1. Electricity generation through the electric utility
2. Private generation of electricity
3. Manufacturing industries and construction
4. Transport: road, domestic aviation, national navigation
5. Energy use in the residential sector
6. Energy use in the commercial/institutional sector
7. Energy use in the agriculture/forestry/fishing sector

The fuel types taken into consideration are: gasoline, jet kerosene, kerosene for household use, gas oil, diesel oil, fuel oil, LPG, lubricating oil, coal, wood and charcoal (under solid biomass). Care has been taken to eliminate the fuel used by international marine and aviation bunkers from the national inventory.

Finally, it is worth mentioning that both the reference approach and analysis by source categories have been carried out and are reported in this inventory.

The total amount of liquid secondary fuels that was imported to Lebanon in 1994 is 3,830628 Tons. The use of solid fuel and biomass fuel is minor and confined to the use of 160,000 Tons of wood, 1,560 Tons of charcoal and 180,000 Tons of coking coal. Data on international bunkers in Lebanon were restricted on International aviation because the amount of fuel that goes on international marine has never been documented and is believed to be minor. Domestic aviation is almost non existent in Lebanon and therefore all imported jet kerosene goes on international aviation except for 1,910 Tons used by few training planes.

Tables 2-5 provide information on fuels used and GHG emissions by fuel source, by fuel type, by sector and by non-CO_2 emissions.

.

Table 2. Summary of CO_2 emissions by fuel source

FUEL TYPE	CONSUMPTION, TJ	CO_2 , Gg
Gasoline	55,694.55	3821.03
Jet kerosine	85.166	6.0285
Kerosene	4.475	0.318
Gas/diesel oil	35,449.23	2,599.35
Fuel oil	56,708.65	4,343.48
LPG	6,907.26	431.261
Lubricants	12.053	0.437
Coking coal	5,040	467.248
Municipal solid wastes	64.995	4.765
Charcoal	46.64	5.363
Wood (Solid Biomass)	2400	550.096
International Bunkers	6,420.96	454.507

Table.3 Summary of CO_2 emissions by fuel type

FUEL TYPE	CONSUMPTION, TJ	CO_2 , Gg
Total liquid fuel (including LPG)	15,492,636	11206.68
Total solid fuel	5,040	467.248
Total biomass	2,446.64	263.221

Table.4. Summary of CO_2 emissions by sector

SECTOR	CO_2 , Gg
Energy Industries	3615.05
Manufacturing Industries and Construction	2774.09
Transport	3957.12
Commercial/Institutional	226.319
Residential	534.25
Agriculture/Forestry/Fishing	571.857
International Bunkers	454.507

Table.5. Summary of non-CO_2 emissions (Gg) by sector.

SECTOR	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Energy Industries	0.1418	0.0283	9.4584	0.7093	0.2364	45.021
Manufacturing Industries and Construction	0.11545	0.02517	7.6684	1.0862	0.2559	24.667
Transport						2.679
Road	1.1221	0.0344	34.824	447.193	83.8708	
Domestic Aviation	$4.2583x10^{-5}$	0.000170	0.0255	0.00856	0.00425	
Domestic Navigation	$9.11\ x10^{-5}$	$1.094x10^{-5}$	0.0273	0.01822	0.00364	
Commercial/Institutional	0.0284	0.001568	0.2844	0.08447	0.01594	1.130
Residential	1.4990	0.0214	1.0281	24.564	2.9153	2.579
Agriculture/Forestry/ Fishing	0.0779	0.00467	0.7798	0.1559	0.0389	3.528
Total	**2.9847**	**0.1157**	**54.0959**	**473.7119**	**87.3411**	**79.6036**
InternatioBunkers	0.0032105	0.0128419	1.926288	0.642096	0.321048	0.14134

III-INDUSTRIAL PROCESSES SECTOR:

In 1994, Lebanese Industry has emitted 1924.063 Gg (1,924,063 Tonnes) of carbon dioxide, 0.0003 Gg (0.3 Tonnes) of carbon monoxide, 0.01112 Gg of nitrogen oxide, 273.888 Gg (273,888 Tonnes) of non-methane volatile organic compounds and 3.382 Gg (3,382 Tonnes) of sulphur dioxide.

The cement industry is the major source for CO_2 emissions from the industrial processes in Lebanon. Cement industry is responsible for 77.2% of the total emissions of the industrial processes followed by the iron and steel industry which produces 21.68% of the total CO2 emissions from industrial processes. Fig. 8 shows the percentage distribution of various industrial sources contributions to CO_2 emissions in Lebanon.

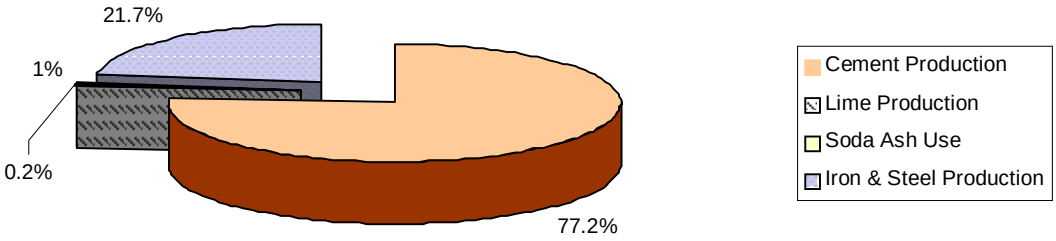

Fig. 8 CO_2 Emissions from Industrial Sources

The NMVOC emissions are mainly produced by the use of asphalt for road paving (98.5% of total emissions by industry) followed by the food and drink industry (1.2%). Fig.9 shows the percentage distribution of various industrial sources contributions to NMVOC emissions in Lebanon.

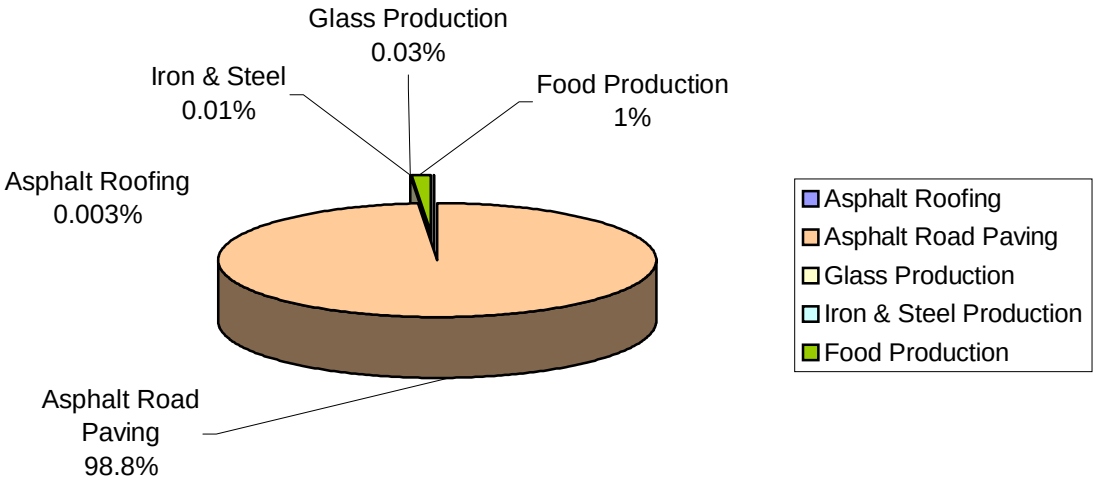

Fig. 9 NMVOC Emissions from Industrial Sources

The emissions of sulphur dioxide SO2 come from three industrial sources. The first source is from the production of sulphuric acid (69.9% of total industrial emissions). The second is the cement industry (26.4% of total industrial emissions) and the third is from the iron and steel mills (3.7% of total industrial emissions). Fig. 10 shows the percentage distribution of various industrial sources contributions to SO_2 emissions in Lebanon.

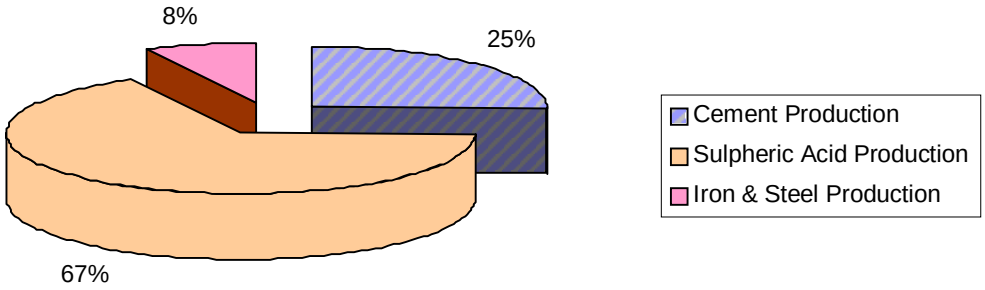

Fig. 10 SO_2 Emissions from Industrial Sources

Carbon monoxide emissions in the industrial sector are very small. The major source is iron and steel mills and the other minor source is asphalt-roofing production.

IV-SOLVENT AND OTHER PRODUCT USE

This category covers mainly NMVOC emissions resulting from the use of solvents and other products containing volatile compounds. It also includes CO_2 and N_2O emissions from anaesthetic and propellant gases. The only relevant part to Lebanon in

this sector is the paint applications, degreasing and dry cleaning. However no estimation of GHG was made in this sector due to non availability of data and emission factors.

V-AGRICULTURE SECTOR:

In Lebanon, emission of greenhouse gases from agricultural activities occur through the following processes:

I- Enteric fermentation and manure management of the domestic livestock emits methane and nitrous oxide.

II- Agricultural burning of crop residues is of minor importance since field burning of crop residue is not a common practice in Lebanon.

III- Agricultural soils are a source of nitrous oxide directly from the soils and from animal production, and indirectly from the nitrogen added to the soils.

The following results for the inventory year 1994 are obtained:

7.60955 Gg of methane, 3.01478 Gg of nitrous oxide, 0.00146 Gg of nitrogen oxides, and 0.04306 Gg of carbon monoxide.

VI-LAND USE CHANGE AND FORESTRY SECTOR:

The land use change and forestry considers the following sub-modules in calculating GHG emission by sources or removal by sinks:

I- Sub-module changes in forestry and other woody biomass stocks:

This sub-module has presented considerable difficulties in the data collection activity since no information or records are available at the institutional level. Therefore, the data derived represents a large degree of uncertainty.
The stocks of woody biomass, needed to calculate the carbon uptake or storage In Lebanon for 1994, were found made of:

a- 75,000 ha of forest trees(65,000 evergreen and 10,000 deciduous)
b- 50,280 thousand non-forest trees which include:

1) 49794 thousand trees of farm and village trees(21,980,000 of evergreen fruit and olive trees and 227,814 of deciduous fruit trees)
2) 486 thousand urban trees (45,000 evergreen urban trees and 36000 deciduous urban trees)

The total increment by these stocks of woody biomass is 248.68666 kt.
The loss of biomass is limited to 200 kt dm of fuel consumption, since other wood use data are not available.

As a result, the change in woody biomass stocks in Lebanon is considered as a sink of CO_2 absorbing 545.18442 kt of CO_2 for the inventory year 1994.

II- Sub-module forest and grassland conversion-CO_2 from biomass:

The natural and man made fires are included in this sub-module. In 1994, around 7500 ha of woodland were affected by fires, and the resulting CO_2 released is 2,880.2812Gg.

The striking result in this module is that forests for year 1994 constitute a source of CO_2 rather than a sink due to the intensive forest fires. The CO_2 emission from land use change and forestry is 2,335.0968 kt.

VII-WASTE SECTOR:

The waste management section of this report deals with two sectors: land disposal of solid waste and wastewater treatment. It provides background information on the type of emissions that contribute to the greenhouse gases from these two sectors, presents the current status in Lebanon of both sectors, describes the methodology followed to estimate the corresponding emissions, and presents the results obtained regarding greenhouse emissions.

The total methane emissions from solid waste disposal on land is 42,804 tonnes (42.803 Gg) approximately. There are no emissions from wastewater and industrial handling systems because for the target year 1994, there was no treatment facilities in Lebanon. The wastewater (municipal, commercial, and industrial) was directly discharged into the sea, rivers, ravines, or septic tanks which indicate that methane or nitrous oxide emissions are insignificant if not non-existent. Note that this situation will change in the future as treatment plants are being constructed around the country and are expected to come into operation by the year 2,000.

VIII. Relative Impact of Greenhouse Gases Effect: Global Warming Potential (GWP):

The impact of a given quantity of gas in terms of weather warming is measured by its global warming potential (GWP). The GWP is defined as the cumulative radiating forcing between the present and some chosen later time horizon caused by a unit mass of gas emitted now, expressed relative to some reference gas (here CO_2 is used). The future global warming commitment of a green house gas over the reference time horizon is the appropriate GWP multiplied by the amount of gas emitted. The GWP of a given gas depends mostly on the thermal efficiency of the gas, on various complex physical and chemical parameters and on its life span in the atmosphere as a direct or indirect greenhouse gas. As a rule, three possibilities of integration timespan are used: 20 years, 100 years and 500 years.

The 20 years possibility appears to be too brief for an assessment of high inertia phenomena such as those found in climatology. In addition, the life span of many greenhouse gases is much longer. A 500 years integration time span is very attractive, but gives highly uncertain projections on changes in the physical and chemical phenomena. The intermediate option, 100 years, leads to reasonable analysis and is the most commonly used option.

Table 6 presents the GWP time horizon referenced to the updated decay response for the carbon Cycle Model and future CO_2 atmospheric concentrations held constant at current level.

Table 6 **Global warming Potential Time Horizon of Greenhouse Gases**

TYPE GAS	LIFE TIME	GLOBAL WARMING POTENTIAL* (TIME HORIZON)		
	(years)	20 years	100 years	500 years
CO_2		1	1	1
CH_4	12 ± 3	56	21	6.5
N_2O	120	280	310	170
HFC-134a	14.6	3400	1300	420

***Source: Climate Change 1995, the Science of Climate Change: Summary for Policy Makers and Technical Summary of Working Group I Report, pg.26.**

With the GWP, the global emissions of the country by sectors can be expressed in the same unit of CO_2 equivalent for the sake of aggregation or comparison. Accounting for the GWP of each greenhouse gas emitted, the CO_2 equivalent for each gas is calculated and the data are summarized in Table 7. Fig. 11 shows also the GWP of greenhouse gases emitted in Lebanon in 1994 for the three calculated time horizons.

The total GWP based on 100 years life span for greenhouse gas emissions in Lebanon is 17665.997 $GgECO_2$ (17.666 $MTECO_2$). If this amount is divided by the Lebanese population for the year of 1994, then the GWP is 4.64 Tonnes Equivalent of CO_2/capita/year.

Table 7 Global Warming Potential of Greenhouse Gases Emitted in Lebanon (1994)

TYPE OF GAS	**GAS** EMISSION	**GWP (20 YEARS)**	**GWP (100 YEARS)**	**GWP (500 YEARS)**
	(Gg)	**Gg Equivalent of CO_2 ($GgECO_2$)**		
CO_2	15,937.8538	15,937.8538	15,937.8538	15,937.8538
CH_4	64.7035	3,623.396	1,358.7735	420.7275
N_2O	4.05459	1135.2852	1,256.9229	689.28
HFC-134a	0.002	6.8	2.6	0.82
	Total GWP	**20,703.899**	**18,556.1502**	**17,048.6813**

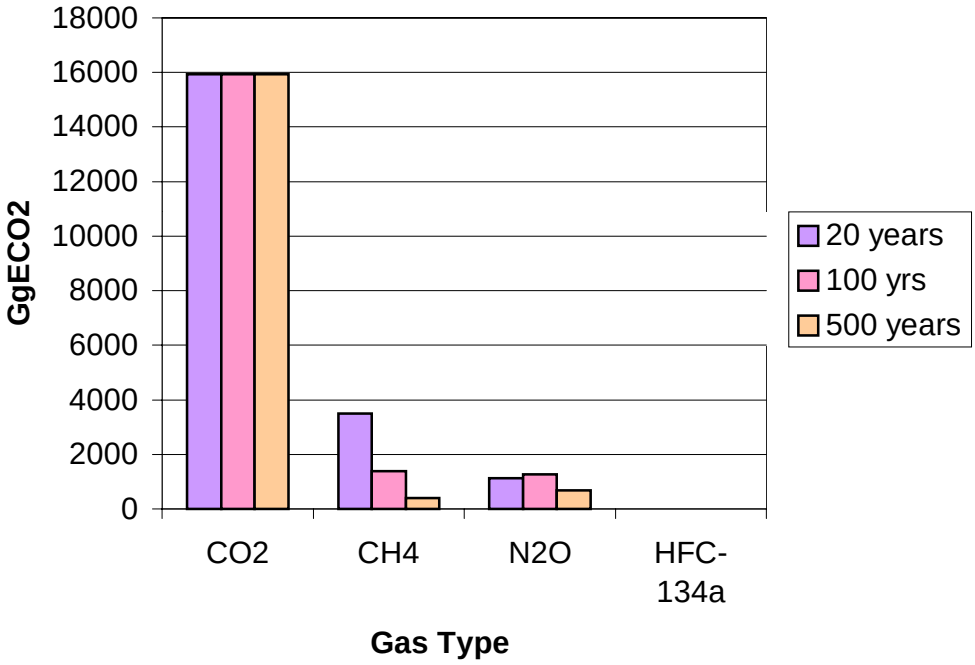

Fig. 11 Global Woarming Potential of Greenhouse Gases in Lebanon (1994)

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

GOA, India, 4 to 6 May 1998

COUNTRY PAPER

MALAYSIA

UNEP/GEF and the World Bank Conference on Climate Change Mitigation in Asia and Financing Mechanisms, Goa, India, 4-6 May 1998

Malaysia Country Overview

by
Chong Ah Look

Introduction

The threat of global warming and climate change caused by escalating anthropogenic emissions of carbon dioxide and other greenhouse gases into the atmosphere calls for deliberate efforts by the global community to address this issue. Article 2 of the Framework Convention on Climate Change (FCCC) sets the objective of the Convention to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Malaysia signed the Convention on 9 June 1993 and ratified it on 17 July 1994. As a party to the Convention, Malaysia is committed to fulfilling its obligations including the communication of information to the Conference of the Parties (COP) in accordance with Articles 4 and 12 of the FCCC.

Strategy

Malaysia has been adopting a pragmatic approach in dealing with the environment, including climate change issues, and has constantly reviewed the need to incorporate environmental concerns in economic development to maintain a balance between the competing demands of economic growth and sustainable development. The principle of sustainable development has been introduced in the chapter on "Development and Environment" in the Third Malaysia Plan (1976-1980) which addressed themes later strengthened in the Sixth Malaysia Plan (1991-1995). The Seventh Malaysia Plan (1996-2000) further elaborated firm policies and measures to protect the environment and sustainable development to upgrade the quality of life, including active participation in international activities in addressing environment issues.

The energy sector has been identified as a major contributor of greenhouse gases into the atmosphere. To reduce the heavy dependence on oil, the Government has identified hydro power and gas, besides oil and coal, as the primary energy sources to meet increasing energy demands. In recent years, most power plants in Malaysia have switched to natural gas as the primary fuel, and new power plants are now using the combined cycle gas-fire turbines which have a higher efficiency than open cycle turbines. The government has launched the "Guidelines for Energy Efficiency in Buildings" which set minimum standards for energy conservation in the design of new buildings.

Malaysia has about 20 million hectares under natural and plantation forests which is 61.2% of the total land area. 54.3% of this area is till undisturbed forest. A total of 12.74 million hectares of forested land have been designated as Permanent Forest Estate. Under the Sixth Malaysia Plan, one of the major programmes is the

rehabilitation of 101,300 hectares of logged-over areas annually and sustaining 1.65 million hectares of rehabilitated areas as permanent forests.

The Environment Quality Act (EQA) was passed in 1974 to prevent, abate and control pollution as well as enhance the quality of the environment. The EQA was amended in 1985 to include 19 types of prescribed development activities subject to mandatory environmental impact assessment (EIA). The impact on climate is one of the areas to be assessed.

The main contributors to the air pollution are emissions from factories and motor vehicles. The EQA therefore sets out to control industrial emissions by controlling:

- the location of new industrial facilities which are potentially polluting near residential areas;
- the burning of trade wastes, particularly open burning;
- the installation of fuel-burning equipment and erection of chimney; and
- the emission of air impurities including black smoke, dust and solid particles, metals and metallic compounds, and gaseous substances.

As for the control of vehicular emissions, the Environment Quality Regulations 1996 were enacted, which adopted a preventive approach to control emissions from vehicles whereby new vehicles must be installed with catalytic converters to comply with emission standards. Additional regulations will be proposed such as the use of natural gas in public service vehicles and to control emissions from motorcycles.

Institutional framework

Environmental management falls mainly under the purview of the Ministry of Science, Technology and the Environment, Malaysia. However, many aspects of the environment are also dealt with by a large number of ministries, agencies and inter-sectoral groups. The involvement of the State Governments' Administrations is also crucial for the success of some of the programmes because the management of land and water, including rivers, riverine fisheries and water supply fall under the jurisdiction of the respective States. Recently the State Governments have agreed to the Federal Government's proposal to form a National Water Council for the efficient management and coordination of water resources in the country.

The National Climate Committee (NCC) was formed in January 1994 under the aegis of the Ministry of Science, Technology and the Environment, Malaysia to coordinate all activities related to climate and climate change. The NCC is chaired by the Secretary General of the Ministry of Science, Technology and the Environment with members coming from the Ministry of Transport (Transport), Ministry of International Trade (Industry), Ministry of Foreign Affairs (International Policies), Ministry of Primary Industries (Forestry), Ministry of Energy, Telecommunications and Posts (Energy), Ministry of Agriculture (Agriculture and Forestry), Economic Planning Unit (Planning and Development), Ministry of Finance, Ministry of Education, Department of Environment, and the Malaysian Meteorological Service as the secretariat. Two subcommittees are formed under the NCC, one on scientific research and impact studies, and the other on climate data. These two subcommittees provide networking with technical departments and research institutions.

The NCC is responsible for the implementation of the country's commitments under the Climate Change Convention, including the coordination and preparation of national communications as required under Article 12 of the FCCC.

Involvement in international programmes on enabling activities

In 1987, UNEP initiated a project "Socio-economic Impacts and Policy Responses Resulting from Climate Change - A Study in Southeast Asia" which involved country studies of Indonesia, Malaysia and Thailand, to generate estimates of potential impacts of climate change using GCMs and scenarios of sea level rise, and to provide recommendations for use by policy makers. The results were published in a UNEP publication entitled "The Potential Socio-Economic Effects of Climate Change in Southeast Asia" (Parry et al., 1992), which has been widely circulated in the region. The Malaysian Meteorological Service as the Technical Coordinator played a leading role in producing the Malaysian component of the report.

Another study, "Regional Study of Global Environment Issues in Malaysia" was sponsered by the Asia Development Bank and completed by the Malaysian Institute of Economic Research (MIER) in 1993.

A project entitled "Enhancement of Technical Capacity to Develop National Response Strategies to Climate Change" was approved by GEF for funding in 1996. The Institute of Strategic and International Studies (ISIS) has been appointed by GEF to undertake this project which is scheduled for completion in November 1998. This is a capacity building project to enhance and develop local expertise to assess the impacts of climate change and formulate mitigation and greenhouse gas abatement policies. In addition, a report will be prepared for submission to the UNFCCC as obligated under Article 12 of the Convention. The project is expected to produce the following outputs:

- A baseline inventory of anthropogenic emissions of greenhouse gases (GHGs) by different sectors;
- Identification of the national sinks for GHGs;
- Development of local expertise in implementing acceptable methodologies for the estimates of sources and sinks;
- Initial national strategies, policies, plans and programmes for reducing GHG emissions;
- National Climate Scenarios;
- Initial understanding of the impacts of climate change on economic and social development; and
- A public awareness and education programme on climate change.

Actions undertaken to manage and share climate change related information

Climate change is a cross-sectoral issue and has impacts (and vice versa) on a multitude of activities. Climate change related information are disseminated as widely as possible through the circulation of reports on climate change to relevant agencies and organizations, the conduct of national seminars and workshops among government agencies, private and non-governmental organizations, and academia.

In December, 1995 a workshop was jointly organized by the National Institute of Public Administration, Department of Environment and the Malaysian Meteorological Service for the public and private sector regarding the opportunities available under the FCCC, Montreal Protocol and GEF.

In August 1996, a national conference on climate change was conducted by the Subcommittee on Scientific Research and Impacts Studies of the NCC to collate all research activities related to climate change and to promote interest in and awareness of climate change issues among local scientists.

A directory of key personnel involved in global change research and studies has been compiled under a IGBP project.

In March 1998, UNEP initiated a research survey to review and analyze the unique circumstances and needs of each participating country before launching the Climate Awareness Programme (CAP). CAP will provide resources, information materials and ideas for raising public awareness of, as well as actions/strategies to be taken in relation to, climate change. The survey was expected to be completed by the end of April 1998.

To increase awareness and arriving at consensus, the government, through the respective agencies, holds regular dialogue sessions with the relevant industries, NGOs and the public. The government also maintains close contact with the Malaysian Climate Core Group which is made up of several NGOs such as the Environment Protection Society and the Malaysian Nature Society.

Media involvement is also important in increasing the awareness and spreading of information widely. Thus interviews with the media and articles on climate change are regularly featured in the news media.

Enhancing endogenous capacity

Developing countries lack the expertise to carry out their commitments under the FCCC, and there is a need to develop their national capacities to address climate change issues in the local as well as international context.

Capacity building in human resource and institutional development will enable the countries to develop national climate scenarios, research in emission and prepare inventories of GHG sources and sinks, conduct impact assessment studies, and identify and prioritize cost effective measures which will assist policy makers and the government to take appropriate measures to harmonize, integrate and formulate policies and strategies to mitigate climate change and its effects, promote sustainable development by incorporating environmental considerations and minimizing the adverse effects of natural resource use, and maintaining the quality of the environment. Human resource development is also considered important to assess and identify which of the available technologies are useful and feasible for the country.

Apart from the formal training of a few experts, other cost effective programmes could be developed to enhance capacity building for a wider group of scientists, such as the following:

- Implement projects designed at capacity building and at the same time producing relevant outputs for climate change, e.g. impact assessment studies, and GHG inventories;
- Develop expert groups through participation at regional projects e.g. detection of climate change, development of regional climate change scenarios, and assessment of technologies;
- Conduct regional courses, workshops, seminars and conferences to exchange information and experiences; and
- Foster closer cooperation through personal contacts and implementation of the One-Stop Regional Information Networking Systems.

Conclusion

Malaysia is committed to fulfilling its obligations in the Convention to address climate change issues and has adopted the precautionary principle to include environmental concerns in the implementation of development projects within the country to ensure sustainable development.

Endogenous capacity building is an important factor to help Malaysia and other developing countries to formulate appropriate strategies and assess available technologies in addressing climate change issues.

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CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

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COUNTRY PAPER

PAKISTAN

1. Results of Mitigation Studies from Pakistan

1.1 Introduction

At the international level, Pakistan's contractual obligations to the United Nations Framework Convention on Climate Change (UNFCCC) include the preparation of a greenhouse gas (GHG) emissions abatement program, a national communication on climate change, and the formulation of a least-cost GHG abatement action plan and strategy. Pakistan ratified the UNFCCC in June 1994. The ratification of the Convention has lead to the undertaking of activities such as the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) Project, which aims to build capacity in Asian countries in the preparation of GHG inventories and mitigation programs.

1.2 National Inventory of GHG Sources and Sinks

According to the Pakistan National Inventory of GHG Sources and Sinks for 1989-90 the total GHG emissions in terms of CO_2 equivalent for the country was 132,706 Gg. The national inventory was prepared using the reporting format and methodologies recommended by Inter governmental Panel on Climate Change (IPCC). Of the total GHG emissions, the energy sector alone accounted for 53 percent of the emissions followed by agriculture that contributed 34 percent, forestry and land-use change with a share of 7 percent while both the Industrial processes and waste had a share of 3 percent each. Three major GHG emissions considered for the inventory preparations were carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 had a share of 57.14 percent followed by CH_4 contributing 42.55 percent to the total national emissions while N_2O had a negligible share of about 0.04 percent.[1]

Forestry and land use change was the second most significant contributor of CO_2 emissions. Of the total CO_2 released during 1989-90, 9,830 Gg or 13 percent was emitted from changes in forest and other woody biomass stocks. Industrial processes were the third leading contributors to CO_2 emissions—3,733 Gg of CO_2 was released from cement production, the only industrial process considered in the current inventory. Agriculture and livestock accounted for 2,146 Gg or almost 80 percent of the total 2,686 Gg of methane emitted during 1989-90.

1.3 Baseline Projection of National GHG Inventories to 2020

The baseline inventory projections of GHG emissions were carried out from 1991 to 2020 for the energy, agriculture, land-use change and forestry and waste sectors . In the year 1991 the total emissions were approximately 140,000 Gg of CO_2 equivalent

[1] Although traditional biomass burned for energy accounted for over 77,447 Gg of CO_2, this estimate was tabulated but not included in the GHG Inventory total discussed above or in the relevant summary sections of this inventory. This was done in accordance with the IPCC guidelines on reporting the GHG inventory.

which increases to about 620,000 Gg of CO_2 equivalent by the year 2020. In 1991 the GHG emissions from the energy sector were 72,490 Gg which is estimated to increase to 481,723 Gg of CO2 equivalent by the year 2020. The share of the energy sector emissions in the total GHG emissions was 52 and 78 percent in the year 1991 and 2020 respectively. The forestry sector GHG emissions are estimated to increase from 10,035 Gg of CO_2 equivalent in the year 1991 to approximately 41,832 Gg of CO_2 equivalent by the year 2020 at an annual cumulative growth rate of 3 percent.

The baseline projections of national GHG inventories to 2020 for the energy sector show that natural gas contributes to 36.6 percent of CO_2 emissions in 1995, followed by 22.9 percent for diesel, 17.7 percent for furnace oil, and 10.3 percent for coal. By the year 2020, the shares of furnace oil and coal are expected to expand to 39.1 percent and 20.4 percent, respectively, while that of natural gas is expected to shrink to 10.6 percent while those of gasoline and diesel are expected to remain at 4.2 percent and 22.1 percent, respectively.

High growth rates in the industry, power generation and transportation sectors contribute to the bulk of the increase in GHG emissions inventory. Availability of natural gas decreases as domestic reserves are depleted. Imported fuel oil and coal will help in meeting fuel demands in power and industry sectors, which will contribute significantly to an increase in the GHG emissions. In the transportation sector, the demand for diesel is expected to grow at a rate faster than that for gasoline. This is attributable to subsidized prices of diesel, which is sold at about half the price of gasoline in the market.

In the agriculture and livestock sectors, potential factors that are likely to determine future emissions include the growth in the population of livestock and the area over which rice is cultivated. While estimates of livestock population growth were prepared using historical growth rates, the area under rice cultivation is expected to stabilize around the current level of 2.1 million hectares. The primary reason for this is the shortage of irrigation water. In the absence of a notable change in the provision of irrigation facilities, the area under rice cultivation cannot be expected to register substantial increases. As rice is an important cash as well as food crop, area under cultivation is not expected to fall significantly either, in the next two decades at least. Future increases in crop output are expected to accrue from productivity increases, i.e., increases in yield per hectare rather than increase in area sown.

1.4 GHG Mitigation Options and Opportunities

The GHG options were developed along with their emissions reductions potential and incremental costs. Given that the energy sector is the most prominent amongst the sectors considered in the GHG inventory, most of the mitigation opportunities considered also relate to this sector. Within the energy sector, the areas of action considered include residential and commercial energy consumption, industry, transportation, power, renewables, etc.

The residential and commercial energy consumption accounts for almost 24 percent of total energy consumption in the country. Five alternatives were identified as possible mitigation options for these subsectors. These included the introduction of energy efficient appliances such as refrigerators, fans, and water heaters, and measures to popularize energy efficient lighting systems and building designs.

Industry is the single largest consumer of energy products in the country, accounting for up to 38 percent of total energy consumed. The mitigation options assessed for industry included the introduction of efficient boilers, the installation of efficient motors, the installation of waste-heat recovery systems, and cogeneration. In addition, the introduction of energy efficient irrigation pumps in agriculture was also assessed as an option. The options were chosen with reference to the energy saving potential of each, and its relevance to the domestic industry structure, and, in the case of irrigation pumps, to productivity in agriculture.

The share of the transportation sector in total energy consumption in the country is estimated at 32 percent, thus making it the second largest energy consuming area after industry. Three options were considered for analysis in this subsector: the promotion of improved engine maintenance practices, i.e., instituting facilities to promote regular engine tuning; the promotion of standard vehicle maintenance procedures such as checks on wheel alignment, brakes, the clutch, etc.; and improved engine design, or the introduction of energy efficient engines in the market.[2] The last option was considered separately for transport vehicles and for tractors.

Power generation was analyzed as a separate subsector, as the power generation industry has certain unique characteristics that merit an in-depth study. The country is presently in the process of initiating an extensive utility deregulation and privatization program. Three options, all of which are currently the focus of debate in the energy sector, were selected for evaluation in this subsector. These included efficiency improvements in electricity and gas T&D systems, respectively, and the possibility of importing gas through an international network of pipelines.

Policy makers in the country have consistently ignored the possibilities of utilizing alternative technologies to facilitate infrastructure provision, such as the provision of electricity and gas, in some of the remote rural areas of the country. Four options were chosen in the renewables subsector: solar photovoltaic systems for lighting and heating, wind energy systems for electricity generation, solar water heaters, and the installation of mini-hydel dams. The option developed in waste management related to setting up waste-to-energy facilities in the country's urban localities.

In addition to the Energy sector, two major sectors were considered for developing an abatement strategy, i.e., agriculture and forestry. Methane emissions from livestock are estimated to be the single most significant source of emission in the agriculture sector, closely followed by emissions from rice paddy fields, which, in Pakistan, are kept inundated for the entire length of the crop season. Mitigation options considered for the sector include the provision of improved feed for livestock and research into water management practices in rice paddy fields.

Forestry was another area where abatement options were analyzed in some detail. The mitigation potential in the forestry sector is considerable, as tree plantations and watershed management activities serve to increase carbon sequestration both above and below ground. Seven options were considered for analysis in this sector. These included rangeland management, watershed management, commercial plantations in irrigated areas, agroforestry, promoting the enhanced natural regeneration process in

2 Engine tuning centers are also being set up under the UNDP/GEF project, Fuel Efficiency in the Transport Sector.

conifer forests and protection of conifer forests, planting in agricultural lands and management of riverain forests.

1.5 Baseline and Abatement Scenario to 2020

1.5.1 Energy

Scenario projections were developed at the subsectoral level. Economic activity levels, structure of the subsectors, number of end-use devices, and energy intensities were specified on the basis of the available data. Projections were developed, taking into account the projected GDP growth rates at national and sectoral levels, population growth rates, and economic activity levels available in various national plans.

Given the structure of the baseline scenario, the mitigation scenario was developed by changing the energy intensities at the end-use level. Data on the degree of energy efficiency that can be used by applying available technologies were used to estimate the technical potential for energy savings. Mitigation targets were set keeping in view the technical potential, and actual energy efficiency achievable given various constraints faced at the end-use level. It was assumed that improvements would start taking place after the year 2000, allowing time for the establishment of an institutional, policy and program framework for the implementation of the actions recommended. The reduction in the primary energy supply in the abatement scenario is of the order of 13 percent of the total primary energy supply in the base case. The major reduction is in the quantity of the petroleum products that has a total consumption of about 31 million TOE against a 70 million TOE demand in the base case. There is an increase in the supply of the natural gas due the substitution of the furnace oil and coal by natural gas on the national level. The increase in the natural gas consumption in the abatement scenario is 118 percent of the natural gas consumption in the base case.

The GHG emissions reduced from the energy sector in the abatement scenario is approximately 18 percent of the base case emissions of the sector in the year 2020 which amounts to about 88,000 Gg of CO_2 equivalent. Energy sector options have a share of approximately 64 percent of the total GHG emission abatement potential in the mitigation scenario.

1.5.2 Forestry

The baseline and abatement scenarios were assessed, using the Comprehensive Mitigation Analysis Process (COMAP) model, including all three of its components, i.e., forest protection, reforestation and biomass. The scenario assumptions in the base-case were developed on the basis of current trends in land use and consumption of forest products in the country. The other important assumptions concerned the rate of biomass depletion, which was assumed to be dependent on the rate of product extraction, i.e., the rate at which wood is extracted to meet the demand for fuelwood and industrial wood. The land use over time was assumed to be constant for all individual categories except for watershed plantations and agroforestry, which are expected to cover more area as a result of the implementation of new forestry projects already being planned under the aegis of the Forestry Sector Master Plan (FSMP), as well as other forestry projects. The area under rangelands and agricultural land is expected to decrease in proportion, as it is assumed that rangelands will be given over to watershed plantations and agricultural land to agroforestry plantations over time.

The GHG emissions reduction attributable to the forestry sector is 38,000 Gg of CO_2 equivalent. This is the second largest sector—after energy sector, in the GHG emission reduction and accounts for about 28 percent of the total GHG emission reduction in the abatement scenario.

1.5.3 Agriculture

The baseline and least-cost abatement scenarios were defined using simple spreadsheets, and incorporating assumptions to project growth rates and estimated costs at each step. In case of Multi-Nutrient Block (MNB), projections prepared included growth rates of livestock populations, estimates of emissions reductions, and benefits in the form of increased milk production. For rice paddy fields, no economic benefits in the form of increased yield, for example, could be estimated, as data was not available. The option was therefore developed based on data relating to emissions reduction per hectare and the estimated costs of investing in a research and dissemination program.

The agriculture sector total contribution to the GHG emission inventory for the year 2020 in the abatement scenario is approximately 75,000 Gg of CO_2 equivalent. The reduction in the emissions in the agriculture sector in the abatement scenario accounts for 7 percent of the total GHG emission reduction.

1.6 National Least-Cost GHG Abatement Curve

The Cost of Emission Reduction Initiatives (CERI) curve developed for GHG abatement initiatives. The curve is basically an engineering GHG mitigation cost curve, which presents a non-optimized ranking of GHG mitigation options according to their economic costs for potential GHG emission savings. A total number of 33 options were analyzed in detail. Of these, approximately two-thirds have a negative incremental GHG mitigation cost, and can therefore be considered as win-win opportunities. Options with a negative incremental cost fall mostly in the energy sector.

In the short term, the focus will be on initiatives that can yield significant GHG abatement in a short time frame, are financially attractive and present win-win opportunities. In addition, preference will also be given to initiatives that can draw upon programs and projects in hand that have a potential for contributing to the GHG abatement objectives, and where implementable policies have already been formulated. In the medium term, initiatives that can benefit from changes in policy framework, and can be accelerated through capacity building, training and awareness programs will be given preference. Opportunities in this category are also mainly limited to the energy sector. The initiatives that will be pursued in the long term will include opportunities that require substantial changes in social structures, norms and practices, and where substantial efforts have to be made to bring about changes at the grassroots level. Most of the programs in the agriculture and land use change and forestry sector fall into this category.

1.7 Proposed Abatement Projects

Five mitigation projects were developed for implementation at the end of the exercise, in keeping with the priority areas identified in the mitigation analysis. These included:

- The institution of an appliance labeling and standardization program

- The establishment of an investment fund for industry
- The establishment of a wind power project in a coastal region of Pakistan
- The introduction of solar powered agricultural water pumping systems
- The dissemination of improved feed for livestock.

1.8 Conclusions

In addition to the projects listed above, the ALGAS project identifies the certain institutional and policy reforms which are integral to the development of climate change programs in the country. These measures include the establishment of a Climate Change Cell in the Ministry of Environment, which will be supervised by a Climate Change Committee formulated under the aegis of the Pakistan Environmental Protection Council. Important recommended policy measures include the removal of cross subsidies in energy prices and the restructuring of public utilities.

As a developing country facing severe resource constraints, Pakistan is obliged to seek ever more efficient ways to utilize its scarce resources. The emphasis of the country's development strategy is in the process of shifting from a more 'growth-oriented' perspective to one more concerned with 'sustainable development.' This shift is reflected in an increased emphasis on energy conservation in all sectors of the economy, on increasing productivity in agriculture through more efficient use of inputs, and on developing systems for the sustainable management of natural resources. Though these objectives were not specifically formulated from a climate change perspective, or in response to global warming issues per se, their relevance to greenhouse gas emissions abatement is obvious. Thus, the Government and the private sector must seek to identify win-win situations, wherein the 'Productivity Gains-GHG Abatement' nexus can be explored to its full potential.

UNEP **GEF** **THE WORLD BANK**

PROCEEDINGS OF

A Regional Conference Sponsored by UNEP/GEF and The World Bank

CLIMATE CHANGE MITIGATION IN ASIA AND FINANCING MECHANISMS

GOA, India, 4 to 6 May 1998

COUNTRY PRESENTATION

PAKISTAN

UNDP/GEF

Economics of Greenhouse Gas Limitation

0Climate Change Mitigation in Asia and
Financing Mechanisms

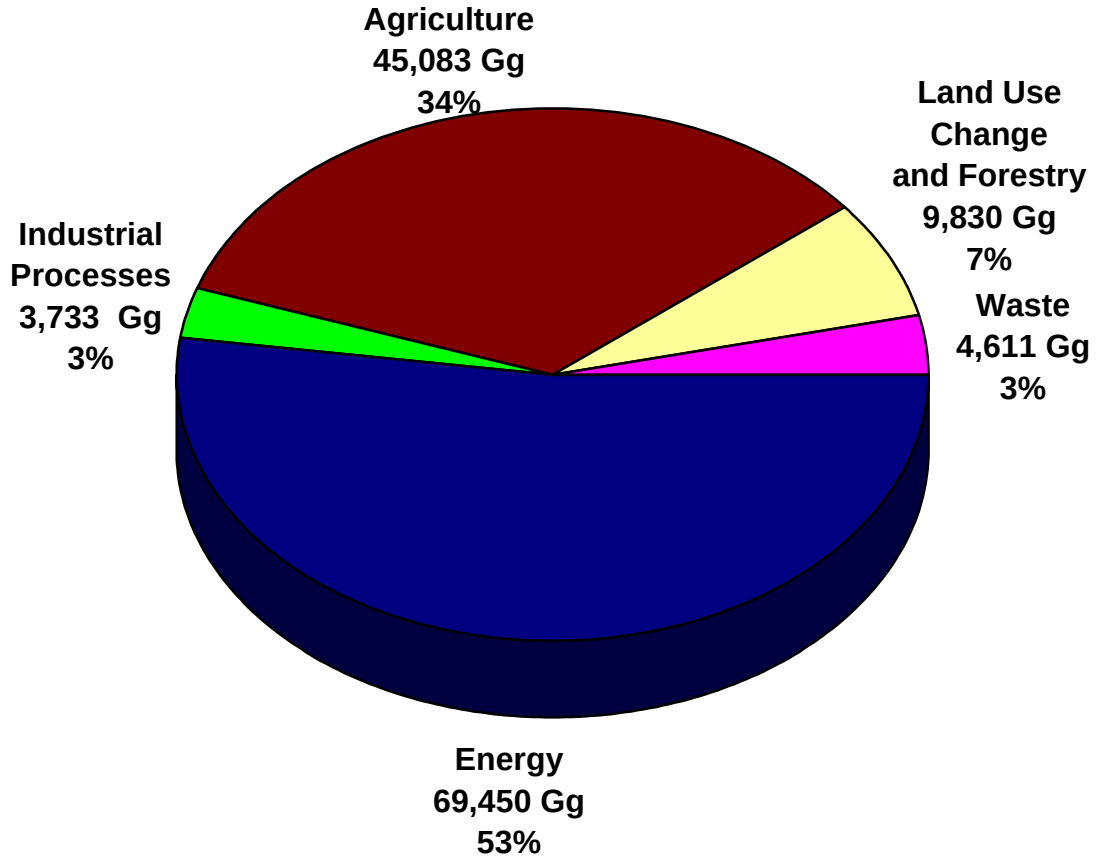
Results of Mitigation Studies from Pakistan

Presented By

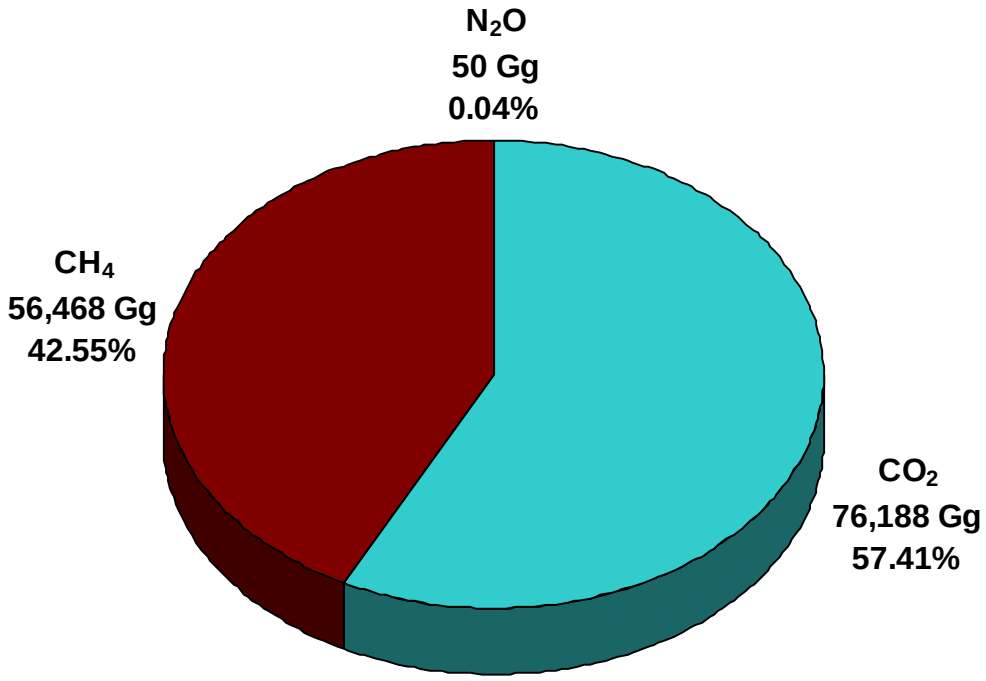
Hagler Bailly Pakistan

UNEP Collaborating Center on Energy and Environment
Environment Department of the World Bank, Goa, India
4-6 May 1998

CO_2 Equivalent National GHG Inventory
by Sector, 1989-90



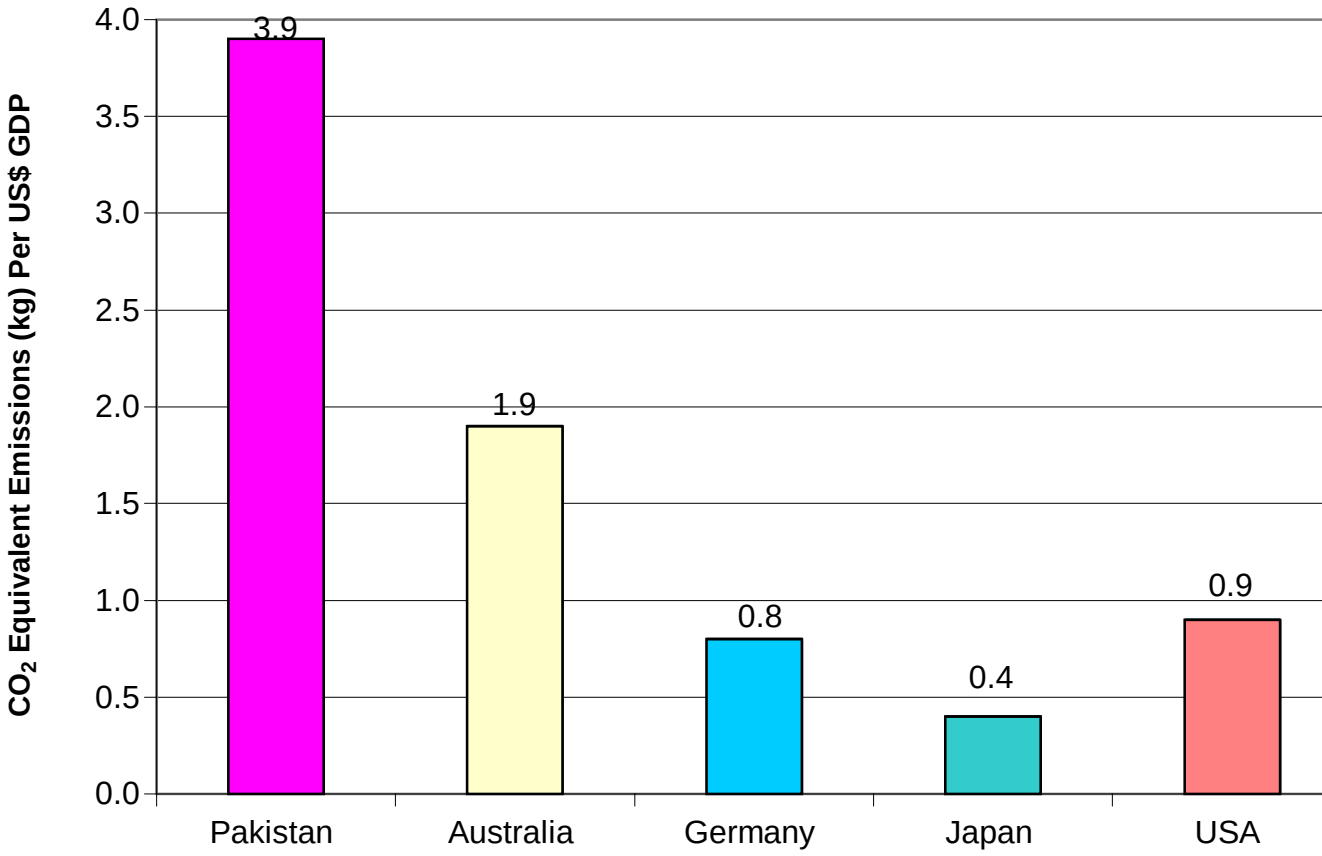
CO_2 Equivalent National GHG Inventory
by Greenhouse Gases, 1989-90



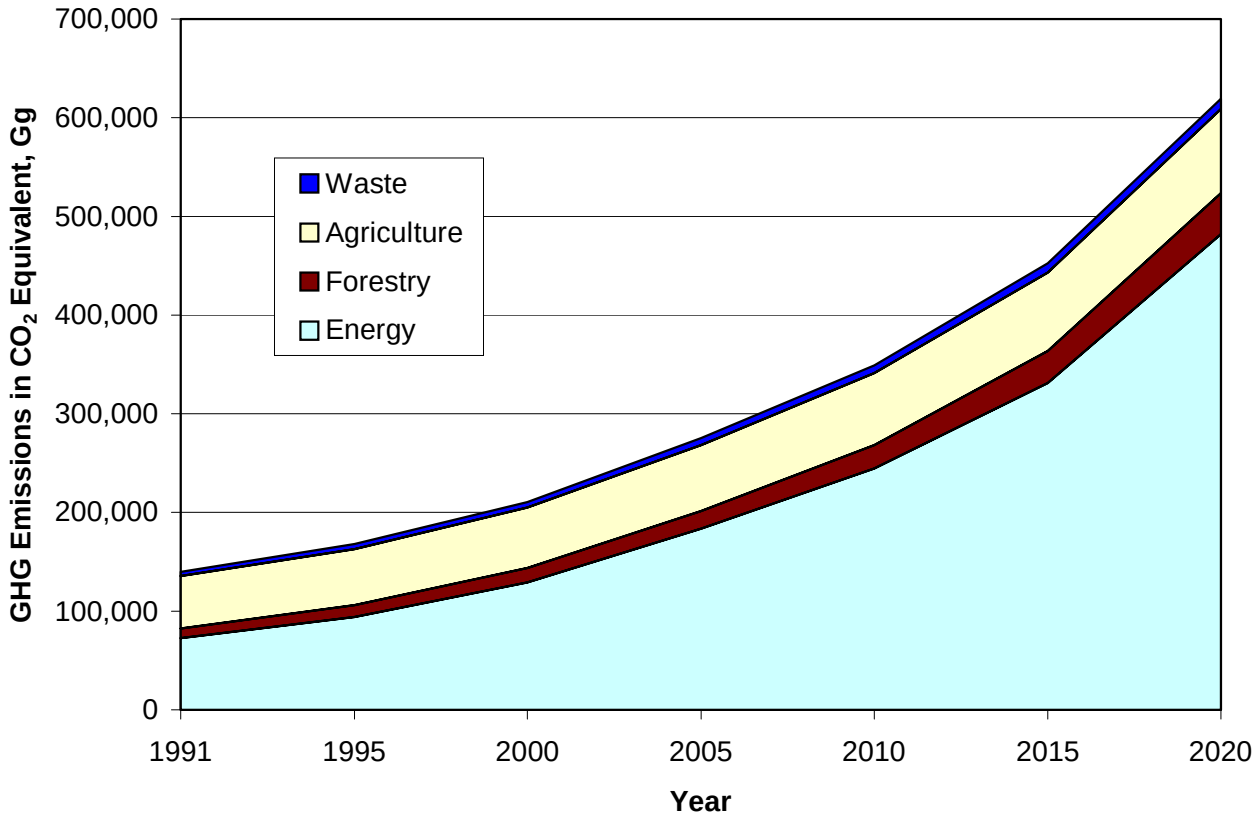
Note: Global Warming Potentials are 21 and 310 for CH_4, and N_2O, respectively

Comparison of CO_2 Equivalent Emissions
Per Person in 1990 and 2020

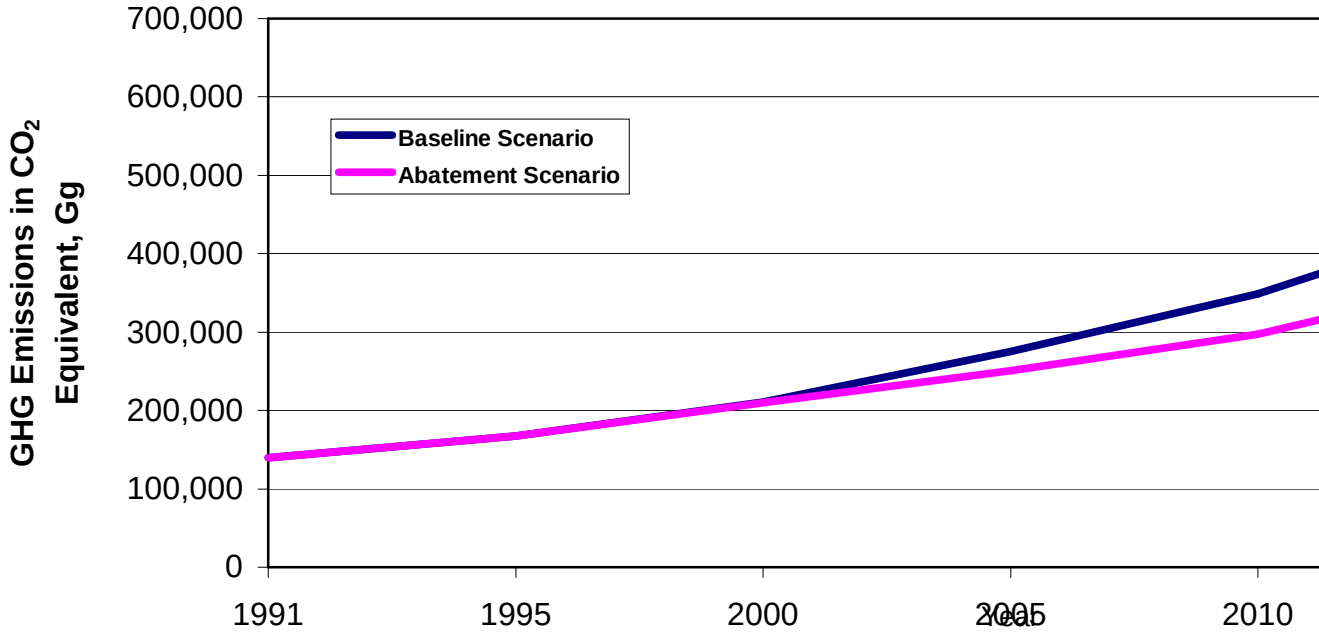
Comparison of CO_2 Equivalent Emissions
Per US$ GDP in 1990



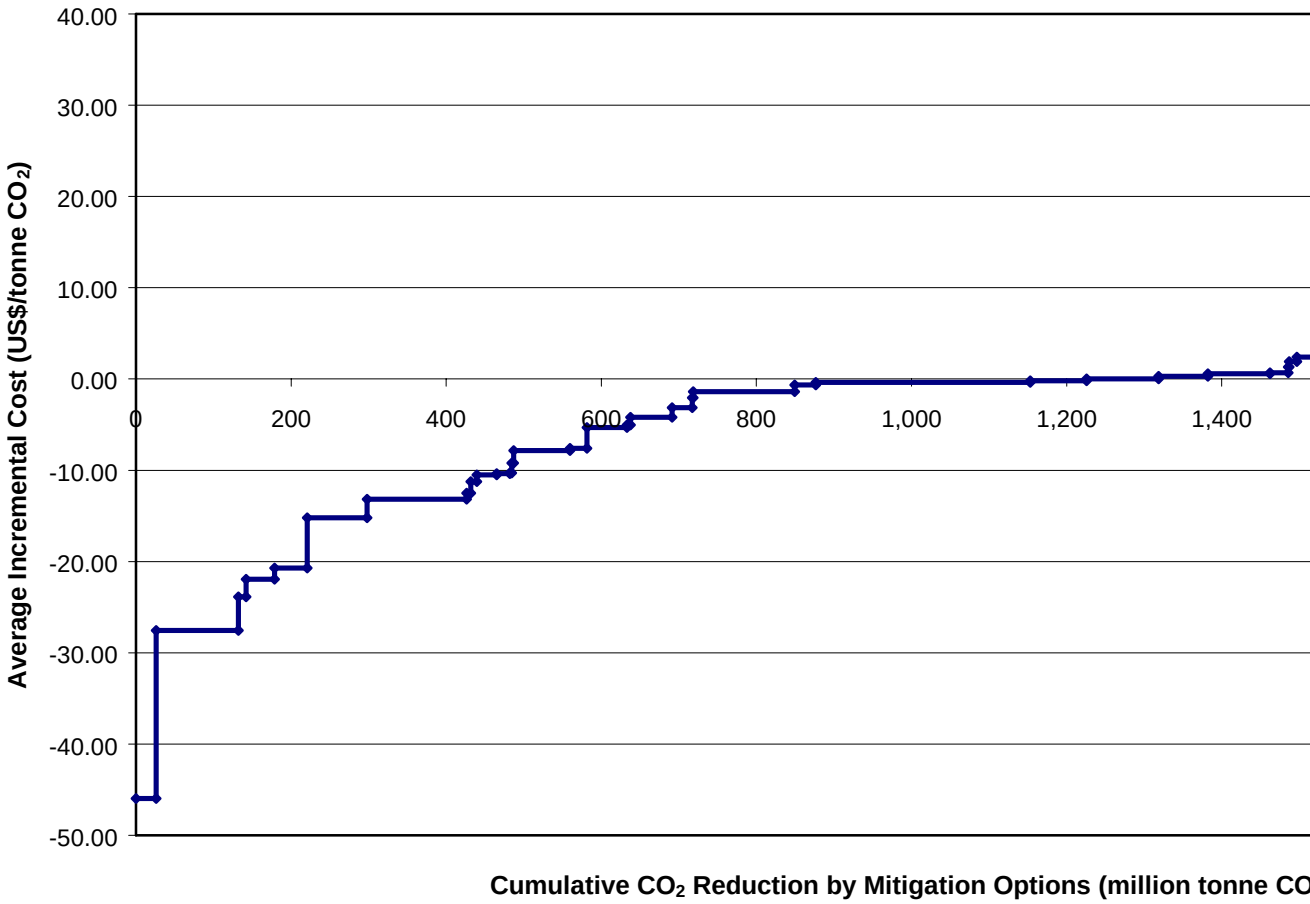
Sectoral Projections of GHG Emissions for
Baseline Scenario



Projections of GHG Emissions by Scenarios



National Cost of Emission Reduction Initiatives (CERI) Curves



GHG Options Ranked According to Average Incremental Cost

reenhouse Gas Mitigation Options	*Average Incremental GHG Mitigation Cost (US$ /Tonne CO_2)*	*Potential CO_2 Abated (Million Tonnes)*	*Cumulative CO_2 by Mitigation C (Million Tonn*
l feed for livestock (MNB)	–45.95	26.1	26.10
tion	–27.56	105.78	131.88
cial plantations	–23.86	10.02	141.90
fficient lights	–21.926	36.77	178.67
fficient fans	–20.72	42.02	220.69
fficiency improvements in tubewells	–15.22	77.46	298.15
n in electricity T&D losses	–13.18	128.36	426.51
fficient motors	–12.49	5.29	431.80
fficient refrigerators	–11.25	7.64	439.44

GHG Options Ranked According to Average Incremental Cost

Continued

reenhouse Gas Mitigation Options	*Average Incremental GHG Mitigation Cost (US$ /Tonne CO_2)*	*Potential CO_2 Abated (Million Tonnes)*	*Cumulative CO_2 by Mitigation C (Million Ton*
ficient boilers	–10.50	25.7	465.14
orest plantations	–10.36	17.04	482.18
energy generation	–10.29	2.24	484.42
ficiency improvements in water heaters	–9.20	2.54	486.96
ficiency improvements in tractors	–7.83	72.78	559.74
ion in coniferous forests	–7.60	21.79	581.53
engine maintenance practices	–5.32	51.65	633.18
r heaters	–5.02	4.43	637.61
t recovery systems	–4.18	53.7	691.31

GHG Options Ranked According to Average Incremental Cost

Continued

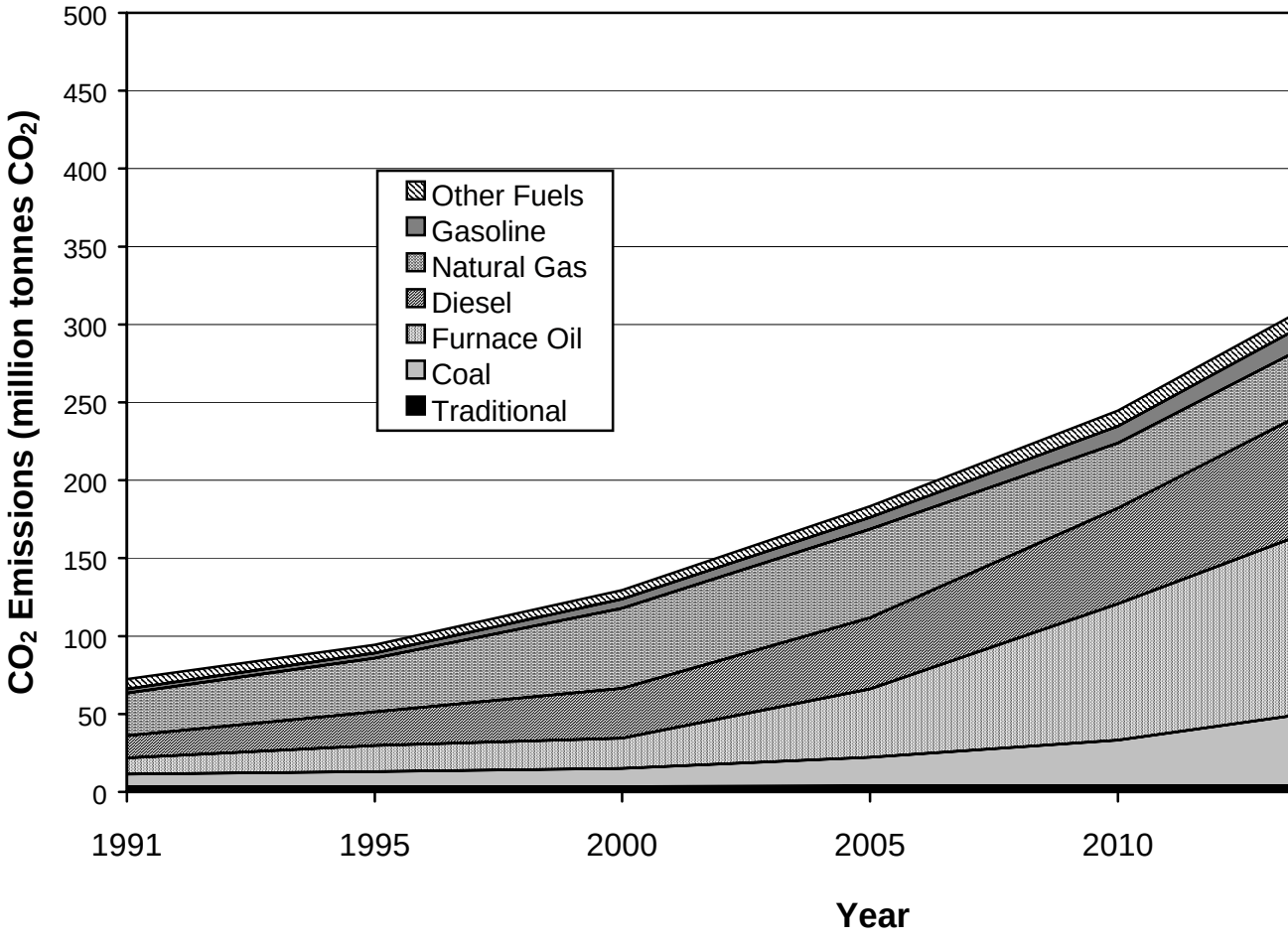
reenhouse Gas Mitigation Options	*Average Incremental GHG Mitigation Cost (US$ /Tonne CO_2)*	*Potential CO_2 Abated (Million Tonnes)*	*Cumulative CO_2 by Mitigation C (Million Ton*
natural regeneration in coniferous	–3.14	26.03	717.34
o hydel plants	–2.05	1.01	718.35
in gas T&D losses	–1.39	130.83	849.18
s on agricultural land	–0.65	27.41	876.59
try / Social forestry	–0.37	276.36	1,152.95
tection in coniferous forests	–0.18	72.99	1,225.94
eduction from rice paddies	0.02	92.79	1,318.73
l plantations	0.29	63.35	1,382.08

GHG Options Ranked According to Average Incremental Cost

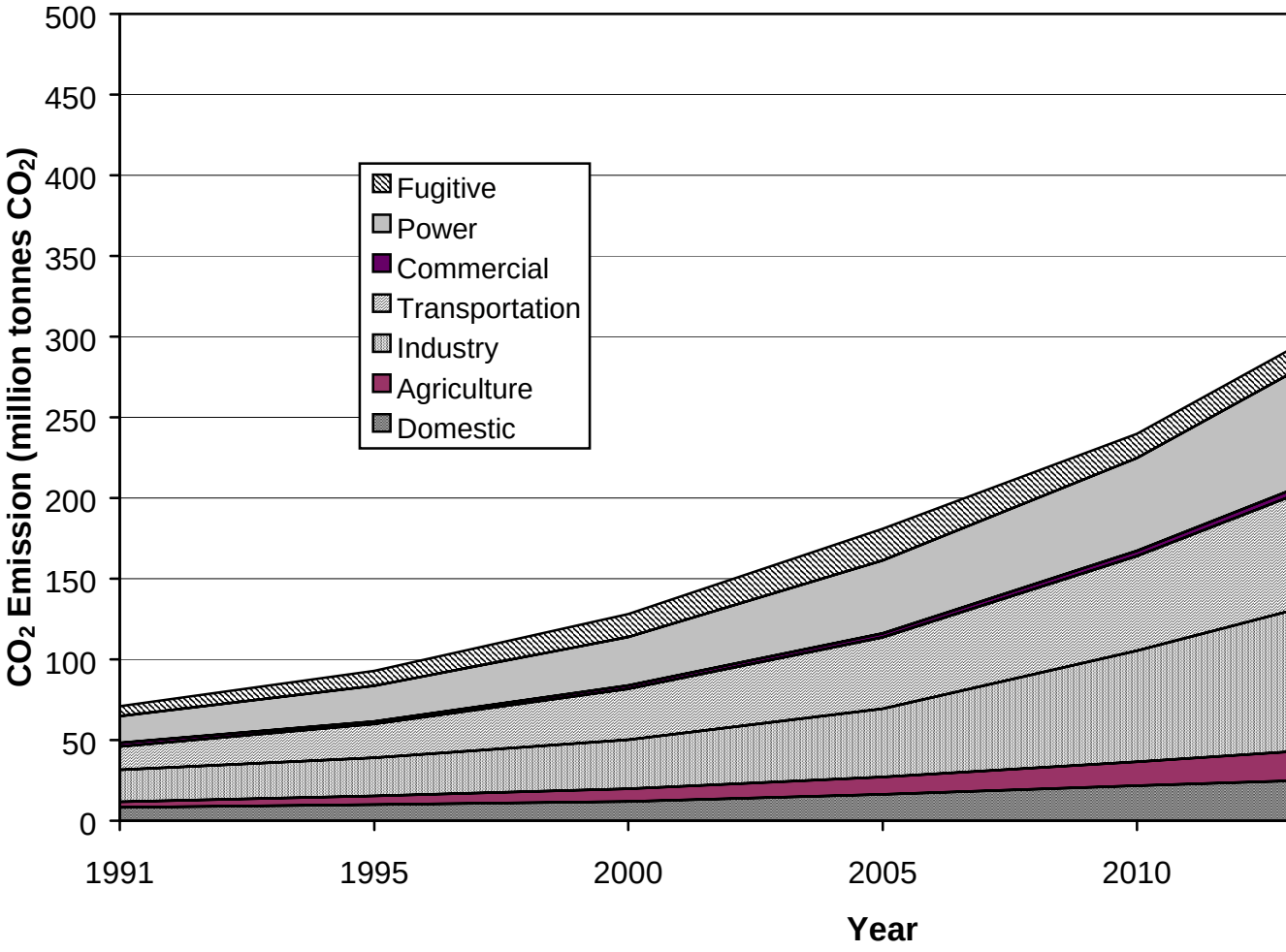
Continued

reenhouse Gas Mitigation Options	*Average Incremental GHG Mitigation Cost (US$ /Tonne CO_2)*	*Potential CO_2 Abated (Million Tonnes)*	*Cumulative CO_2 by Mitigation C (Million Ton*
l management	0.57	80.18	1,462.26
ents in vehicle maintenance practices	0.66	23.42	1,485.68
er generation	1.31	1.51	1,487.19
ents in building design	1.92	9.76	1,496.95
n of oil & coal with natural gas	2.39	238.26	1,735.21
ents in engine design	11.59	106.6	1,841.81
ovoltaic systems	28.29	0.587	1,842.40

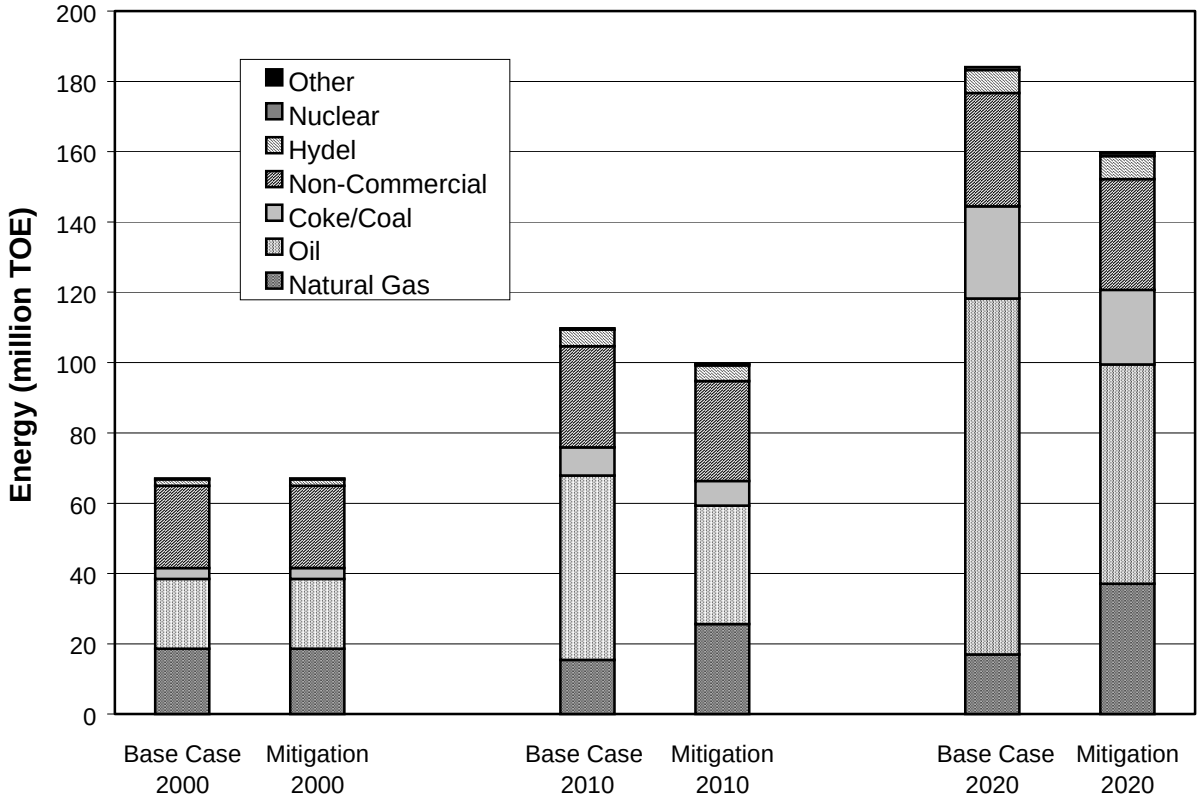
Projection of Energy Sector GHG Emissions by Fuel



Projection of Energy Sector GHG Emissions by Subsector



Impact of Mitigation Scenario on Primary Energy Supply



Pakistan National GHG Abatement Strategy

- **Short Term**
  - **Improvement in appliance efficiencies**
  - **Reduction in T & D losses**
  - **Substitution of oil and coal with natural gas**
  - **Transport sector fuel efficiency improvements**
- **Medium Term**
  - **Energy efficiency improvements in industry**
  - **Promotion of renewable energy**
  - **Improvements in building design**
- **Long Term**
  - **Promotion of afforestation and forest protection programs**
  - **Dissemination of improved feed for livestock**
  - **Institution of water management practices in rice cultivation**

Proposed GHG Abatement Projects

- **Residential Sector**
  - **Appliance labeling and standardization program**
- **Industry**
  - **Investment fund for energy efficiency**
- **Renewables**
  - **Wind power project at Pasni, Balochistan**
  - **Solar powered agricultural water pumping**
- **Agriculture and Livestock**
  - **Development and dissemination of improved feed technology for increased livestock productivity and lower methane emissions**

Priority GHG Abatement Project

Investment Fund for Energy Efficiency

- **Rationale**
  - **Limited availability of capital identified as the principal barrier in the implementation of energy efficiency measures in industry**
- **Objectives and Description**
  - **Set up a dedicated fund for financing energy efficiency in industry**
  - **Place a financial structure to effectively manage and allocate funds**
  - **Initial size of investment fund: US$ 50 million**
- **GHG Abatement Potential**
  - **Improvement in boilers: 25.7 million tonnes; Co-generation: 105.78 million tonnes; Waste Heat Recovery: 53.7 million tonnes**
- **Project Finance**
  - **International financial assistance agencies**
  - **Federal and provincial government**

Conclusions and Recommendations

- **Prepared the Pakistan National GHG Inventory and developed a feasible national least-cost GHG abatement action plan and**

implementation strategy for Pakistan

- **Pakistan intends to undertake the following measures for GHG abatement**
  - **Strengthen the institutional base for the implementation of climate change policies and programs through the establishment of:**
    - **Climate Change Cell at the Ministry of Environment, Local Government and Rural Development**
    - **Climate Change Committee under the Pakistan Environmental Protection Council**
  - **Short term: Remove subsidies and cross-subsidies in energy pricing and privatize public utilities**
  - **Medium term: Implement win-win opportunities including fuel substitution in domestic and transport sectors; develop GHG abatement options in industry and promote renewables**
  - **Long term: Develop GHG abatement in the forestry and agriculture sectors**
- **Overall potential for reduction of GHG emissions through these measures is estimated at 1,842 million tonnes of CO_2**