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**CLIMATE CHANGE MITIGATION IN ASIA
AND FINANCING MECHANISMS**

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PHILIPPINES

Mitigating Climate Change: The Philippine Case

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The Government of the Philippines signed the UN Framework Convention on Climate Change on June 12, 1992 and the Philippine Congress ratified it in 1994. The Philippine Government has also subsequently created the Inter-Agency Committee on Climate Change (IACCC).

The GOP is currently preparing the Philippine Country Study to address climate change. The first phase of the work was financed by a grant from the US Country Studies Program which is led by the US Department of Energy. The Study includes the following elements: (a) development of a National Inventory of GHG Emissions and Sinks; (b) vulnerability assessment and evaluation of adaptations of coastal resources; (c) identification of alternative programs and measures to promote mitigation and/or adaptation to climate change; (d) public information and education campaign; and (e) development of the National Action Plan on Climate Change.

Other studies in the Philippines related to climate change are the following:

- UNFCCC - CO₂ Mitigation Study in the Philippines - The CO₂-Mitigation Study has the primary objective of defining and describing an approach to record, analyze and verify CO₂ emissions from carbonaceous fuel burning in the energy sectors.
- Regional Study on Global Environmental Issues - The study is sponsored by Asian Development Bank (ADB) for eight Asian countries, including the Philippines. It is conducted by the US Climate Institute and Environmental Protection Agency (USEPA) to study the socioeconomic impacts of climate change and policy options to cope with climate change.
- Cooperative Program of the USEPA and the International Rice Research Institute (IRRI) on the Global Impacts of Climate Change.
- The Asia Least Cost Gas-Abatement Strategies Project sponsored by the Asian Development Bank.

The IACCC has already organized working groups to oversee the implementation of climate change activities and conduct workshops concerning GHG emission inventory for the Philippines.

1990 National Inventory of GHG Sources and Sinks

With 1990 as the base year, the ALGAS report came out with the Philippine greenhouse gas inventory. Land use change and forestry accounted for 50% of emissions from all sectors which is considered a very high figure for such sector when compared to other countries. This figure is mainly a result of large scale deforestation activities which have been abetted only in the early part of 1990. Up to 1990, Philippine forests continued to be cut at an alarming rate of 100,000 hectares per year. This was already an improvement from the previous decades' record of 300,000 hectares per year. Despite this, abandonment of managed lands provided for an uptake or sink.

The energy sector came in second with 26.4%. Most of the emissions from this sector came from the transformation or power production industry and the transportation sector. Fugitive fuel emissions accounted for 0% because the Philippines has no significant oil or coal production industry.

Roughly half of emissions from the agriculture sector came from rice cultivation or the flooding of rice fields. The rest came from enteric fermentation, manure management, agricultural soils, and field burning of agricultural residues.

Philippines National Greenhouse Gas Inventory in 1990 (Gg)

Sources and Sinks	CO ₂ Removals	Net CO ₂	CH ₄	N ₂ O	NO _x	CO	CO ₂ Equivalent	% of Total CO ₂ Equivalent
Total(Net) National Emissions	99,253	124,025	1,474	30.36	199.6	3034.7	164,390	100.0
1. All Energy (Fuel Combustion+Fugitive)		38,245	228.0	1.42	181.7	2,182.8	43,472	26.4
A. Fuel Combustion								
1. Energy and Transformation Industries		12,115	0.4	0.11	32.90	2.4	12,158	
2. Industry		8,449	2.4	0.41	31.90	332.4	8,627	
3. Transport		10,640	1.6	0.42	85.20	500.1	10,804	
4. Commercial-Institutional		1,703	0.2	0.01	2.40	0.5	1,710	
5. Residential		1,862	0.3	0.02	2.80		1,875	
6. Traditional Biomass Burned for Energy		42,965**	215.0	0.44	16.00	1,338.2	4,649	
7. Agriculture		640	0.0	0.01	10.50	8.7	643	
8. Non-Energy and Others		2,836					2,836	
B. Fugitive Fuel Emissions								
1. Oil & Natural Gas Systems				0.7				15
2. Coal Mining				7.4				155
2. Industrial Processes		4,132					4,132	2.5
A. Cement Production		3,272					3,272	
B. Iron & Steel		846					846	
C. Paper & Pulp		14					14	
3. Agriculture		903.2	24.98	13.4	695.7	26,700	16.3	
A. Enteric Fermentation		250.4					5,238	
B. Manure Management		66.5	6.61				3,446	
C. Rice Cultivation		566.6					11,899	
D. Agricultural Soils				18.31			5,676	
E. Prescribed Burning of Savannas			0.7	0.01	0.60	18.6	18	

F. Field Burning of Agricultural Residues			19.4	.05	12.8	677.1	423	
G. Others								
4. Land use Change and Forestry	99,253	81,647	17.9	0.12	4.5	156.8	82,060	49.9
A. Change in Forest & Other Woody Biomass Stocks	97,922	2,623					2,623	
B. Forest and Grassland Conversion		80,355	17.9	0.12	4.5	156.8	80,768	
C. Abandonment of Managed Lands	1,331	-1,331					-1,331	
D.Others		0					0	
5. Waste		324.5	3.84				8,005	4.9
A. Solid Waste Disposal on Land		173.0					3,633	
B. Wastewater Treatment		151.5					3,182	
C. Others			3.84				1,190	
Bunker Fuel Emissions		1280**					1280**	

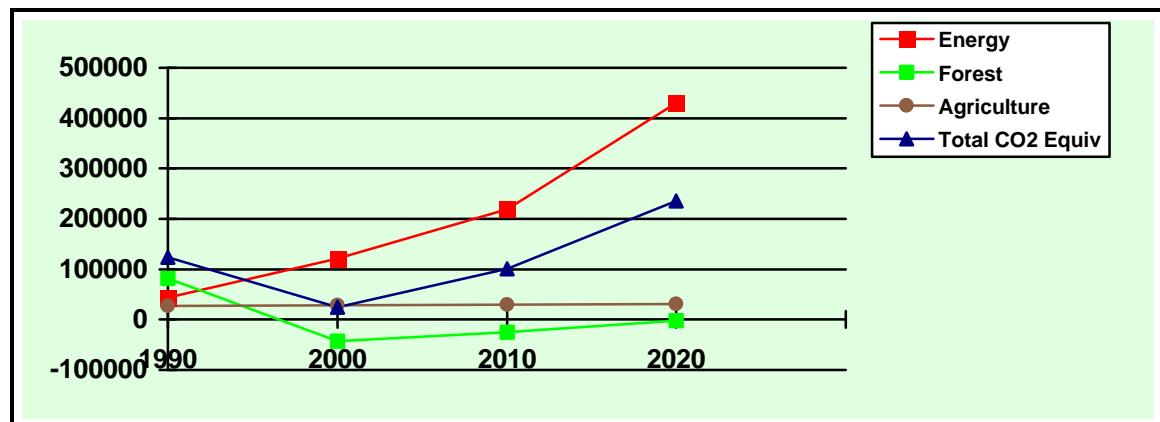
** not included in the totals

Business-As-Usual (BAU) Projection of National GHG Inventories to 2020

The projected GHG emissions of the energy, forestry and agriculture sectors were based on the Philippine Medium-Term Development Plan (1993-1998), 1996-2025 Philippine Energy Plan (PEP) Update, Medium Term Agricultural Development Plan (1993-1998), and DENR Forestry Master Plan (1990).

The growth rate of GHG emissions from the energy sector is faster than those of the agriculture and forestry sectors. The projections made in the BAU scenario show that in the year 2020 the total CO₂ emissions from the energy sector will be about 429,963 Gg, which is about 93.8% of the total national emission.

The forestry sector is the highest CO₂ equivalent emitter in 1990 representing 50.1% of the total national GHG emissions. In 1995 onwards, the forestry sector become a C sink for all other sectors. From 1995 to 2020, the sector exhibits gradual uptake of CO₂.



Baseline Scenario of GHG Emission in the Energy, Forestry and Agriculture Sectors in Gg of CO₂ Equivalent

The growth of total GHG emissions in the three sectors show an increasing trend starting year 2000. The average annual growth rate from year 2000 to 2020 16.45%.

The Energy Sector

Philippine policies and measures for the energy sector have not yet incorporated climate change mitigation measures. Mitigation measures in this sector should be considered top priority given the projected trend of greenhouse gas emissions coming from this sector.

Policies

The Philippine government's energy policies are formulated by the cabinet-level Department of Energy (DOE). The culmination of these policies may be found in the Philippine Energy Plan (PEP) which is modified by the DOE regularly to reflect changes in policy directions as well as responses to external developments. The latest version of the PEP is the Philippine Energy Plan 1996-2025 and a subsequent supplement, the Philippine Energy Plan 1996-2025 Update.

In addition to the DOE, another important institution is the National Power Corporation (NAPOCOR), a government corporation -- soon to be privatized -- involved in electricity generation, transmission, and bulk distribution. The NAPOCOR regularly prepares a Power Development Program (PDP), which sets the direction of development of its generating capacity. In particular, its choice of technologies for its power mix has direct impact on the future volume of greenhouse gas emissions of the country. The PEP and the PDP, together, basically cover the country's sources of fuel, the burning of which generates greenhouse gases.

Executive Order 462 is a presidential issuance that is hoped to bring about the commercialization and thus, expansion, of the use of new and renewable sources of energy such as solar and wind power. However, it is debated within energy circles that the law is insufficient in encouraging private sector investment because of the nature of the source of energy itself which requires high investment costs. The realization of its primary objective of eventually enabling the country to export energy from renewable sources is much doubted.

Public Policy Issues

Several public policy issues influence any program on climate change mitigation for the energy sector. These are:

1. Fossil Fuels v. Renewables
2. Nuclear v. non-Nuclear
3. Private v. Public Transport Modes

The bias in favor of fossil fuel use for energy is one of the major blocks in the development of programs and policies for the expansion of renewable sources of energy. The heavy subsidy given to the conventional energy sector and the lack of incentives for improving the renewable energy sector comprise the main issue in this debate.

The use of nuclear energy in the Philippines has seen its light and death in the Bataan Nuclear Power Plant project which was considered one of the major sources of graft attributed to President Marcos and his cronies. The fact that the Philippine government lost billions of dollars in this single project and continues to pay its contracted debt, not to mention the questionable design and overall structural integrity of the plant, gave nuclear energy a bad name in the Philippines. Because of this, it is fairly certain that no nuclear energy project would ever be entertained by both the Philippine government and the Filipino people. Nuclear energy is synonymous to destruction and kickbacks.

The lack of prioritization of developing public modes of transportation has engendered a private car culture in the metropolitan centers of the Philippines. The purchase of private automobiles is unregulated to a large extent. At the same time, there is an obvious neglect of mass transport systems, with the public heavily relying on highly pollutive and inefficient jeepneys rather than buses and light rail systems mainly because of the government's inability to improve the mass transport systems for decades past.

Proposed Government Policies and Measures

The sectoral report on energy for the Philippine National Action Plan came out with the following proposals:

1. Energy and Transformation
 - Gradually Shift the energy mix towards renewable energy
 - Build commercial prototypes to accumulate operating data.
 - Least-cost planning and Full-cost accounting
 - Reevaluate the various planning software
 - Conduct more research on technology cost trends: solar; wind; biomass; and mini-hydro energy power sources.
 - Raise efficiency targets
 - Supply-side efficiency improvements: power plant efficiency improvement; transmission loss reduction; replacement of coal plants with N-gas combined cycle plants.
 - Demand-side efficiency improvements: energy conservation; use of efficient technology.
 - Reduce unnecessary energy consumption.
 - Strict implementation of emission control schemes: update emission standards; strengthen implementing government agencies; strict licensing standards and regulations.
 - Energy-efficient designs for new building structures.
2. Transportation
 - Traffic Improvement Schemes
 - Development and use of efficient mass transport systems.
 - Support for non-motorized transport modes
 - Emission Control Schemes
 - Strict implementation of emissions control standards.
 - Improved fuel and vehicle efficiency.
3. Industry
 - Encourage energy efficiency measures.
 - Promote energy conservation.
 - Use of alternative non-CO₂-emitting industrial processes.

On the other hand, the ALGAS draft report has come out with the following mitigation options with their corresponding cost:

Implementation Time Frame	GHG Abatement Initiative	Potential GHG Emissions Reduction (MT of CO ₂ Equiv.)	Cost of Initiative (US \$/ton of CO ₂)
Energy Supply Side			
Short to Medium Term	System Loss Reduction	69.7	(-) 17.2
Short to Medium Term	Heat Rate Improvement	157.7	(-) 5.1
Short to Long Term	New and Renewable Energy		
	Wind	7.3	(-) 1.64
	Solar	3.7	1.36
	Biomass	3.7	0.27
Medium to Long Term	Natural Gas	55	2.4
Energy Demand Side			
Short Term	Use of CFL	33	(-) 26.3
Short to Medium Term	Hi-eff Air Con System	44	(-) 6.1
Short to Medium Term	Hi-eff Refrigerators	11	(-) 5.4
Short to Medium Term	Hi-eff Industrial Motors	7.3	(-) 13.7
Short to Medium Term	Hi-Eff Boilers	11	(-) 26
Transport			
Medium to Long Term	Hi-Eff Transport System	40.3	-2.90

The Agricultural Sector

Total Forestry and Land Use Sector CO₂ Emission/Uptake in the Philippines is presented in the following table:

Land Use Changes	Total Emission/Uptake */ (kt C)	Total Emission Uptake (kt CO ₂)
Change in Forest and Biomass Stock	+ 715	+ 2,622
Forest and Grassland Conversion	+ 21,726	+ 79,662
Burning of Forest (for Trace Gases)	+ 111	+ 407
Abandonment of Managed Lands	- 363	- 1,331
Net C Emission	+22,189	+ 81,360

NOTE: + = Emission
- = Uptake

The following is the Projected CO₂ Emission/Uptake From Forestry and Land use as given in the ALGAS draft report:

YEAR	Emission/Uptake (kt CO ₂)
1990	+ 81,360 (Emission)
2000	- 43,163 (Sink)
2010	- 25,448 (Sink)
2020	- 2,324 (Sink)

This projections are based on the existing master plan for the forestry sector presently being implemented by the Department of Environment and Natural Resources. It is also the best mitigation option for the forestry sector as it closely corresponds to proposals for mitigation in this sector. So unlike the energy and the agricultural sector, the mitigation policies for the forestry sector are already in place and are being implemented. Continued implementation of the masterplan which limits logging to residual and secondary forest growths while banning logging in protected areas, environmentally critical areas and old growth forests would result in the projected net uptake of ghg instead of emissions.

Policies and Measures

Executive orders were issued that contained the prescribing guidelines and establishing a regulatory framework for the prospecting of biological and genetic resources (EO No. 247, May 18, 1995) and on Community-based Forest Management (EO No. 263). Also issued were republic acts for the establishment and management of national integrated protected areas system (RA 7586); increasing the forest charges on timber and other forest products (RA 7161).

The Local Government code of 1991 (RA 7160) required the devolution of some DENR functions to the LGUs such as the implementation of the Integrated Social Forestry Program, management and control over communal forests with an area not exceeding 50 sq. km., establishment of tree parks and greenbelts, and enforcement of laws related to mangrove resources conservation within municipal waters.

The Department of Environment and Natural Resources (DENR) also instituted measures in its implementation of environmental laws. These include the institutionalized shift in logging from the old growth (virgin) forests to the second growth (residual) forests (AO No. 24, 1991); guidelines for the implementation of the shift in logging from the old growth to the second growth forests (MO No. 8, 1991); guidelines for the implementation of the Community Forestry Program (DAO No. 22, 1993); establishment and promulgation of the guidelines for the implementation of the Forest Land Management Program and for the issuance of long-term Forest Land Management Agreements (DAO No. 23, 1993).

For protected areas, the DENR issued the implementing rules and regulations of the NIPAS (DAO No. 25, 1992); the guidelines for the establishment of buffer zones for protected areas (Dept. Memorandum Circular No. 16, 1993); rules and regulations for the identification, delineation and recognition of ancestral land and domain claims (DAO No. 2, 1993); and the implementing rules and regulations on the prospecting of biological and genetic resources (DAO No. 20, 1996).

The department also instituted log control and monitoring system (DAO No. 4, 1996); institutionalized the Multi-Sectoral Forest Protection Committees within its system (DAO No. 17, 1995); and the rules and regulations for the Socialized Industrial Forest Management Program (DAO No. 24, 1996).

The government's Master Plan for Forestry Development focused on the relationship of man and with the environment and on forest management and development. This master plan included the following programs on people-oriented forestry; soil conservation and watershed management; integrated protected areas system and biodiversity conservation; urban forestry and forest protection;

the management of dipterocarp forests, mangroves, pines and other natural forests; forest plantations and tree farms; and programs for the wood-based and non-wood forest-based industries.

Proposed Government Policies and Measures

- Rehabilitation of denuded forest lands - reforestation of grasslands and other denuded areas.
- Sustainable management of the remaining natural forests.
- Community-based forest management - to make forest dependent communities more self-reliant, self-sufficient and effective partners in sustainable forest management. Involves the active participation of these communities in the rehabilitation, protection and utilization of forest resources.
- Protected area management - preserve areas with high biodiversity conservation values: old-growth forests and mossy forests.
- Watershed-based integrated area forest management.
- Revitalize and rationalize forestry research and development

The Agricultural Sector

The following is the summary of the 1990 emissions of green-house gases from the agricultural sector:

No	Sub-sectors				CH ₄	CO	N ₂ O	NO _x	CO ₂ Equivalent
		CH ₄ (Gg)		(Gg)		(Gg)			(Gg)
1	Livestock	Enteric Fermt'n.	Manure Mngt.						
	a. Carabao	153.55	8.37		161.9				
	b. Cattle	77.80	3.54		81.3				
	c. Hog	7.73	54.08		61.8				
	d. Goat	11.31	0.50		11.8				
	Sub Total	250.39	66.49		316.8		6.61		8,684
2	Rice Field	CH ₄ (Gg)							
	a. Continuously flooded	502.38			502.4				
	b. Intermittently flooded	64.23			64.2				
	Sub Total	566.61			566.6				11,899
3	Agricultural Soils		N ₂ O (Gg)						
	Direct Emissions		13.22				13.22		
	Indirect Emissions		5.09				5.09		
	Sub Total		18.31				18.31		5,676
4	Prescribed burning of Savanna								
	Grassland				0.71	18.51	0.01	0.20	18
5	Burning of Agric. Residue								
	Rice/Sugarcane				19.35	677.10	0.05	12.8 1	423
			Total Emissions		903.46	695.61	24.98	13.0 1	26,700

Policies and Measures

The Medium-Term Agricultural Development Plan (MTADP) for 1993-1998 had the twin goals of people empowerment and global competitiveness with four banner programs: Grains Production Enhancement Program Development Program (GPEP) for rice and corn; Key Livestock Development Program (KLDP); Key Commercial Crops Development Program (KCCDP); and Key Fisheries Management and Development Program (KFMDP). It had used the Key Production (KPA) approach in which government support were focused in areas where land and water resources were to be put to best use. Initially, 1.9 million hectares of land had been identified to be best suited for cereal production (1.2 million hectares for rice and 0.9 million hectares for corn). The remaining 3.1 million hectares of the existing 5.4 million hectares of agricultural area originally planted to rice and corn (including marginal lands) were to have been converted into either commercial or livestock farms.

The MTADP includes programs for grains production enhancement for rice and corn; and livestock, commercial crops and fisheries management and development. Among the plans proposed programs is the launching of a nationwide program for sustained increase in domestic food production. A policy framework to stabilize food prices and reducing supply fluctuations through trade will be established. And a buffer stock will be maintained for lean production periods and emergency purposes and subsidized rice will be subsidized for the poorest segments of the population.

Under the Philippine Agenda 21 (PA 21), food security will be ensured through the promotion of integrated approach covering all aspects of agricultural operations; rationalization and strengthening of farmers' organizations; establishment of an information support system that will provide integrated and consolidated weather, soils, agricultural technology and market information. The passage of legislative bills to help and protect farmers and agricultural lands will be advocated along with the formulation and implementation of a national agricultural land-use policy that will address the need for integrated management of the ecosystems for sustainable agriculture.

The government recognized that it is necessary to assess land degradation and encourage integrated crop and livestock farming systems in agricultural marginal lands to sufficiently remedy the impacts of the loss of marginal lands. PA 21 promotes the use of chemical-free agriculture and diversified but intensive farming systems with appropriate capability-building programs to address the negative impacts of excessive use of fertilizers and chemicals and the implementation of a community-based resources management with provision of financial support system to farmers.

The DA has now also adopted the Balanced Fertilization Program in support of the Gintong Ani Program. This is a new intervention which will provide location-specific fertilizer recommendations for organic and inorganic fertilizers in order to reduce the effect of the very wide variations in the soil and climatic conditions (Aggietrends, 1997). The program aims not only to ensure that soils will sustain high crop yields over long cropping season without causing depletion of the natural resource base, but will also provide guidelines for strategic distribution of appropriate fertilizers and future research direction and guidelines on economics of fertilizer use.

In the agricultural sector, the measures taken include: reduction of programmed area of irrigation; adjustment of the cropping calendar and farming activities; utilization of low-water use crops; rotation of water supply distribution for irrigation; optimum utilization of rainfall; improvement of irrigation systems and the conjunctive use of shallow wells.

Proposed Government Policies and Measures

The necessary changes in agricultural management practices include: use of heat- and drought-resistant varieties, improved farm management, sustainable farming, organic farming, diversified farming, optimum and efficient use of fertilizers and chemicals, increase effectiveness/flexibility of irrigation; natural rainfall management. Other measures also include the following:

- For animal production: use of tubular polyethylene bio-digesters and the use of urea-molasses mineral block as nutrient supplement;
- Liberalization of agricultural trade barriers and change in existing subsidies;
- Development of conservation management practices and institutionalization of agricultural drought management;
- Use of sulfate fertilizers to reduce methane emissions;
- Use of rice straw, water management and low-emitting cultivars;
- Upgrade food storage/distribution systems;
- Promote and implement judicious land-use planning; and
- Study/review and improve existing policies associated with production, processing, storage, transport and marketing.

The following table shows the ALGAS report's assessment of investment cost and impact on yield for mitigation options in the agricultural sector:

Options	Investment cost,(\$)/ha for the alternate practice	Baseline cost,(\$)/ha for crop production	Total cost,(\$)/ha	Baseline yield, MT/ha/yr	Incremental yield. MT/ha/yr	Financial value of production, \$/ha	
		311	311	3.5		Baseline 353	Alternate
1. Composting	(41)		270		0		353

2. Sulfate fertilizer	9		320		0.5		403
3. Water mgt.	2		313		0		353
4. Low CH ₄ emitting cultivar	1		312		2.3		585

Note: () - Cheaper than the alternate practice.

Composting rice straw is projected to reduce methane emissions by 10%. The use of ammonium sulfate will bring about reduced methane emissions by 10% during the dry season and by 30% during the wet season. Water management in the irrigation of crops particularly rice would result into a 30% reduction of methane emissions and the use of low-methane cultivars into 50% reductions while increasing yield by 65%.

GHG Mitigation Options in Agriculture

Technologies	Estimated Cost and Benefits	Reduction in CH ₄ Emission	Incremental Cost (M\$/ Gg CH ₄)	Constraints
Composting	Very high potential for GHG emission abatement (CH ₄)	10 %	20.26	Lack of incentives
Use of sulfate fertilizers	Increased rice yield	10% - 34%	28.29	No existing policy on importation of fertilizers
Water management		30 %	4.83	
Short season cultivars		50 %	4.34	

An examination of the projected action agenda embodied in the Philippine Agenda 21 indicates that some of the measures recommended in the sectoral plan for agriculture to address climate change are already included in the sustainable development planning document even if climate variability/change had not been part of the basis when the Philippine Agenda 21 was drawn.

Implementation of a genuine land reform program will ensure sufficient support services to enable even subsistence farmers to earn a decent living. Formulating and implementing a National Agricultural Land Use Policy will address the need for integrated management of the ecosystems for sustainable agriculture. An assessment of land degradation and encouraging integrated crop and livestock farming system in agricultural marginal lands should sufficiently remedy the impacts of loss of marginal lands. The mix of sustainable development strategies that the Department of Agriculture is executing to attain food security will ensure that there will be enough food for everyone. The promotion of a chemical-free agriculture and diversified but intensive farming systems with appropriate capability-building programs will address the negative impacts of excessive use of fertilizers and chemicals. Promotion of a community-based resource management together with provision of financial support system to farmers in the form of incentives and the like will immensely help the small land-owning farmers.

However, while sustainable development has been the underlying principle of all these strategies, the projected impacts of climate change had not been specifically factored in. It is for this reason that there still exists an urgent need to address these projected impacts of a warming climate on the agricultural ecosystem and agricultural production in the development plan of the DA.

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SRI LANKA

Climate Change Mitigation Studies in Sri Lanka

*Rupa Wickramaratne**

Introduction

In Sri Lanka, Climate Change Mitigation Studies have received low priority and have been limited to an ADB-sponsored preliminary study followed by an initial assessment of some mitigation options in the energy and agricultural sectors, with technical assistance from the US Country Studies Program. The major focus was on options for the mitigation of carbon dioxide emissions from the energy sector. Owing to funding constraints, only the potential for reduction of carbon dioxide emissions resulting from the various mitigation options were quantified; analysis of monetary costs and benefits or policy/programs for adoption of the options were not undertaken. For the non-energy sector, a very limited study on mitigation of methane emissions from rice fields was carried out.

ENERGY SECTOR

Energy generation in the power, transport, domestic and industrial sectors and from industrial processes was investigated.

Sources of Energy Biomass and hydroelectricity are the main indigenous sources. Nearly all fossil fuel requirements are imported in the form of crude oil and processed into lighter fractions; refined products are also imported according to demand. On an average, during 1991-93, biomass contributed 70% of total energy, petroleum 25% and hydroelectricity 5%. Of the commercial energy, 50-60% is consumed in the transport sector.

Methodology Baseline scenarios were established with 1990 as the base year and mitigation scenarios upto the year 2015 arrived at using Markal-Macro analysis. Published consumption, demand and economic data relevant to Sri Lanka and published IPCC mitigation technologies were used for this purpose. Since rapid economic and social changes are expected in Sri Lanka over this period, three economic scenarios to reflect low, medium and high economic growth were considered. Five percent reductions to medium and high scenarios were also introduced and corresponding emissions determined, together with corresponding savings in expenditure wherever possible.

The Power Sector

Baseline Scenario It was assumed that there would be no changes to the present policies and practices on energy sector development and management and in particular, no changes in the patterns of supply and consumption of fuel. Demand for petroleum products was expected to grow at rates determined by the expected increase in economic activities. Likewise, electricity demand was expected to increase in accordance with economic development and population growth. Improvement of transmission and distribution as planned by the Electricity Board was included in the Business-as-Usual (BAU) Scenario.

Demand for power The sectors with significant electricity consumption are the industrial (40%), residential(34%) and commercial (26%) sectors. The average growth for the demand for power is

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likely to increase with the implementation of government policies of industrialization and decentralization and the urban development programs; the forecast upto the year 2020 is given in Table 1. The major subsectors of demand were found to be lighting, refrigeration and electric motors(fans) for the residential sector. In the industrial sector, electric motors consumed a large portion of energy with lighting as the second consuming subsector, whilst in the commercial sector electric energy consumption for lighting and motors were nearly equal.

Table 1. The electricity demand (Gwh/Yr.) forecast until the year 2020 for the dominant sectors

Year	Residential	Industrial	Commercial	Total
1995	1305	1563	984	3852
2000	1848	2518	1698	6064
2010	3224	6133	4348	13705
2020	4913	12421	10265	27599

Source : Fernando, Wijeratne & Tennakoon (1997)

Based on the demand for power in the various subsectors, the average growth rates of power were estimated for the three scenarios corresponding to LOW, MED(medium) and HIGH economic growth, and were taken as 7.8%, 8.8% and 9.9% respectively. Markal-Macro was used to establish carbon dioxide emissions for BAU under the three scenarios. Table 2 shows emissions corresponding to the base year , for the period upto 2015. In the case of the power sector values correspond to the MED scenario and for industrial processes to high economic growth.

Table 2. Carbon Dioxide Emissions under Baseline Scenario

Sector	CO ₂ Emission in Gg					
	1990	1995	2000	2005	2010	2015
Energy(Fossil)	3306.18	5181.39	7071.97	12528.82	17585.91	29304.68
Power(MED)	8.51	615.78	1904.09	6445.06	10541.10	21139.20
Transport	2213.42	3188.72	3481.51	4067.40	4641.37	5298.24
Domestic	550.49	727.48	896.29	1055.11	1233.93	1444.36
Industry	533.76	649.41	790.08	961.25	1169.51	1422.88
Energy (Biomass)	12172.70	13148.86	14447.06	15942.52	17678.05	19721.07
Domestic	8718.00	8945.69	9333.26	9720.80	10108.38	10511.41
Industry	3454.70	4203.17	5113.80	6221.72	7569.67	9209.66
Industrial(HI)	244.53	906.09	124.14	1700.08	2330.31	3192.73
Total	15723.41	19236.34	21643.17	30171.42	37594.27	52218.48

Source : Ratnasiri (1998)

Mitigation Scenario The year 1990 was taken as the base year but since the study was carried out in 1997 available statistical data in real terms were incorporated upto 1995. The timeframe used was 25 years. Socio-economic variables such as economic and population growth rates, rural/urban population etc. were obtained from published data. A discount rate of 10% was assumed. Candidate

technologies for hydro and thermal power production in Sri Lanka and other data on the power sector of Sri Lanka were from already published material, as were data on advanced technologies.

The options considered for mitigating emissions in the power sector are (i) better demand side management through the gradual introduction of compact fluorescent lamps and (ii) improving the efficiency of refrigerators, home appliances and industrial equipment. In energy generation, options included were maximizing on hydropower and the introduction of natural gas. Emissions under mitigation options in the power generation sector are given in Table 3.

Table 3. Emissions under Mitigation Options in the Power Generation Sector

Year	CO ₂ Emissions in Gg				
	LOW-MO	MED-MO	MED-MO+5%	HI-MO	HI-MO+5%
1995	615.78	615.78	615.78	615.78	615.78
2000	1552.65	1755.15	1667.39	2083.00	1979.00
2005	4032.47	5050.87	4804.02	6418.10	6097.00
2010	6432.73	8495.24	8070.48	11067.70	10514.40
2015	13893.00	17901.90	17006.80	23769.00	22581.40

Source : Ratnasiri (1998)

The Transport Sector

Greenhouse gas emissions were calculated separately for CO₂ and non CO₂, and for different types of vehicle, the railway, local marine and local air transport, for the period 1990 to 1992. IPCC procedures were used for this purpose. Results are summarized in Table 4.

Table 4. Summary of Emissions from Transport Sector

Year	Road Transport	Railway	Local Marine	Local Air	Total
1990	1925.08	84.405	6.458	198.273	2214.2
1991	2006.07	67.560	11.500	232.550	2317.7
1992	1999.47	68.178	6.867	259.970	2334.4

Source : Fernando, Wijeratne & Tennakoon (1997)

Baseline Scenario Data on the use of different modes of transport were analyzed and predictions of the baseline scenario for the transport sector made accordingly. Energy consumption and emissions from road transport for the years 1996 to 2010

were estimated assuming the average energy use and emissions per vehicle of each category as in the IPCC guidelines. The BAU emission scenario for the railway sector assumed that the railway vehicle population would continue to remain stagnant. Energy consumption for local marine and local air transport were also estimated. The overall emissions for the BAU scenario of the transport sector are presented in Table 5.

Table 5. BAU Scenarios Emissions from Transport Sector (kt CO₂/a)

Year	Road	Railway	Local Marine	Local Air	Total

	Transport				
1990	1946.395	85.0731	6.0065	198.1410	2235.6150
1995	2810.935	78.9953	7.7136	291.0720	3188.7159
2000	3056.007	79.0000	7.1464	339.3540	3481.5070
2005	3572.358	79.0000	7.9027	408.1400	4067.4007
2010	4076.790	79.0000	8.6590	476.9250	4641.3740
2015	4652.450	79.0000	9.4876	577.3025	5298.2400

Source : Fernando, Wijeratne & Tennakoon (1997)

Mitigation Scenario The mitigation scenario with improved technical efficiency of vehicles so as to increase fuel economy was analyzed. It was assumed that road vehicles would have an average improvement of efficiency of 30% from and after the year 2000, trains 25%, air and marine transport 25%. Fuel switching was also considered as a mitigation option but this was limited to road vehicles. First the extreme case of a shift of fuel to LPG in all new road vehicles after the year 2000 was considered and then a switch to compressed natural gas (CNG).

The overall emissions under these mitigation scenarios are given in Table 6 (a) and (b).

Table 6. Overall Emissions under Mitigation Scenarios

(a) Efficiency improved transport for the Transport Sector

	CO₂ Emissions in Gg	
Year	BAU Scenario (includes road, rail, local air and marine)	Mitigation Scenario (Efficiency improved transport)
1995	3188.716	3188.716
2000	3470.459	3413.940
2005	4051.351	3875.639
2010	4625.325	4333.205
2015	5279.499	4863.888

Source : Fernando, Wijeratne & Tennakoon (1997)

(b) Fuel switching of new road vehicles

	CO₂ Emissions in Gg		
Year	BAU Scenario	LPG Model	CNG Model
1995	2810.935	2810.935	2810.935
2000	3056.007	2998.831	2989.786
2005	3572.358	3342.568	3344.439
2010	4076.790	3677.951	3639.510
2015	4652.450	4062.009	3972.728

Source : Ratnasiri (1998)

Combustion activities in the Residential sector

Fuelwood, LPG and kerosene are used as fuels for combustion activities in the domestic sector, the first two for cooking . Commercial energy sources such as kerosene and electricity are used mainly for lighting with a diminishing quantity used as energy for cooking , owing to higher costs as compared to fuelwood or LPG.

Baseline Scenario Annual fossil fuel consumption figures for the years 1985 to 1992 were analyzed to arrive at a growth rate of demand for fuels in the residential sector and the growth trend used to estimate consumption levels for the years 1995 to 2015.

The CO₂ emissions from kerosene lamps and cookers, for this period, were estimated using IPCC methodology.

Mitigation Scenario Mitigation options considered for the domestic sector include the following:

Lighting Replacement of the kerosene bottle lamp with the chimney lamp or petromax lamp, which could increase the efficiency of combustion of kerosene for light. Use of solar- based photovoltaic lighting could also be recommended.

Electrification of rural households was not considered a suitable mitigation option for kerosene lamps.

Cooking A shift from the kerosene cooker with an average efficiency of 24% to the LPG cooker, the current efficiency of which is 40%, and also improvement of the efficiency of the LPG cooker to 42% with the introduction of sealed burners, reflective resources and thermostatic burners. The reduction of CO₂ emissions in residential cooking is shown in Table 7.

Table 7. Reduction of CO₂ Emissions in Residential Cooking.

Year	Emission (kt)			Percent
	BAU Scenario	Mitigation Scenario	CO ₂ Reduction	Reduction over BAU
1990	208.912	208.912	0	0
1995	296.037	296.037	0	0
2000	381.052	381.052	0	0
2005	456.072	454.807	1.265	0.277
2010	551.091	544.346	6.745	1.220
2015	665.990	650.450	15.540	2.330

Source : Fernando, Wijeratne & Tennakoon (1997)

Combustion activities in Industry

Energy for industry is derived mainly from electricity, petroleum fuels and firewood for the operation of boilers, furnaces/ kilns and dryers. Firewood and other biomass are used in the small manufacturing industries.

Fuel consumption data were used to estimate CO₂ emissions from the industrial combustion activities. In a sectoral analysis of energy consumption the food and beverages industry, the textile industry and the non-metallic mineral products industries were by far the most significant energy users. Mitigation options for these industries were given priority. Several mitigation options such as better maintenance of energy consuming equipment, adoption of energy conservation measures, modification of existing equipment and changing to new technologies were considered. Results of the analysis are given in Table 8.

Table 8. Emissions under Mitigation Options from the Industrial Sector

Year	CO ₂ Emissions in Gg	
	BAU Scenario	Mitigation Scenario
1995	4852.575	4852.575
2000	5903.877	5790.908
2005	7182.966	6713.249
2010	8739.176	7782.496
2015	10632.540	9021.841

Source : Ratnasiri (1998)

NON-ENERGY SECTORS

Industrial Processes

Cement and lime production are the chief sources of CO₂ emissions in the non-energy industrial sector. Two BAU scenarios, HIGH and LOW, with growth rates of 6.5% and 2%, respectively, were considered for cement. The growth of the lime industry was based on the 6.5% growth rate of the building industry. Mitigation options recommended included (I) the reduction of product losses (and CO₂ emissions by the installation of dust collectors and (ii) improved management of end use of cement and lime, which could lead to a reduction in requirements of these materials and consequently decrease production of the materials and emissions of CO₂. Emissions under mitigation options are given in Table 9.

Table 9. Emissions under Mitigation Options from Industrial Processes

Year	CO ₂ Emissions in Gg					
	Cement High Growth		Cement Low Growth		Lime	
	BAU	Mitigation	BAU	Mitigation	BAU	Mitigation
1995	828.60	828.60	828.60	828.60	77.49	77.49
2000	1135.26	1075.49	914.84	866.67	106.16	101.74
2005	1555.40	1473.50	1010.06	956.88	145.45	139.39
2010	2131.03	2018.83	1115.19	1056.47	199.28	190.98
2015	2919.70	2765.98	1231.26	1166.43	273.03	261.65

Source : Ratnasiri (1998)

Agriculture

According to the Sri Lanka Emissions Inventory Summary in the ADB-sponsored study(1994), agriculture is the largest emissions source of those estimated, accounting for about 38% of the total. Rice cultivation is the major source in this category, its methane emissions accounting for about 67% of the total, with livestock accounting for 32%. Consequently, identification of methane mitigating options assumes importance. This study also refers to the role of forestry as an important source of greenhouse gas sinks but its mitigation potential has not been assessed in Sri Lanka.

Under the US Country Studies Program options within some local rice varieties, fertilizer combinations and water management practices were investigated. Detailed analysis of costs or studies on adoption of programs/ policies were not undertaken. The results of this preliminary study led to the conclusion that the best cost-effective strategy for the mitigation of methane flux of the local rice fields without affecting the yield would be to flood the rice fields intermittently in 14 day cycles during the first month after transplanting and thereafter, to submerge and drain the fields in 7 day cycles for the rest of the cropping season while using urea containing fertilizer. There were several limitations to this study. The experimental site was not in a major rice growing area and only three rice varieties were used. Other fertilizer mixtures and aspects of intermittent flooding need to be tested. Automation of measuring systems and sampling systems would also be an improvement. This is, however, a first step and the first chemical investigation in Sri Lanka on methane emission potential with respect to rice cultivation.

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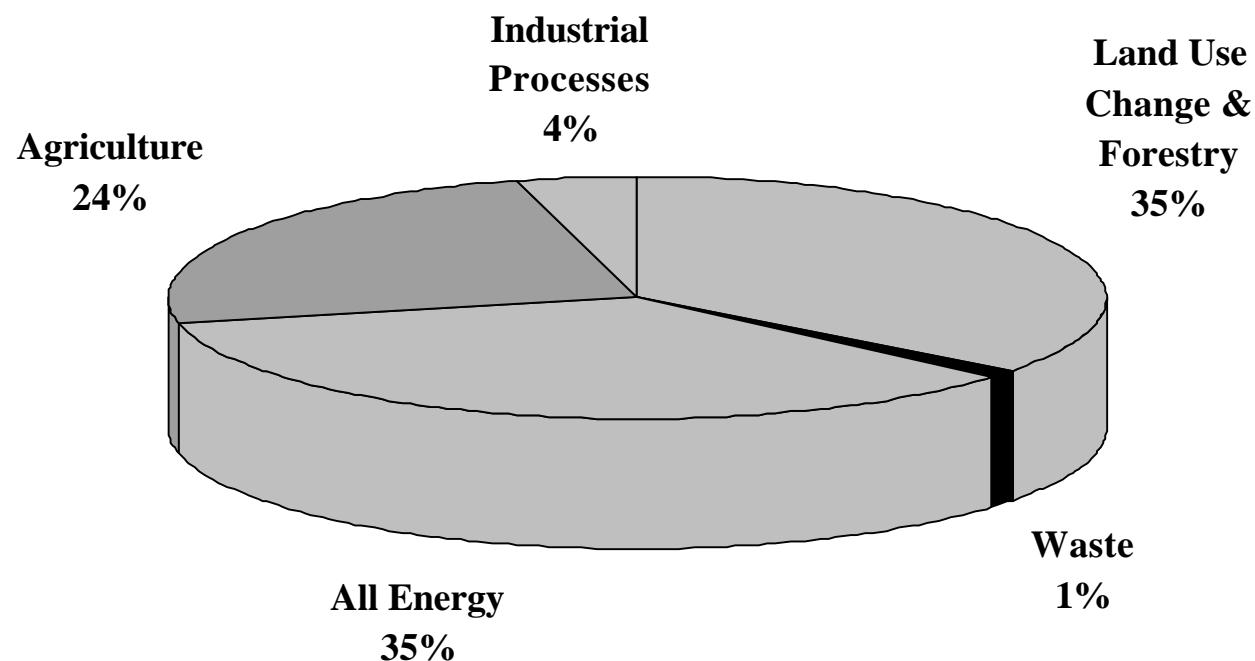
**CLIMATE CHANGE MITIGATION IN ASIA
AND FINANCING MECHANISMS**

GOA, India, 4 to 6 May 1998

COUNTRY PRESENTATION

THAILAND

1990 CO₂ Equivalent National GHG Inventory by Sector
(Total Emission = 225,000 Gg)



Priority Investment Projects - Energy Sector

Short Project Title	Key Objectives of the Project	Potential investment agency	Non quantifiable benefits
Fuel Switching	promote use of natural gas in power production;	private sector	less pollution
microhydro	promote commercial microhydro electricity production	village, government community	indirect benefits from forest protection

Priority Investment Projects - Non - Energy Sector

Short Project Title	Key Objectives of the Project	Potential investment agency	Non quantifiable benefits
forest management	enhance stake holders' participation in forest management	government, bilateral	indirect benefits from reforestation
private sector reforestation	promote role of the private sector in reforestation	private sector	indirect benefits from reforestation

Thailand became Party to the Convention

Signed - **12 June 1992**

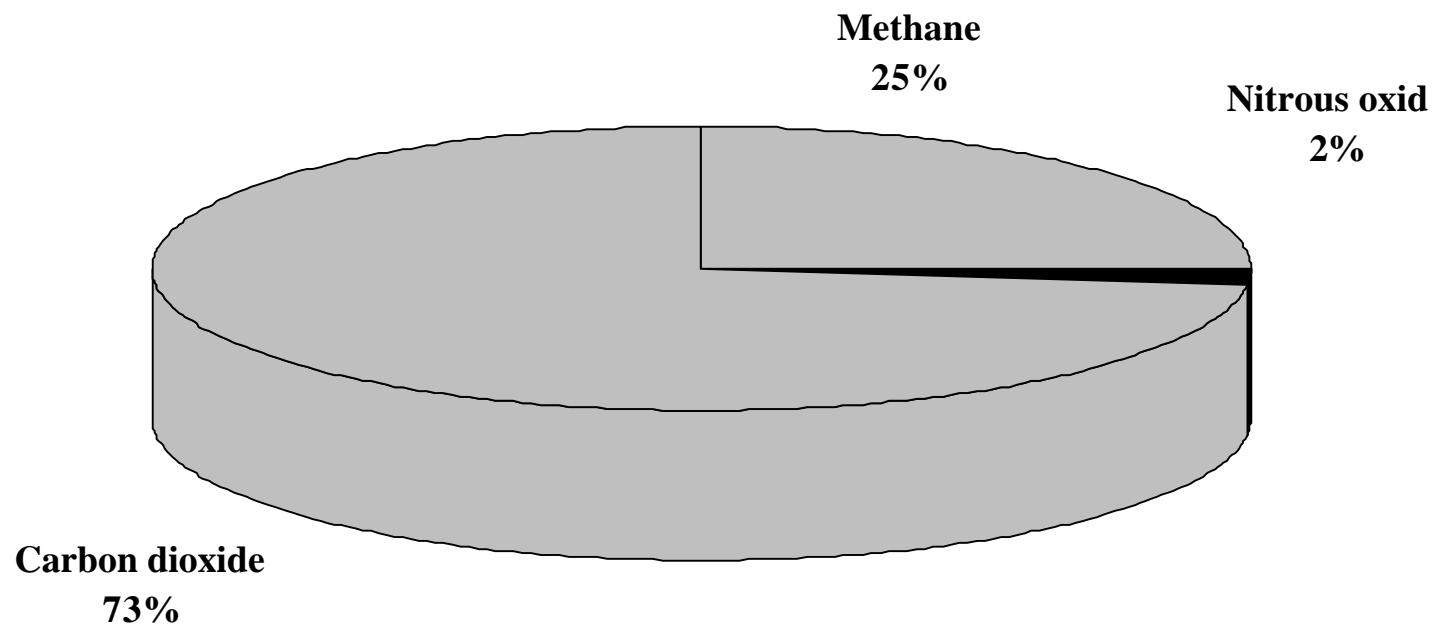
Ratified - **28 December 1994**

Entered into force - **28 March 1995**

Due date for - **28 March 1998**

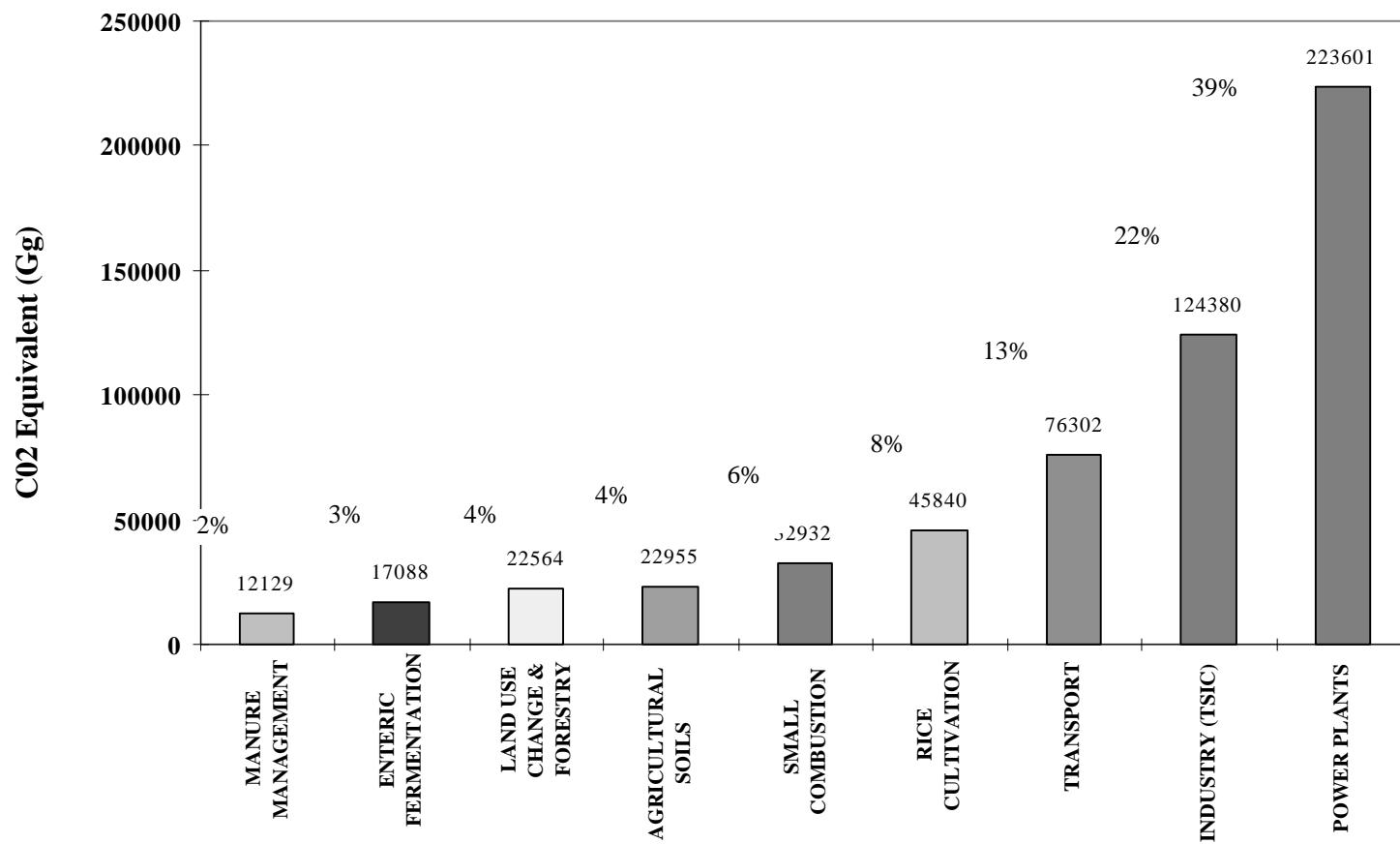
National Communication

1990 CO₂ Equivalent National GHG Inventory by Gases

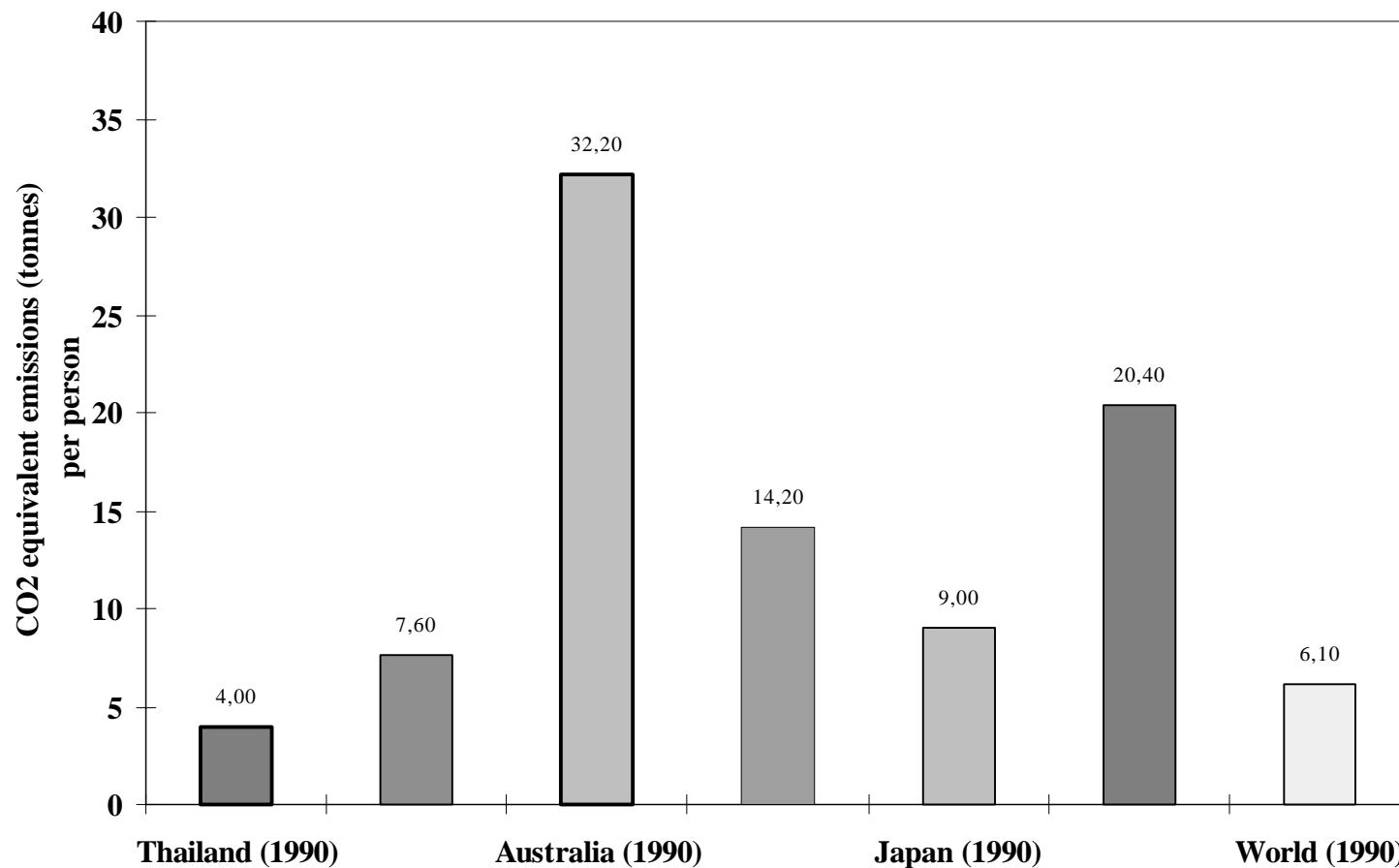


SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES							
GREEN HOUSE GAS SOURCE AND SINK CATEGORIES	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC
Total National Emissions and Removals	188,956,32	-24,96058	2,74637	11,31	505,39	2,340,27	671,90
1. All Energy (Fuel Combustion + Fugitive)	76731,25	0,00	117,58	1,48	480,73	1630,73	671,70
A. Fuel Combustion	76731,25	0,00	9,82	1,48	480,73	1630,73	651,00
B. Fugitive Emissions from Fuels	0,00	0,00	107,75	0,00	0,00	0,00	20,70
2. Industrial Process	9806,72		0,32				0,10
Solvent and Other Product Use							
3. Agriculture	0,00	0,00	2454,22	9,64	17,66	463,05	0,00
A. Enteric Fermentation			530,13				
B. Manure Management			115,98				
C. Rice Cultivation			1786,06				
D. Agricultural Soils				9,15			
E. Prescribed Burning of Savannas							
F. Field Burning of Agricultural Residues			22,05	0,49	17,66	463,05	
G. Others							
4. Land Use Change & Forestry	102418,35	-24960,58	28,17	0,19	7,00	246,49	0,00
A. Change in Forest and Other Woody Biomass Stocks	20709,92	-812,50					
B. Forest and Grassland Conversion	81708,42		28,17	0,19	7,00	246,49	
C. Abandonment of Managed Lands		-24148,08					
D. Other							
5. Waste	0,00	0,00	146,09	0,00	0,00	0,00	0,00
A. Solid Waste Disposal on Land			121,41				
B. Wastewater Treatment			24,68				

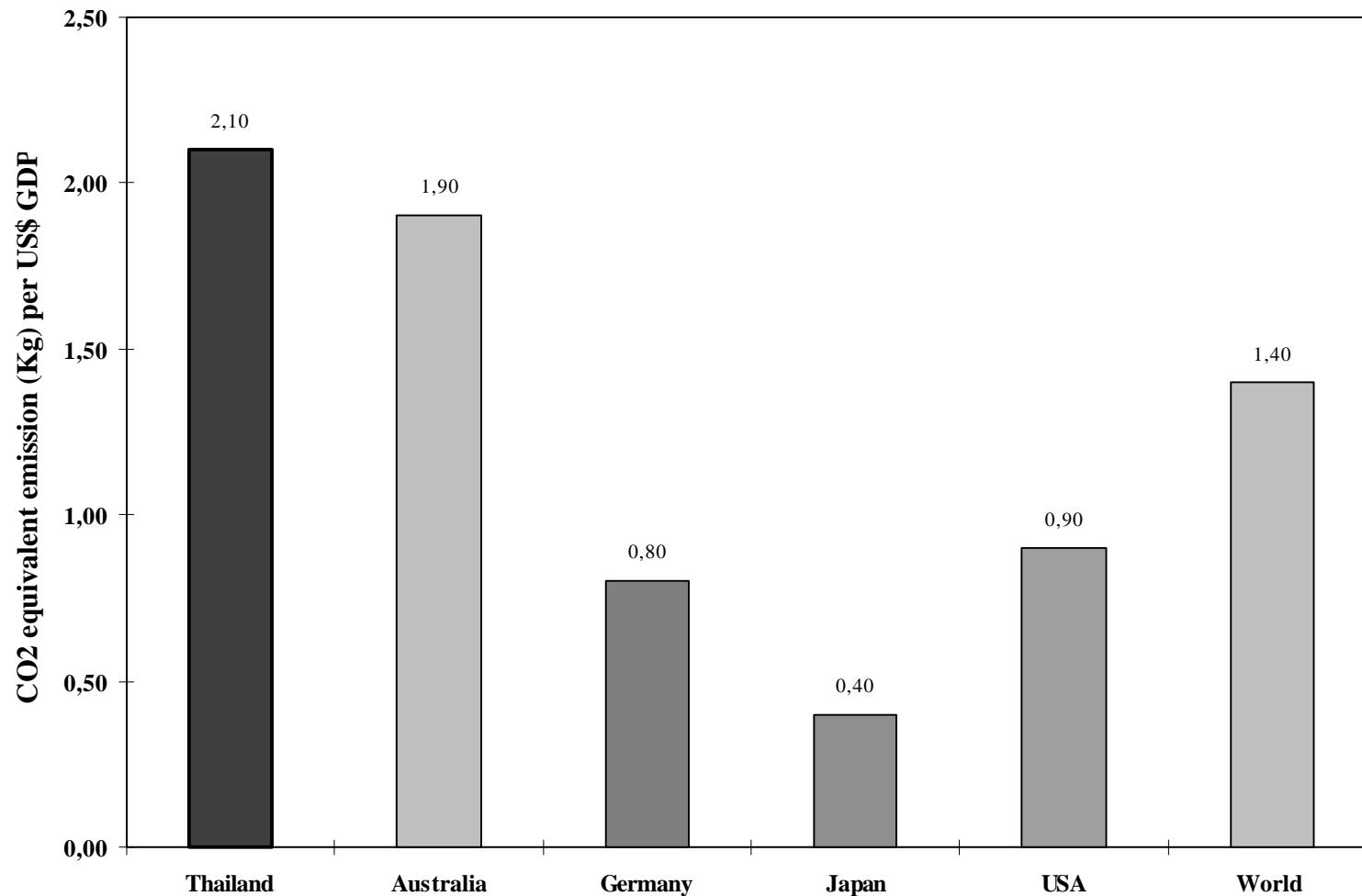
Ranking Expected Greenhouse Gas Emission From various subsector in 2020 (expressed in carbon dioxide equivalent)



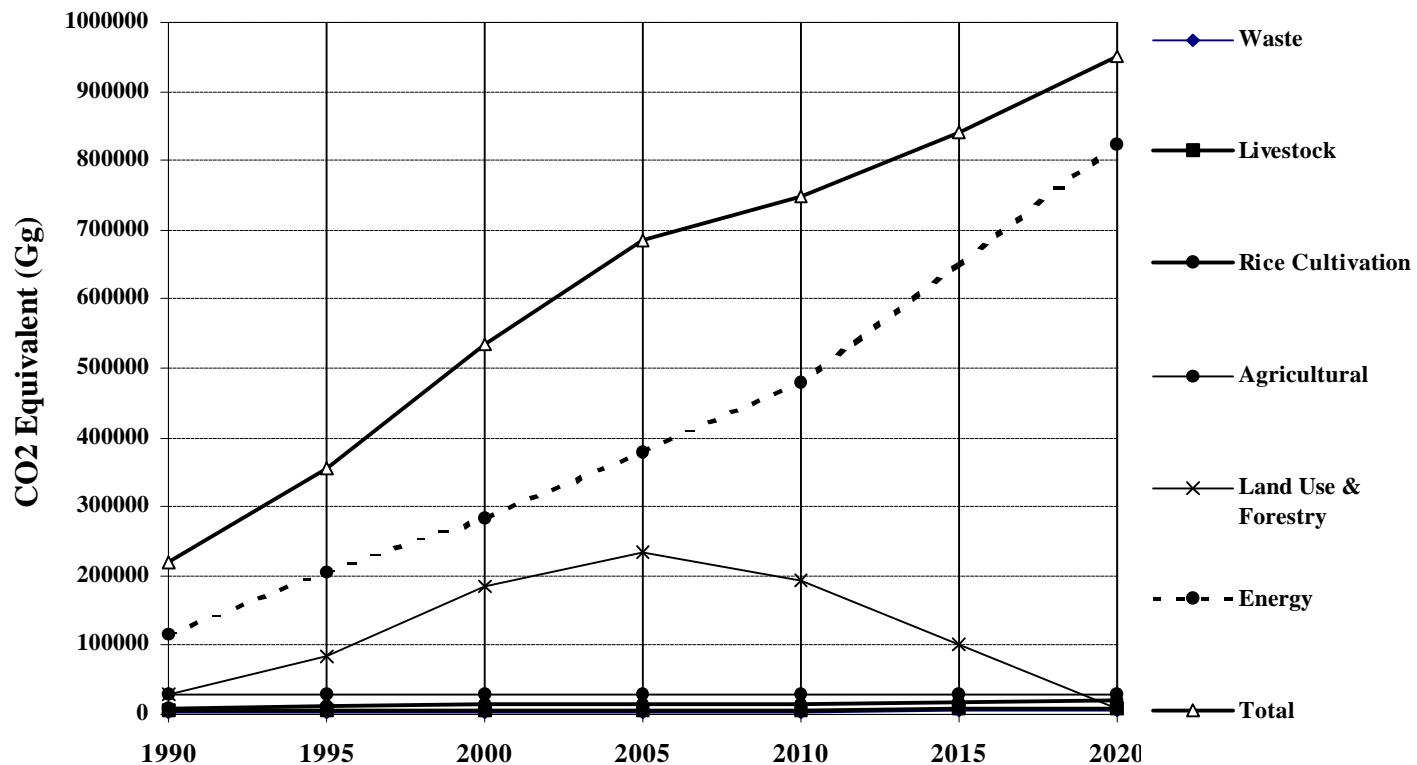
Comparison of CO₂ Equivalent Emission per Person in 1990 and 2020



Comparison of CO₂ Equivalent Emission per US\$ GDP in 1990



Sectoral Projections of GHG Emissions for Business - As - Usual (BAU) Scenario



Comparing Thai Emissions with Global Emission (estimated by World Resource Institute)

CO₂ Emissions

	Energy Emissions (Million Tonnes)	Forest Emission (Million Tonnes)	Total (Million Tonnes)	Per capita (Tonnes)
Global	22,000	3,400	25,400	4.48
Thailand	83 (0.4 %)	77 (2.3 %)	160 (0.6 %)	2.8 (62.5 %)

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CLIMATE CHANGE MITIGATION IN ASIA
AND FINANCING MECHANISMS
GOA, India, 4 to 6 May 1998

COUNTRY PAPER

VIET NAM

VIET NAM NATIONAL REPORT: Greenhouse Gas Limitation

*Mr. Le Nguyen Tuong
Mr. Nguyen Khac Hieu*

1 Country profile

1.1 Status of Climate Change and Environment Activities.

Viet Nam is located in Southeast Asia, sharing a land border with China, Laos and Cambodia. It has a land area of 330,990 Km², and stretches 1,650 km from North to South, 600 km at its widest and a 50 km at its narrowest. It consists of more than 1 million Km² of water surface, with 3,260 km of Coastline, and thousands of small islands, especially in Tokin Gulf. Viet Nam is the 12th most populous country in the world with the population growth rate of 2.5%. About 20% of the population lives in the urban areas, while 80% in rural area.

Viet Nam can be divided in three geographical regions - the South, the Central and the North. The Mekong Delta in the South and the Red River Delta in the North are separated by the thin central strip. This clear distinction in geographical regions is also reflected in economic development.

There are about 2,860 small and big rivers in Viet Nam, among all the rivers, the Red River and the Mekong River are the largest and most important one.

Viet Nam is located in the inter - tropical zone, but because of its long north - south span, climate conditions vary from sub - zero temperatures in the northern mountains to the year - round heat of the Mekong Delta.

Viet Nam ratified the UNFCCC on 16 November 1994. The Hydrometeorological Service (HMS) has been assigned by the Government to take full responsibility for Climate Change issues and for implementing programs related to the objectives of the UNFCCC.

Other studies in the Viet Nam related to climate change are described below:

- "Regional studies on Global Environment issues":

The study is sponsored by ADB for eight Asian Countries, including Viet Nam. It studied the socioeconomic impacts of climate change and policy options to cope with climate change.

- "Vulnerability Assessment in Viet Nam" funded by Netherlands. Started in 1994 and its objective was to undertake the vulnerability and impacts assessment on coastal zone.
- "Socio - economic and physical approaches to analyzing climate change impacts in Viet Nam" funded by UK. This 24 months research project started in April 1996. It is an interdisclop - linearily study of socio - economic vulnerability to climate change impacts in the coastal zone of the Red River Delta of Viet Nam.
- ADB/GEF-UNDP project " Asia Least Cost Grenhouse Gas Abatement Strategy- ALGAS" assisting 12 asian countries in assessment GHG batement options and development of the least cost abatement strategy.
- UNDP/UNITAR/GEF "CC: TRAIN" (phase 1) - Its objective was to assistthe countries in formulating climate change policy for the implementation of the UNFCCC.

1.2. Macro-economy

Viet Nam's recent macroeconomics performance has been impressive. The following major targets of the 1991 - 1995 five years plan were formulated :

- Average annual GDP growth rate of 5.5 - 6%.
- Average annual gross industrial output value growth rate of 7.5 - 8.5%.
- Average annual gross agricultural output value growth rate of 3.7 - 4.5%.
- Export earnings in five years : USD 12 - 15 billion.
- Import expenses in five years: USD 16 billion

The economy has gradually overcome stagnation and to date it has basically got out of the crisis. The following features has been characterized in the economy:

- Relating high economic growth rate in almost sectors and industries.
- Production can already cover consumption and the economy proceeds to generate an internal capital formation by itself.
- Living conditions of different strata of population have recorded a certain improvement.
- Hyper inflation was liquidated and the inflation rate is controllable.

In the two years 1996 and 1997 the GDP was 258 609 and 295 700 VND billion whereas the GDP per capita was 3 430 and 3 800 thousand VND in 1996 and 1997 respectively. Following quantum expressed the sectoral structure of Viet Nam's economy in 1996 - 1997.

Table 1: Sectoral structure of Viet Nam's economy in 1996 - 1997.

Sector	1996	1997
Industry and construction	30.7	31.7
Agriculture, Forestry and fishing	27.2	25.7
Service	42.1	42.6

The GDP structure projected for the the period 1994 - 2030 by the Development Strategy Institute shown in the Table 2. According to the structure the following baseline scenarios have been developed.

Table 2: Economic structure projected for the period 1994 - 2030.

Sector	1994	2000	2010	2020	2030
Industry	30.0	33.5	37.3	38.1	38.8
Agriculture	27.5	19.5	11.0	6.3	4.0
Service	42.4	47.1	51.7	55.6	57.2

Source: Ministry of Planning and Investment, 1996.

1.3 1993 National Inventory of GHG sources and sinks.

The total net emission by gasses in Viet Nam using 1993 as base year were: 64,062 Gg CO₂, 2,588 Gg CH₄, 14.63 Gg N₂O, 182.09 Gg NOx and 3127.56 Gg CO. Using a GWP of 1 for CO₂, 21 for CH₄, and 310 for N₂O, the contribution of these three gases in terms of CO₂ equivalent or GWPs, is equivalent to total CO₂ of 111.7 million tonnes. Which is contributed by:

- Carbon dioxide, 64 million tonnes.
- Methane, 54.4 million tonnes of CO₂ equivalent.
- Nitrous oxide, 4.5 million tonnes of CO₂ equivalent.

The three sector with emitted largest quantities of GHG are Agriculture Energy and Forestry.

The Agriculture sector contributed to 48 million tonnes of CO₂ equivalent, while the Energy sector emitted 27.5 million tonnes of CO₂ equivalent, the Forestry sector emitted 31 million tonnes CO₂ equivalent .

1.4 GHG inventory project up to 2030

Emission in the future will be increased mainly causing by the fossil fuel consumption.

Emission from the energy sector in 2030 is projected to 396 million tons CO₂, it is more than 10 time higher than 1993.

GHG emission from agriculture sector will also increase but with lower growth rate compared with energy sector. The GHG emissions from agriculture is projected from 47 M tons CO₂ equivalent in 1993 to 68 M tons CO₂ equivalent in 2030.

In the forestry sector, the amount of CO₂ is projected to decline from 29.9 million tons in 1993 to 4.2 million tons in the year 2000 and the net sequestration of 21.7 million tons in 2010 and 32.1 million tons in 2030.

The Table 3 showed the GHG inventory projection to 2030.

Table 3: Projection GHG emission in Sectors (Tg) of CO₂ equivalent to 2030.

Tg	1993	2000	2010	2020	2030
Energy	27.5	44.48	103.40	187.82	396.35
Forestry	29.88	4.20	-21.70	-28.40	-32.10
Agriculture	46.60	52.50	57.20	64.70	68.29
Total	111.69	101.18	138.90	224.12	432.54

2. Data and Models used in this study

2.1 GHG emission factor

The IPCC default emission factors is used in the Viet Nam GHG inventory.

2.2 Global warming Potential (GWP's)

CO₂ equivalents are based on GWP's of 21 for CH₄ and 310 for N₂O

2.3. Description of approaches and model used for mitigation options:

2.3.1 Energy:

In order to identify the optimization strategies which satisfy energy demand the optimal strategy could be determined based on EFOM-ENV model. EFOM is a supply-technico-economic energy model that simulates or optimize the primary energy requirements and the related investments in energy production and consumption.

In EFOM-ENV model the energy flow begins with primary energy through energy transportation to the final energy demand..The energy supply and demand are represented by systems as follows :

- Energy Supply Systems

- Coal system (COAL-SS)
- Oil System (OIL-SS)
- Gas System (GAS-SS)
- Central Electricity System (CENTELEC-SS)
 - (i) northern system and
 - (ii) southern system.
- Traditional Fuel System (TF-SS)

- Energy Consumption Systems

- Industrial system (INDUSTRY-SS) :
 - * Metallurgy and Machinery subsetor
 - * Construction material subsector
 - * Others
- Household system (HH-SS)
 - * Rural households
 - * Urban households
- Transportation system (TRANSPOR-SS)
- Agricultural system (AGRICULT-SS)

2.3.2 Forestry:

COMAP (Comprehensive Mitigation Analysis Process) model was used for developing and assessing forestry mitigation options in this study. COMAP is intended to guide an analyst in undertaking a comprehensive assessment of the role of forest sector in a country's climate change mitigation efforts (Sathaye and Stephen Meyers, 1995). This approach includes several specific steps such as screening to identify mitigation options signified to the country, developing the mitigation options which could be implemented on the various available lands, estimating of the emission reduction or carbon sequestration per unit area for each mitigation option and, evaluating the cost-effectiveness of identified mitigation options.

In the study, two sub-models: FORPROT and REFOREST of COMAP model are used for assessing 4 forestry mitigation options.

2.3.3 Agriculture:

The following approach have been used to assess the mitigation options in agricultural sector:

- 1) Noting that the global environmental objective is to reduce GHG emissions.
- 2) Identify that the goal is to increase agricultural productivity which supported by the program:" Making intensive cultivation higher to the food crops and bio-diversification of agricultural system".
- 3) Incorporate global environment objectives in national development objectives.
- 4) Aware that the global environment objectives of reducing GHG emission can be met without compromising the goal of increasing productivity in the agriculture sector.

3. Baseline and Abatement Scenario

3.1. Baseline and Abatement Scenario in energy sector

3.1.1 Baseline Scenarios

Energy development Scenarios.

Table 4: Energy demand forecast for period 1994 - 2030. (Unit: ktoe)

	1994	2000	2005	2010	2020	2030
Household sector	5472.27	6535.59	7071.76	7841.57	9889.36	17710.34
Urban	1037.976	1938.651	2299.195	3153.235	5419.075	9704.738
Rural	4434.294	4596.939	4772.565	4688.335	4470.285	8005.6
Service sector	274.5	476.67	674.59	996.62	1487.72	2664.28
Transport sector	2082.67	4046.69	6164.13	8525.77	14252.59	25524.22
Industry sector	2610.66	5676.95	10752.51	16158.6	32300.92	57846.03
Agricultural sector	354.11	479.39	621.74	694.42	620.93	1111.991
Total	10794.21	17215.29	25284.73	34216.98	58551.52	104856.9

Source: Calculated by MEDEE-S Model from this report

Energy Demand Scenarios

Models for forecasting energy demand in the future are mostly based on proposed economic growth rate. Normally, there are three economic development scenarios appropriated to high, medium and low growth rate scenarios. Therefore, energy demand forecast is carried out based on these economic development scenarios.

Energy Supply Scenarios

Energy supply scenarios were set up as follows:

- Based on potential energy sources such as coal, oil, gas, hydropower and other energy resources.
- Based on energy development policy.
- Apply new and modern technology for energy transportation and production.
- There is also a large potential for energy efficiency improvement on the supply, transmission and distribution of energy.

3.1.2. Abatement Scenario

- Use production technologies with less energy consumption such as replacing dry production technology for wet production technology in cement production.
- Improvement in energy efficiency in fuel combustion processes used in Industry replacement of old low efficiency boiler by energy - efficient industrial boilers ;
- Highly efficient household electric equipment;
- Improvement of efficiency of cooking stoves.
- Energy efficient lighting ;
- Replacement of existing electric motors by highly efficient electric -

Increased vehicle efficiency.

3.2. Baseline and Abatement Scenario in Forestry Sector

3.2.1. Baseline Scenario

Recently, a plan for reforestation and natural reforestation of 5 million additional hectares by 2010 was adopted by the Government. However, for the forestry sector the likely trends scenario is developed. Based on current trend, it is assumed that the deforestation rate will continue to be on the average of 100,000 hectares per year. likewise, the level of reforestation effort is not enough to offset the deforestation. The reforestation rate is about 70,000 hectares per year and the survival rate is 100% assumed as same as in the COMAP analysis. In addition, 3 billion scattered trees will be planted up to the year 2030 and 2.4 million hectares of protection forests will be conserved over the period 1994-2030.

3.2.2. Abatement Scenario

The following options are developed for the abatement scenario :

- 1.85 million hectares of degraded forests will be promoted for natural regeneration in combination with reforestation at a rate of 50,000 ha per year.
- 1.95 million hectares of degraded land will be converted into forest plantations at a reforestation rate of 130,000 ha per year.
- 6.5 million hectares of natural forest will be protected. Logging and timber harvesting will not be allowed in the areas.
- 4 billion scattered trees, equivalent of about 1.65 million hectares, will be planted up to 2030.

By carrying out the above options, total carbon abated was about 1,238 Tg equivalent of 4,539 Tg CO₂ while under baseline scenario, the amount of CO₂ abated was only 2,144 Tg CO₂.

3.3. Baseline and abatement scenario in Agricultural sector

3.3.1. Baseline scenario.

Viet Nam is agricultural country, 80% of it's population involved in agriculture on about more 7 million hectares : The urban population is projected to increase from 19.9% in 1994 to 55% in 2020 and 65% in 2030 there fore the rural population will decrease to about 45%, 35% in 2020, 2030 respectively. Because of urbanization, GDP contribution of agriculture will drop from 29.9% in 1993 to 6.3% in 2020 and 4.0% in 2030.

The area under rice cultivation is projected to increase from 6.5 Mha in 1993 to 8.0 Mha in 2030.

The livestock population is projected to increase from 6.2 M head (dairy and Buffalo) in 1993 to 13.6 M head in 2030.

3.3.2. Abatement scenario

1) By the year 2030, it carries out intermittent drainage of 5.5 M ha of rice paddy under controllable irrigation, a reduction of methane emission from rice field about 50 kg/ha/year will result in a total of mitigation of 5,005 Gg CH₄.

2) Providing the quality of improved (processed) animal feed to 4.2 Mt/year will result in a reduction of 5 kg CH₄/head/year on a total of 4.4 M head animal. This will result in a total mitigation of 385 Gg CH₄/year.

4. Sectoral Mitigation Options:

4.1 Energy sector

Energy scenarios

Apart from the base line scenario there were 5 energy consumption scenarios and 2 energy supply scenarios.

a. Energy consumption scenarios

- Efficiency Improvement in Cooking
- Compact Fluorescent Lamp (CFL)
- High Efficiency Refrigerators
- Air Conditioning
- More Efficient Industrial Motors.

b. Energy supply scenario

- Fuel Switching in Power Generation
- Wind power plants

Table 5: Differences of CO₂ Emission and Costs by Various Mitigation Scenarios Compared to Base Scenario,(energy sector).

	Base line	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7
CO ₂ emissions (Mt)	7520	7299	7470	7254	7362	7308	7506	7416
Cost (Mil. US\$)	43800	43414	43631	42842	43101	43159	44096	43598
ΔCO ₂ emissions (Mt)	221	50	266	158	212	14	104	
ΔCosts (Mil. US\$)	-386	-169	-958	-699	-641	296	-202	
Cost per ΔCO ₂ reduction	-1.75	-3.38	-3.60	-4.42	-3.02	21.14	-1.94	

Source: Calculated from this study.

- ENV-1: Efficiency improvement in coal cooking
- ENV-2: Compact fluorescent lamps
- ENV-3: Energy efficient refrigerators
- ENV-4: Energy efficient air conditioners
- ENV-5: High efficient electric motors
- ENV-6: Fuel Switching in existing thermal power plant
- ENV-7: Wind power plant.

4.2. Forestry sector:

4.2.1. Forestry mitigation options:

Description of potential areas under each land category actually available for the mitigation options is given in Table 6

Table 6: Potential areas for different forestry mitigation options (Unit: kha)

Land categories	Total land area	Forestry mitigation options				Area converted to agriculture and others
		Reforestation	Enhanced natural forest generation	Forest Protection	Scattered tree planting	
Group A:						
Waste land/Savannas						

1. Woody	3,183	400	1,100	283	1,000	400
2. Shrub and grass	6,690	2,000	1,000	2,224	1,000	466
3. Rocky	628	0	0	628	0	0
Group B:						
Nature forest						
1. Evergreen	1,335	0	0	1,335	0	0
2. Secondary	4,625	0	0	4,625	0	0
3. Young	1,275	400	300	475	0	100
4. Mixed	1,017	553	300	64	0	100
Group C:						
Plantations	900	0	0	900	0	
Total	19,653	3,353	2,700	10,534	2,000	1,066

Source: Ministry of Agriculture and Rural Development, 1996

Table 7: Mitigation option category and the size of area allocated annually for each option.

Option No	Land categories	Option category	Target area (ha)	Rate of planting (ha/yr)
F1	Waste land / Savannas and Natural forest land	Enhanced natural regeneration	1,850,000	50,000
F2	Waste land / Savannas and Degraded forest land	Reforestation	1,950,000	50,000
F3	Natural forest land	Forest protection and conservation	6,500,000	-
F4	Waste land, Urban / Farm land	Scattered trees	1,640,000	44,000

The cost input used for the forestry mitigation options is presented in Table 8

Table 8: Cost input used for each forestry mitigation option.

Cost component	Forestry mitigation options			
	Enhance natural regeneration	Reforestation	Natural forest protection	Scattered trees
Initial cost	\$ 150 per ha	\$340 per ha	\$10 per ha	\$ 160 per ha
Maintenance cost	\$ 2 per ha per year	\$ 5 per ha per year	\$ 4 per ha per year	\$ 2 per ha per year
Recurrent cost *	\$ 300 per ha	\$ 405 per ha	-	\$ 646 per ha

* At the end-year of rotation

4.2.2 Assessment of Forestry mitigation options:

By using COMAP model, the 4 identified forestry mitigation options are developed and assessed. The COMAP outputs indicated under the abatement scenario, total carbon abatement would be 1,238 Tg. Planting scattered trees and reforestation options have lower mitigation potential while the two others have higher mitigation potential.

Comparison of the four forestry mitigation options is presented in Figure 1 and (Table 9).

Table 9: COMAP output for the 4 forestry mitigation options

Option No	Option category	Mitigation Potential (tC/ha)	Present Value of Benefit		Present Value of Cost	
			(\$/tC)	(\$/ha)	(\$/tC)	(\$/ha)
F1	Enhanced natural regeneration	47.2	1.48	64.45	0.84	36.52
F2	Reforestation	40.6	6.86	718.4	2.19	86.7
F3	Natural forest protection	132.7	0.69	91.04	0.33	43.45
F4	Scattered trees	47.7	9.65	421.98	0.95	41.44

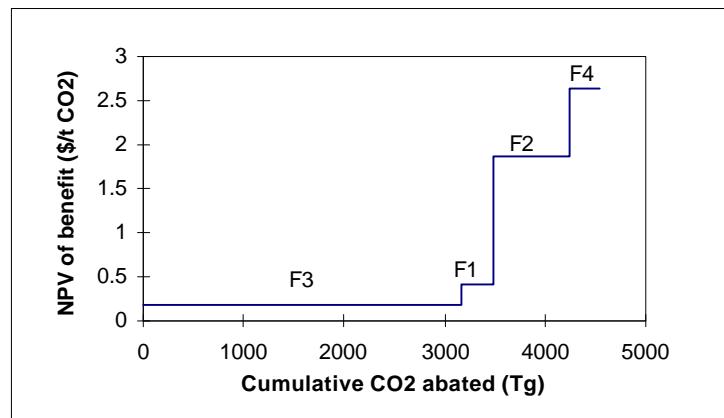
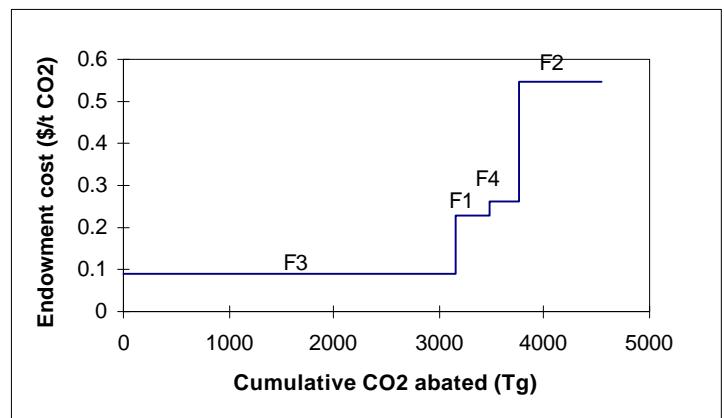


Figure 1: Comparison of the four forestry mitigation options

4.3 Mitigation options in agricultural sector.

4.3.1 Mitigation option for methane emission from rice cultivation.

The option focuses on management of irrigation water with a system of draining rice fields during the growing season in the areas with secure irrigation supplies. These areas are: the Red River Delta, the North Central Coast, the South Central Coast and the Me Kong River Delta.

4.3.2 Mitigation option for methane emission from livestock:

Improving the feed digestibility through mechanical and chemical processing of the feed by chemical and physical treatment of low quality crop residues that are fed to ruminants can enhance animal productivity and lower CH₄ emissions per unit product.

4.3.3 Cost - effectiveness of methane emission option.

The following cost effectiveness indicators used in assessing the methane emissions reduction options are incremental cost and NPV of net benefits.

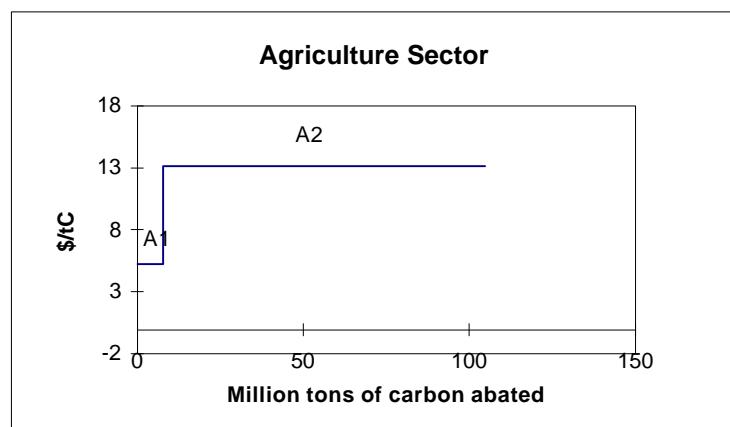
- Methane emissions avoided were estimated for the two options: (i) water management (50 kg/ha/year), and (ii) improving nutrition (5kg/head/year).

- The incremental cost for the two options were all positive, with the water management giving the highest cost: US\$ 1.01/kg methane reduce followed by improving nutrition at US\$ 0.40/kg.

- The NPV of net benefits is an indicator of the net direct benefit to be obtained from option with the water management of US\$ 0.54/kg of methane avoided followed by improving nutrition at US\$ 0.07/kg

The relationship between the potential carbon reduction and cost per unit carbon reduction by two agricultural mitigation options: improving nutrition (A1) and water management (A2) (figure 2).

Figure 2: CERI Curve for Agriculture Sector



The description of GHG mitigation options on agricultural sector and their assessment results are summarized in Table 10

Table 10: Mitigation options in Agricultural Sector.

Scenario	Description	Total Methane abated (Gg)	Life cycle cost	Aggregate incremental investment required (US\$ mill.)
Baseline	<ul style="list-style-type: none"> - 6.5 Million ha of rice cultivation in 1993, growing up to 7.1 in 2000, 7.3 in 2010 and 8.0 in 2030. - 1.7 Tg CH₄ emitted in 1993, 1.9 Tg CH₄ in 2000, 2.0 Tg CH₄ in 2010 and 2.2 Tg CH₄ in 2030. - The population of livestock is 6.6 M of cattle and buffaloes in 1993 growing up to 13.6 M in 2030. - 425 Gg CH₄ emitted in 1993, 560 Gg CH₄ in 2010 and 1026 Gg in 2030 			
Water management in rice field	Projection to 5.5 million ha of rice paddy with water management and under intermittent draining on the rice growing season in 2030	5005	US\$/tC abated 13.12	5620
Improving nutrition through mechanical and chemical feed processing	Projection to 4.4 million head of buffaloes and cattle providing with mechanical and chemical feed processing.	385	US\$/tC abated 5.19	92

5. Greenhouse Gas Abatement Action Plan:

5.1. Energy sector

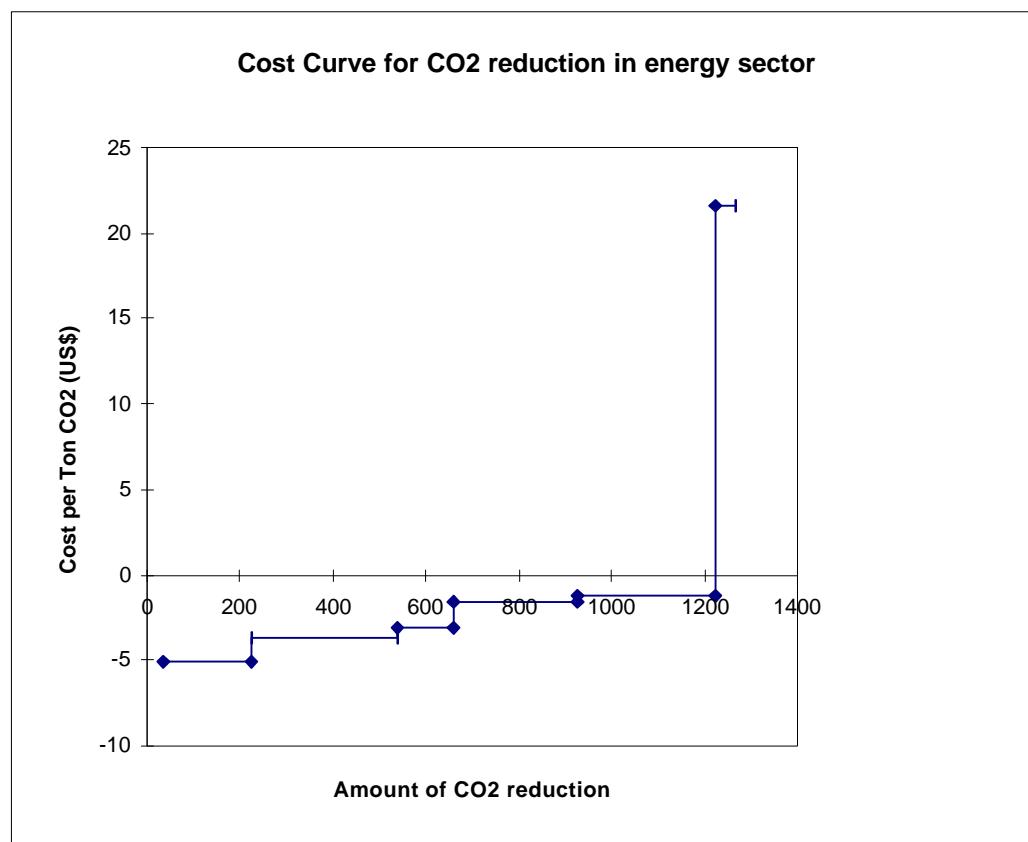
5.1.1. Cost of Emission Reduction Initiatives (CERI) Curve in energy sector:

CERI curves in Energy sector under this study were developed by using the EFOM - ENV model. 7 GHG abatement scenarios were estimated using EFOM - ENV model. These abatement scenarios are shown in Table 11 and figure 3.

Table 11 : Cost of CO₂ reduction

	Option	Amount of CO ₂ reduced (M tons)	Cost of CO ₂ reduction (US\$)
1	Energy efficient Air conditioners	158	-4.42
2	Energy efficient refrigerator	266	-3.60
3	Compact fluorescent lamps	50	-3.38
4	High efficient electric motors	212	-3.02
5	Wind power plant	104	-1.94
6	Efficiency improvement in coal cooking	221	-1.75
7	Fuel Switching in existing thermal power plants	14	21.14

Figure 3: Cost of Emission Reduction Initiatives (CERI) curve for energy



5.1.2- GHG abatement strategy action plan:

The content of the strategy:

- Promotion conservation and efficient use of energy.
- Promotion rational use national energy resources.
- Utilization of new and renewable energies.
- Integration of social and environmental concerns in the implementation of program economic sustainable development.

The major contents and action plans of the GHG abatement strategy are presented in the Table 12.

Table12. Summary of National Least-cost Abatement Strategy Initiatives in Energy

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million tonne of CO ₂)	Cost of initiative (US\$ tonne of CO ₂)
Short term (1998-2005)	-Fuel switching	14	21.14
	-Wind power construction	23.1	-1.94
	-Improvement of efficiency in cooking	49.1	-1.75
	-CFL	11.1	-3.38
	- High efficient air conditioning	35.1	-4.42
	-High efficient refrigerator	59.1	-3.60
	-High efficient electric motors	47.1	-3.02
Medium term (2005-2015)	-Wind power construction	38.8	-1.94
	-Improvement of efficiency in cooking	61.3	-1.75
	-CFL	13.8	-3.38
	- High efficient air conditioning	43.8	-4.42
	-High efficient refrigerator	73.8	-3.60
	-High efficient electric motors	58.8	-3.02
Long term (beyond 2015)	-Wind power construction	43.3	-1.94
	-Improvement of efficiency in cooking	92.0	-1.75
	-CFL	20.8	-3.38
	- High efficient air conditioning	65.83	-4.42
	-High efficient refrigerator	110.8	-3.60
	-High efficient electric motors	88.3	-3.02

5.2 Forestry sector:

1- *On reforestation:*

- Develop feasible reforestation projects in which more productive plantations are established in order to meet the growing demand of wood for industrial use and fuelwood in the country.
- Reforestation efforts should give more attention to:
 - Local socio - economic conditions of the plantation sites and the approach of participation of the local people for planning and implementation of the plantation programmes. In fuelwood deficit areas, in particular, community forestry approach needs to be explored.
 - Consideration should be given to natural reforestation schemes if necessary combined with natural regeneration, enrichment or other silvicultural measures.
 - A limited number of species has used for reforestation. Research should provide locally focused advice on the right species and the best seed resource.
 - Maintenance of plantations, also involving where necessary replanting, is an integral part of the reforestation effort. It ought to be realized that maintenance costs largely do determine the success or failure of a programme.

2. *On forest protection:*

- To improve the protection and management of the existing forest within the special - use forest land.
- To expand the protection forest area to around 7 million ha.
- Creating non - forest - based livelihood opportunities.

3. *On planting scattered trees:*

- Spreading the movement of planting scattered trees at a rate of 400 million trees / year.
- Allocate land to the households for practicing cultivation in forestry-agriculture systems.
- Expanding urban forestry.

4. *Information and education:*

- To raise public awareness about environment protection including forest protection and management.
- Adequate information and education campaign for each mitigation option.

The potential GHG emissions reduction and cost of each initiative in the Forestry sector are presented in Table13

Table 13: Potential GHG emissions reduction and Present value of costs for Forestry Mitigation Options

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million ton of C)	Present Value of Costs (US\$ ton of C)
Short-term	- Forest protection	476.2	0.6
	- Enhanced natural reforestation	35.9	1.3
	- Reforestation	95.2	2.6
	- Planting scattered trees	31.8	1.5
Long-term	- Forest protection	862.5	0.3
	- Enhanced natural reforestation	87.3	0.8
	- Reforestation	209.6	2.0
	- Planting scattered trees	78.7	1.0

5.3. Agriculture sector

The goals of the agricultural sector are:

- To satisfy the food requirement for the people's consumption in any situation, to sufficiently assure the food source to make a strong development of breeding and enough raw material for the industry, to further increase the export volume with high effect.
- To develop all high valuable tree kinds via the intensive cultivation, new plantation in order to respond to the requirement of raw materials for processing industry.
- To form the regions of concentrated breeding, the firms of processing food - stuffs with several shape/scale types.

These goals are supported by the following programs:

- Making intensive cultivation higher to the food crops.
- Diversification of agriculture.

The environment objective of the agriculture sector is to assure the food requirements of the country by strategies and technologies that are most appropriate, cost-efficient and environment-friendly. However the GHG reduction has not been included in this strategies.

The GHG abatement action plan shall focus on water management in rice fields and improving nutrition through mechanical and chemical feed processing.

In the Short-term: (2005 - 2010)

Within the short-term, GHG abatement shall have been a component of the environment impact assessment for agriculture related projects and activities.

Water management in the rice field with the intermittent draining during growing season will be researched and developed in the pilot area such as Red River Delta then extend to Mekong River Delta then extend to Mekong River Delta with the benefit areas of about 3.0 million ha.

At the same time, nearly 2 millions heads of buffaloes and cattle will be fed by improved method of animal nutrition through the use of mechanical and chemical feed processing.

Table 14: The aspects of technical, finance, policy and institution to options in agricultural sector.

Options	Technical aspects	Financial aspects	Policies	Institutional aspects
Water Management	<ol style="list-style-type: none"> Planning water conservation in the rice cultivation areas. Expansion of high yield varieties of rice. Saving water on irrigation with high effectiveness 	<p>Financial sources included:</p> <ol style="list-style-type: none"> Government investment for main pumping system and main irrigation canal. Farmers investment (in-kind). Investment from oversee organization: (GEF, ADB, WB) 	<ol style="list-style-type: none"> Land tenurial rights. Bank for lending credit to farmers with low rate of interest. Low fee for the use of irrigation system 	<ol style="list-style-type: none"> Joint committee between agricultural agencies and farmers. Marketing: Including the purchase of Government to farmers products.
Improving nutrition	<ol style="list-style-type: none"> Providing animal food for high yields. Developing of advanced hybrid varieties. Upgrading firms of producing the concentrated strains 	<ol style="list-style-type: none"> Government investment for feed processing industry. Farmers investment 	<ol style="list-style-type: none"> Assured markets and price of animal products. Bank for lending credit to farmers with low rate of interest 	<ol style="list-style-type: none"> Contribution of animal food to farmer. Joint committee between agricultural agencies and farmers.

In the Long -term: (2020 - 2030)

The same activities are assumed to be undertaken beyond 2015 with the adjustment in terms of target setting per option. The question will be raised for what new options and strategies have to be formulated.

It is continued with 5.5 million ha of rice field under water management, this total area is comprised of 1.102 million ha in the Red River Delta, 0.59 million ha of the North Central Coast, 0.497 million ha of the South Central Coast and 3.269 million ha of the Mekong River Delta.

In this period, a total of 4.4 millions head of buffaloes and cattle would be provided with the improved nutrition through mechanical and chemical feed processing.

The aspects of technical, finance, policy and institution to implement the options in agriculture sector presented in table 14.

6. Conclusions:

1. The mount of GHG emission in Viet Nam is 111.7 Tg of CO₂ equivalent. It is expected that the amount will be increased dramatically in the coming decades because of fossil fuel consumption to meet energy demand in the country. Total CO₂ emissions would be increased from 101 Tg in 2000, to 139 Tg, 224 Tg and 433 Tg in 2010, 2020 and 2030 respectively

2. 13 GHG abatement options including 7 energy options and 6 non-energy options have been developed for this study. List of the options in Energy, Forestry and Agriculture sectors are as follows:

Energy sector:

- 1) Energy efficient air conditioner
- 2) Energy efficient refrigerator
- 3) Compact Fluorescent Lamp
- 4) High efficient electric motors.
- 5) Wind power plant
- 6) Efficiency improvement in coal cooking
- 7) Fuel switching in existing thermal power plants

Forestry sector:

- 1) Enhanced natural regeneration
- 2) Reforestation
- 3) Forest protection and conservation
- 4) Scattered trees

Agriculture sector:

- 1) Water management
- 2) Improving nutrition.

3. At present value of cost regards, in general, the model outputs showed that almost energy options have negative values whereas non-energy options in the opposite. It is found that forestry options as the options with highest abatement potential and lower costs, while agriculture options as the options with lowest potential and higher costs .

4. main activities for GHG emission abatement:

In Energy sector:

- Promoting conservation and efficient use of energy.
- Promoting rational use national energy resources.
- Utilizing of new renewable energy.

- Integrating of social and environmental concerns in the implementation of economic sustainable development porogram

In Forestry sector:

- Strengthening the national protection capability by means of protecting the existing forests, increasing the rate of forest plantation, speeding up regreening of bare hills.
- Increasing forest coverage.
- Improving economic results of sectoral operations.

- Providing a large number of employment for local people through reforestation and forest conservation activities.

In Agriculture:

- Promoting water management from rice paddy in order to increase the yield of rice.
- Improving nutrition through mechanical and chemical feed processing.

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

SECTION II

CONTRIBUTIONS FROM
UNEP, UNFCCC AND INVITED EXPERTS

UNEP

GEF

THE WORLD BANK

PROCEEDINGS OF
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CLIMATE CHANGE MITIGATION IN ASIA
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PAPER

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SUMMARY OF THE TECHNICAL GUIDELINES USED IN THE PROJECT: THE ECONOMICS OF GREENHOUSE GAS LIMITATIONS

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1 Introduction

This document is a summary version of the technical guidelines for climate change mitigation assessment developed as a part of the Global Environment Facility (GEF) project *The Economics of Greenhouse Gas Limitations; Technical Guidelines* (UNEP 1998). The objectives of this project have been to support the development of a methodology, an implementing framework and a reporting system which countries can use in the construction of national climate change policies and in meeting their future reporting obligations under the FCCC. The methodological framework developed in the guidelines covers key economic concepts, scenario building, modelling tools and common assumptions. It was used by several country studies included in the project.

2 Policy issues

United Nations Framework Convention on Climate Change (FCCC) (UN 1992) reflects the concern of the global community to the threat of climate change due to increasing greenhouse gas emissions. The convention committed the world community to limit the emissions of greenhouse gases, enhance greenhouse gas sinks and facilitate adaptation to climate change. The Kyoto Protocol that followed it in 1997 took it a step further by including specific targets of reductions of GHGs for Annex 1 countries.

As part of the FCCC commitments, all parties need to prepare and communicate national greenhouse gas inventories, develop and communicate programmes containing measures to mitigate climate change and to facilitate adaptation to climate change. The FCCC also provides for compensation of incremental cost of the mitigation measures to the eligible parties. The support for enabling activities that includes preparation of communication has been extended through GEF to the non-Annex 1 parties. With this, it is expected that all the parties will be able to develop comprehensive climate change strategies at national level.

3 Basic common country study approach: An overview

National climate change mitigation studies will vary in coverage, details and sophistication of assessment efforts involved. This is a consequence of different national institutional capacities, analytical tools and statistics. Some countries have participated in other similar study activities and can utilise already implemented models, while others have few experiences in climate change assessment.

The guidelines are purposely defined broadly to enable national analysis to be carried out with different focus and depth. It is however recommended that all countries follow a common analytical structure. The common elements in this analytical structure are summarised below:

(i) Comprehensive evaluation of national social and economic development framework for climate change mitigation.

- Comprehensive description of national framework for climate change mitigation including: base year statistics on GDP structure, social conditions, energy balance, aggregate GHG inventory, major land use activities, population.
- Evaluation of main national economic and social national development trends and the GHG emissions that are expected to occur as a result of economic development.
- Overview of other climate change studies including impact-, adaptation-, inventory and mitigation studies.

(ii) Baseline scenario projection

- 10-15 year baseline scenario projection for GHG emissions from energy consumption and land use activities.
- 30-40 year baseline evaluation of main development trends.

(ii) Mitigation scenario(s) projection(s)

- Identification of mitigation options related to the most important future sources and sinks sectors.
- Screening of mitigation options
- Assessment of reduction potential and cost of mitigation scenarios.
- Integration of GHG reductions and costs across measures and sectors, through construction of GHG mitigation marginal cost curves.

(ii) Macroeconomic assessment

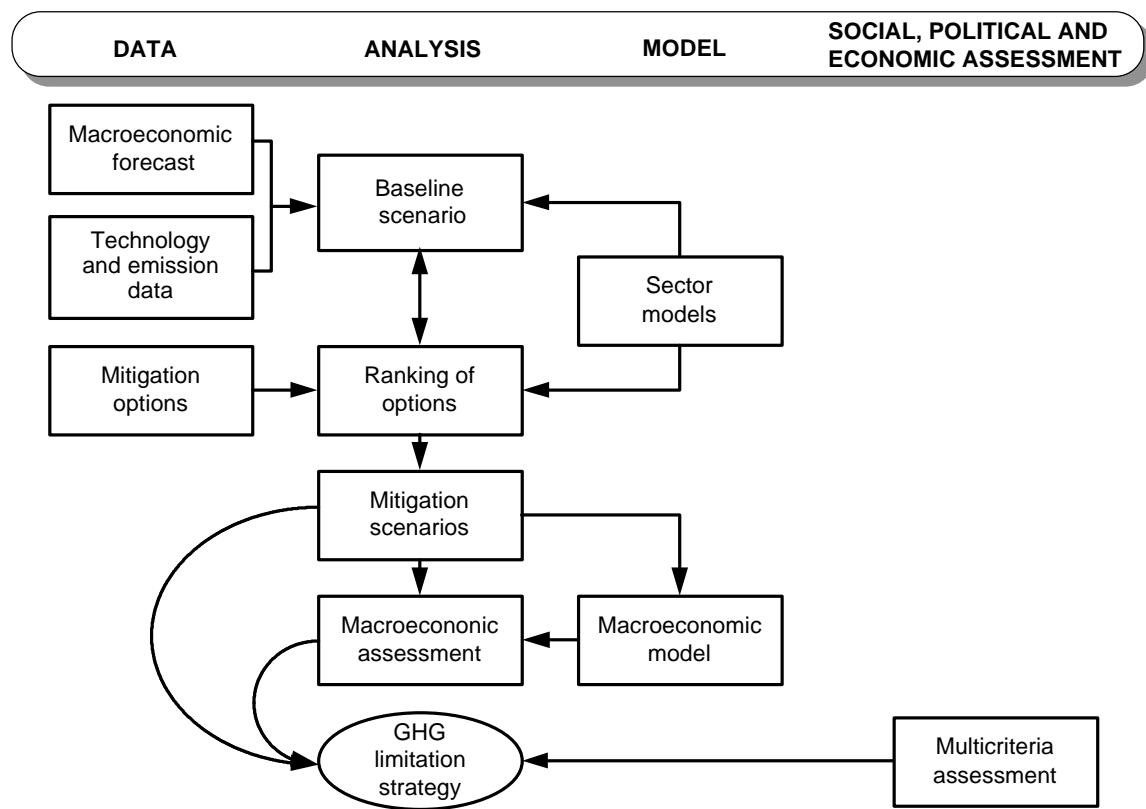
- Qualitative description of main macroeconomic impacts of national climate change mitigation strategies.
- Assessment of key macroeconomic parameters.

(ii) Implementation issues

- Identification of main implementation requirements including financial support, technologies, institutional capacity building, regulation policies and further improvements of the national decision framework.

The common analytical structure of the country studies is shown in Diagram 1.

Diagram 1 Common analytical structure of the country studies.



These country study steps can be conducted at many different levels of sophistication ranging from a broad description of main development trends and statistics to a formalised modelling at sector and macroeconomic level. These basic country study elements emphasise the establishment of a broad overview of the most important national activities related to future GHG development trends as a background for a more detailed assessment of individual mitigation options

4 Development of baseline scenarios

4.1 National scenario concepts

National mitigation assessment should consider the impacts of implementing climate change mitigation strategies in relation to a “business-as-usual” baseline projection that by definition assumes that the policies included in the mitigation scenario are not expected to be in place in the baseline. Thus, the baseline projection will be generated using a set of assumptions that would depict the expected pattern of economic development, as currently formulated in formal government plans, or as interpreted through current governmental policy objectives. This baseline projection is used to assess the “sacrifices” of allocating *additional* resources to mitigation policies compared with the non-policy case. The non-policy case will in the following be termed as the baseline scenario

Climate change mitigation involves the implementation of *individual projects, sectoral strategies and comprehensive national action plans*. To the extent possible, this should also include the assessment of various policy options for achieving these

options. The assessment involves a systematic comparison of the mitigation- and the baseline scenario and these two scenarios should therefore be constructed on the basis of consistent assumptions.

Major scenarios include:

- Activity projections for main GHG emitting sectors and sinks. For most countries, this will include the energy sector, industry, transportation, agriculture, and forestry, other land use activities and waste management.
- Technological development related to the main GHG emitting sectors and sinks.
- Technological development related to mitigation projects.
- Market behaviour and implementation aspects related to mitigation projects.
- Another set of assumptions should be defined for alternative sensitivity cases. These include assumptions on technology costs, discount rates, fuel prices and other international background parameters.
- Alternative policy instruments for achieving sectoral and national level goals.

In the case of national analysis, the scenario assumptions should reflect the decision problem facing the individual country given a set of assumptions on economic development and mitigation efforts in a broader international context.

The mitigation assessment can consider individual projects, sector strategies and cross-sectoral national strategies. Baseline definitions should be defined in accordance with these aggregation levels. Scenarios can, following that, be defined at *project*, *sector* and *national* level.

Project assessment considers the implementation of individual mitigation projects. A baseline case will in this case be defined to show how the same activity would develop without the mitigation project.

Sector assessment considers the total impacts of implementing either a large number of mitigation projects in a sector or making structural changes to the system, such as large-scale fuel switching. The technical potential and costs of individual mitigation projects are in many cases interdependent and the project impacts should therefore be assessed at sector level. Sectoral models for the system as a whole represent a preferable approach. Sectoral assessments should also include efforts to evaluate different types of policies to achieve sector-level goals.

National assessment focuses on the total impacts of implementing mitigation projects and system changes in one or more sectors. The focus should here be on the wider sectoral and macroeconomic impacts such as land allocation, capital and foreign exchange demand, trade, employment, consumption, production, and other macroeconomic impacts. National assessments should also include efforts to evaluate different types of policies to achieve sector-level and national goals.

4.2 Baseline scenario and projections

As previously stated, the assumptions that are used to define the baseline scenarios should assume that the government has not instituted the specific GHG emission reduction policies considered in the mitigation scenario. Since climate change

mitigation in many countries is not among the key national social and economic development priorities, the participation of developing countries in global climate change efforts must be structured in a way where main national development priorities can be fulfilled alongside the implementation of mitigation strategies. Thus, national baseline scenarios should be consistent with these national development priorities. The mitigation assessment that follows will consider the cost and other impacts of integrating mitigation policies in broader national development programmes.

The baseline scenario assumptions should as already said be developed to reflect the costs of climate change mitigation in relation to a non-policy case. The assessment involves a comparison of GHG emitting activities in the mitigation- and baseline scenarios. The assumptions on technological development, sectoral production practices and cost parameters in these two scenarios have major implications on the assessed mitigation potential and cost.

4.3 Baseline typology

Cost is always measured as an incremental cost relative to a given baseline case, and the costs are, therefore, to a high degree, given by the assumptions underlying such baseline cases. Baseline definition is following that one of the most critical issues in mitigation costing studies.

Three main typologies of baseline definitions are:

1. The economic efficient case
2. The business-as-usual case.
3. The most likely case.

The economic efficient case reflects what in economics is called efficient resource allocation. The economy is here assumed to utilise all production factors efficiently implying that the implementation of mitigation projects always will imply economic losses (costs).

The business-as-usual case. The baseline case is here constructed as a continuation of current trends. It can for example be that the structure of energy supply systems, agricultural production and other land use activities are assumed to continue in the future with the exception that already approved sectoral development plans are integrated in the baseline scenario.

The most likely case is the compromise between *The economic efficient case* and *The business-as-usual case*. This implies that the most likely case can include assumptions on a gradual transformation to market liberalisation policies and other adjustment programmes.

The business-as-usual case and *The most likely case* are both reflecting a state of the economy, where markets and institutions do not behave perfectly (according to the principles of efficient resource allocation). No-regret mitigation options (defined as climate change mitigation options with negative costs) will in these two latter cases exist if it is furthermore assumed that it is possible to identify policies that have the ability to correct these market and institutional failures without incurring larger implementations costs than the benefits incurred.

In conclusion, the baseline can be defined in several different ways and it is therefore important that the scenario definition entail explicit assumptions about activities and technologies related to main projects to be analysed in mitigation scenarios. These assumptions should, in addition to cost and efficiency parameters, include parameters relating to non-market goods like environmental quality and social impacts.

4.4 Inclusion of climate change impacts in the baseline scenario

In making a baseline projection, it may be important to include the impacts of climate change on climate sensitive sectors in which mitigation takes place. This is because both emissions reductions and the costs of mitigation can depend on the impacts of climate change. This is especially true for the forest and land use sectors, the agricultural sector, and the energy sector.

4.5 Sources for national baseline development

Important data sources for national baseline scenario construction are official economic development programmes, environmental development programmes and specific sector planning documents. Such official planning documents should be critically assessed as background material for national baseline construction. This includes an evaluation of consistency, reality and policy implications of the projections.

An important starting point for baseline scenario construction is the assessment of macroeconomic development trends that are connected to the major GHG emitting sectors, as projected under a development path assuming that the specific climate change mitigation case is not a policy objective. The aim of this macroeconomic assessment is to identify key national economic priority areas and the implications for future GHG emission and policy options.

It is often the case that the time horizon of official national plans will be no more than five to ten years. This means that a special analysis will be required to extend the projections to cover the longer time horizons. The longer-term projections can be more aggregate than the short-term projections, due to lack of information and uncertainty about developments in specific sectors. The focus should be on the main future trends in population, sectoral economic growth and technological progress in parallel with a number of specific development factors. These factors include future development of the informal sector, major infrastructural investments, land use changes and natural resource management. It is, in the long-term, important to assess the main structural changes in the productive sectors and the shift from the informal- to the formal sector of the economy.

5 Mitigation cost assessment

The national mitigation scenarios serve as a structural framework for assessing the impacts of implementing alternative climate change mitigation policies. These policies include the implementation of individual projects, sectoral strategies and national action plans. The mitigation scenarios should be based on a screening of potential individual projects for the sectors.

National studies should not try to be exhaustive in the selection of mitigation projects in the sectors or across sectors but should rather focus on projects relating to the most important national sources and sinks. The mitigation analysis should, therefore, focus on the assessment of individual mitigation projects for sectors where the mitigation effort can be expected to have significant impacts. Furthermore the selection of projects should furthermore as far as possible, include low, medium and high cost options to provide a general overview of the economic implications of alternative emission reduction targets.

The implementation of mitigation policies will have implications on a variety of parameters including environmental effects, social impacts, GHG emissions and monetary costs and benefits. The parameters to be quantitatively assessed should be chosen specifically for the project being analysed. The integration of non-economic parameters in the decision process is very important

The formal mitigation assessment as described in the Technical Guidelines (UNEP 1998) focuses on the assessment of economic costs and benefits and other impacts of implementing climate change strategies in relation to a national non-mitigation policy case, here called the baseline scenario. The guidelines define a common analytical structure broad enough to allow national studies to use different scenario concepts, analytical tools and models.

Actions taken to abate GHG emissions or to increase the size of carbon sinks will generally divert resources from other alternative uses. The purpose of the methodological framework outlined in the Technical Guidelines is to estimate the value of the resources which society must give up when an action is taken to mitigate the effects of climate change, as opposed to not taking that action. These resources are measured in relation to a “no action” reference, or “base case” which represent a scenario in which the economy follows its normal development path, without any policies to mitigate the effects of climate change. Incremental cost concept is one of the key concepts used in measuring the value of the resources.

5.1 Incremental costs

Mitigation costs by definition should be assessed as the costs of following a mitigation strategy measured as the “incremental” change in relation to the defined non-greenhouse gas policy case – the so-called baseline scenario.

The rationale for focusing on incremental costs is that the resources demanded by a mitigation activity have an opportunity cost - they are, in principle, taken away from other alternative uses. The prices used to value the specific resource components therefore should reflect their value in best alternative use which either can be reflected in market prices, shadow prices or opportunity costs.

The incremental cost concepts is an integral part of the FCCC (UN 1992) and is here used to establish a set of principles for financial transfer to non-Annex I countries. The Global Environment Facility following that has used the incremental cost concept in as the financing principle in their Operational Strategy (GEF 1994).

From a country's point of view there is a distinction between the cost of a project (total or marginal) and the incremental cost. Both concepts are relevant for decision making. The incremental cost concepts is the relevant one to reflect social welfare, while the total cost of a project reflects more the financial requirements.

5.2 Cost assessment approach

The cost concepts in the guidelines are defined on the basis of traditional cost-benefit analysis as applied in international guidelines for project assessment. The aim of the cost-benefit analysis is to measure the project impacts in comparable units. The term costs is used here to denote negative impacts while benefits denote positive impacts. Benefits, following that, can also sometimes be denoted as negative costs.

It is important to note that social cost-benefit analysis is not a technique, but an approach that provides a rational framework for project choice on the basis of specified national objectives and values. The aim is to integrate the national cost assessment in a broader national decision framework for climate change mitigation. Some of the valuation approaches presented in the Technical Guidelines are:

- Cost-Benefit Analysis
- Cost-Effectiveness
- Multi-attribute Analysis

Social cost-benefit analysis can be carried out in different ways depending on the assumptions applied to the impacts considered. A further development of the cost-benefit analysis is the multi-attribute-analysis where monetized costs and benefits as well as other quantitative impacts are considered in an integrated objective function. Box 1 gives an overview of valuation approaches.

Box 1 Cost assessment approaches.

Traditional cost benefit analysis

The basic idea is to measure all negative and positive project impacts in the form of monetary costs and benefits. Market prices are used as the basic valuation as long as markets can be assumed to reflect “real” resource scarcities. It is recommended that other cases should use shadow prices. Shadow prices are meant to reflect prices that would occur in a “perfect” market.

Cost effectiveness analysis¹

A special sort of cost benefit analysis where all costs of a portfolio of projects are assessed in relation to a policy goal. The policy goal in this case represents the benefits of the projects and all other impacts are measured as positive or negative costs². The policy goal can for example be a specified goal of emission reductions for GHG’s and other emissions resulting. The result of the analysis can then be expressed as the costs (\$/ton) of GHG emissions reduction.

Multi-attribute analysis

The basic idea of the multi-attribute analysis is to define a framework for integrating different decision parameters and values in a quantitative analysis without assigning monetary values to all parameters. Examples of parameters that can be controversial and very difficult to measure in monetary values are human health impacts, equity, and irreversible environmental damages.

5.3 Main cost concepts

One can distinguish the assessment of *social- and private costs and benefits*. *Social* costs reflects all costs to society including private costs and externalities, while private costs include only the costs faced by the firms. Another often-used concept is financial costs which measures expenditures, or outlays, of money seen from the perspective of an implementing entity.

Economic opportunity cost or economic cost

An economic cost of producing a commodity is the value of the scarce resources that have been used in producing it. This, in turn, is measured in terms of the value of the next best thing, which could have been produced with the same resources and is called *economic opportunity cost*. In designing mitigation cost strategies the objective is to minimise the *economic opportunity cost* of the programme. *Economic opportunity cost* is sometimes called just the *economic cost* and is closely related to *social cost* and are in this context used interchangeably. It is also related to the concept of *shadow price*, both of which are discussed below. For a more complete discussion of these concepts see Markandya, Halsnæs and Milborrow (1997).

¹ The term cost-effectiveness analysis is sometimes used in more narrow way, where only the financial costs and no indirect positive and negative costs - of a private agent in meeting a specific policy goal is considered.

² Negative costs, with the exception of the benefits of the policy goal, will correspond to benefits of the policy.

External cost, private cost and social cost

The term *external cost* is used to define the costs arising from any human activity that are not accounted for in the market system. For example, emissions of particulates from a power station affect the health of people in the vicinity but there is no market for such impacts. Hence, such a phenomenon is referred to as an *externality*, and the costs it imposes are referred to as the *external costs*. These external costs are distinct from the costs that the emitters of the particulates do take into account when determining their outputs (e.g. prices of fuel, labour, transportation and energy). Categories of costs influencing an individual's decision-making are referred to as *private costs*. The total cost to society is made up of both the *external cost* and the *private cost* and together they are defined as *social cost*.

$$\text{Social Cost} = \text{External Cost} + \text{Private Cost}$$

Estimation of mitigation costs necessitates working with social costs³.

Shadow Prices

The above discussion concluded that the proper cost to consider in GHG projects is one based on *economic opportunity cost*. As noted above, where markets operate competitively and efficiently, the prices will reflect the opportunity costs and can be used to estimate the correct costs. In many instances, however, this will not be the case, and some correction will need to be made. The corrected market price, which should be equal to the *economic opportunity cost* of the resource, is called the *shadow price*.

5.4 Cost assessment levels

The costs assessed at project, sector and macroeconomic level are defined in accordance with the system boundaries determined for the level for which costs are being assessed.

- Project Level: The assessment at *project level* considers an individual project assuming that this project is an isolated implementation without affecting any other part of the economy.
- Sector Level: The assessment at *sector level* considers a case where a number of mitigation projects are implemented in one specific sector. Technical interdependencies between projects in that sector and economic impacts on production inputs and final products of that sector are to be included, but the macroeconomic development and other economic sectors are assumed exogenous.
- Macroeconomic Level: The *macroeconomic assessment*, finally, considers the full socio-economic impacts of implementing mitigation strategies in one or more sectors, and the interaction of the different sectors and the economy.

A full assessment of all policy impacts is very complicated especially if non-marginal changes are generated in factor markets or final consumption across different markets and sectors. Significant impacts on other markets or indirect economic impacts can only be completely integrated in the cost assessment in a Computable General

³ Where the pricing of commercial goods is such that it includes both the private cost and the external cost (i.e. it is based social cost) it is referred to as *full cost pricing*.

Equilibrium (CGE) modelling framework. The development of such a framework is generally very demanding and the section on macroeconomic assessment therefore outlines a framework for a simplified assessment of a number of the key general equilibrium impacts.⁴

5.5 Cost Effectiveness Analysis

For programmes that estimate the cost of achieving a certain reduction in GHGs the main criterion is normally cost of GHG removed.

The cost-effectiveness criterion involves a comparison of final cost flows and GHG emission reduction occurring at different points in time. The cost flows can be compared in a net present value, NPV_c .

$$NPV_c = \sum_{t=0}^T \frac{C_t}{(1+i)^t} \quad Eq. 1$$

where i is the interest rate and C_t is the cost at time, t .

The GHG emission reductions occur at different points in time in the same ways as the costs. Therefore the time specific value of these reductions have a major implication for the calculated emission reduction costs. There is a high uncertainty about climate change damages and it is therefore difficult to assign a time specific value to emission reductions. It is therefore suggested to use a simplified approach where the GHG reductions are discounted with the same discount rate as used in the above-specified NPV_c formula. The net present value of emissions reduction (NPV_e) can then be calculated as:

$$NPV_e = \sum_{t=0}^T \frac{E_t}{(1+i)^t} \quad Eq. 2$$

The costs can also be represented as levelised costs, where the annual costs - as well as GHG emission reductions - are transformed to constant annual flows over the lifetime of the investment. Mitigation projects that imply constant annual emission reductions can be directly compared with levelised cost at a given point in time. The total levelised cost, C_0 of a project can be calculated with the following formula:

$$C_0 = NPV_c \frac{i}{1 - (1+i)^{-t}} \quad Eq. 3$$

and the levelised GHG emission reduction can similarly be calculated as:

$$E_0 = NPV_e \frac{i}{1 - (1+i)^{-t}} \quad Eq. 4$$

Guidelines for project assessment use a number of different concepts to compare cost-effectiveness of projects. The most often used concepts are net present values (NPV), internal rate of return (IRR) and levelised costs. These concepts basically provide similar project rankings. The relationship between the NPV, IRR and levelised costs is further explained in Box 2.

⁴ The main problems in developing countries are the lack of data for a CGE model and the potential rapid growth and shift between sectors. These two problems together make the output of CGE models for developing countries very uncertain.

Box 2 The NPV, IRR and Levelised Cost Concepts.

The NPV concept

The NPV determines the present value of net costs by discounting the stream of costs back to the beginning of the base year ($t=0$).

$$NPV = \sum_{t=0}^T \frac{C_t}{(1+i)^t}$$

The IRR concept

The IRR is defined as the rate of return on an investment which will equate the present value of positive and negative cost components of an investment with zero. It is found by an iterative process and is equivalent to the discount rate i which satisfies the following relationship:

$$NPV = \sum_{t=0}^T \frac{C_t}{(1+i)^t} = 0$$

The levelised cost concept

The levelised cost is, as already shown, a transformation of the NPV using the formula

$$C_o = NPV \frac{i}{1 - (1+i)^{-t}}$$

The use of the concepts NPV, IRR and levelised costs as project ranking criteria is valid given a number of assumptions:

NPV

An investment I_1 is more favourable than an another investment I_2 if: the NPV of I_1 is larger than the NPV of I_2 . It should here be noticed that the use of NPV's to compare the cost-efficiency of projects requires that some discounting principles are applied to the annual GHG emission reductions. The NPV can in terms of NPV/GHG reduction be used as ranking criteria for investments with different time horizon.

IRR

An investment I_1 is more favourable than an another investment I_2 if the IRR of I_1 is larger than the IRR of I_2 . This ranking criteria however is neutral to the scale of the costs and the GHG emission reduction achieved by the project. The IRR can therefore only be used as an initial screening criterion. The IRR can be used as ranking criteria for investments with different time horizon.

Levelised cost

An investment I_1 is more favourable than an another investment I_2 if the levelised cost of I_1 is less than the levelised cost of I_2 . The levelised cost should be calculated for a similar lifetime of the investments of with the inclusion of a terminal value for long-term investments.

The full *economic costs* of a project (in so far as they can be monetised) and not just the direct financial costs, measuring the cost effectiveness can be formulated as:

$$C_{Full} = C/E \quad Eq. 5$$

Where C and E can either both in net present values (as defined in Eq. 1 and 2 or the levelised costs (as defined in Eq. 3 and 4).

The full economic costs, C_{Full} , is distinguished from the direct financial cost of the project and which will be discussed below. Note that for C_{Full} , all costs are economic costs, as described in economic opportunity cost or economic cost. The values of C_{Full} will depend on the precise value attached to the different components of costs and, as noted earlier, these costs are uncertain, with ranges of values rather than a single value. In view of this, it is important to present a range of such values and to indicate the impacts from which the uncertainty arises. Related to that, it will be useful to present a more detailed table of the components of the costs by time period, so that the policy-maker can draw on this information should it be considered necessary.

5.6 Choice of discount rates

The debate on discount rates is a long standing one (see IPCC 1996). As that report notes, there are two approaches to discounting; an ethical approach based on what rates of discount should be applied, and a descriptive approach based on what rates of discount people actually apply in their day-to-day decisions.

- The ethical approach suggest that a discount rate that reflects the preferences of society to investments in long term sustainability impacts associated with climate change mitigation be used.
- The descriptive approach argue that the marginal rate of return on capital is the appropriate discount rate.

The former leads to relatively low rates of discount (around 3 percent in real terms⁵) and the latter to relatively higher rates (in some cases very high rates of 20 percent and above). The arguments for either approach are unlikely to be resolved, given that they have been going on since well before climate change was an issue.

In addition to discounting future costs and benefits there is the further issue of whether or not future emission reductions should be discounted when compared to present reductions. The justification for discounting is that emission reductions in terms of reduced impacts have a time specific value. The choice of the appropriate rate, however, remains an unresolved issue and, again, taking a range of plausible values is the only solution.

One point perhaps which should be noted relates to the use of low discount rates for appraising GHG programmes in developing countries, where capital is scarce and market rates of discount are very high. This low real rate for mitigation programmes can be justified on the ethical grounds mentioned above. The scarcity of capital, on the other hand, can be dealt with by having a shadow price for capital that is $>$ one.

⁵ The real rate of discount is the market rate net of inflation. Thus if a market has a discount rate of 12% and inflation is 8% then the real rate is 4%.

6 Assessment of broader social and environmental impacts of mitigation policies

Climate change mitigation policies have a number of important impacts additional to those measured as direct resource costs connected to the implementation of a specific project. These impacts include indicators that either can be measured in monetary units, in physical units or as more qualitative information. Some of such impacts are in relation to employment, income distribution, environmental changes, and sustainability indicators.

6.1 Evaluating employment effects of GHG projects and policies

If a project creates a job, this has a benefit to society, to the extent that the person employed would otherwise not have been employed. In other words, the benefits of employment are equal to the social costs of the unemployment avoided as a result of the project. These benefits will depend primarily on the period that a person is employed, what state support is offered during any period of unemployment, and what opportunities there are for informal activities that generate income in cash or kind.

A physical measure of the extent of the employment created is therefore the first task of any project assessment. The data that have to be estimated are:

- the number of persons to be employed in the projects,
- the duration of time for which they will be employed,
- the present occupations of the individuals (including no formal occupation),
- their gender and age (if available).

This physical information should be reported in a summary table for the project, to be used in the selection criteria discussed in the section A framework for integrating quantitative and qualitative impact assessment. In addition, however, it is possible to place some money value on the employment, or to deduct from the payments made to the workers the value of the benefits of the reduced unemployment.

6.2 Income distribution and poverty

The impacts of GHG limitation projects on income distribution and poverty are of great importance and merit careful attention and treatment. The main effort has to be devoted to collecting information on which income groups and which sections of the population are affected by the measures proposed. The measures will impose costs as well as benefits and both are important. The breakdown of data on who is impacted need not take the form of household income alone, but could include, for example, rural and urban households, households classified by race etc. A matrix of the distribution of gains and losses is required, classified in the categories that are believed to be important both for a correct estimate of the true costs of the project as well as for a successful implementation of the project. If the analysis fails to identify groups who would lose as a result of the project, but who have the power to block it or to thwart its effective implementation, the whole exercise will be a failure.

6.3 Valuation of joint environmental products

Climate change mitigation projects will in many cases have other environmental impacts than decreased GHG emissions. Substituting coal fired power production with hydro power will, for example, result in reduced sulphur and particulate emissions in addition to reduced GHG emissions also imply decreased nitrogen and. On the other hand, hydro power projects have a number of other environmental impacts such as changes in the aquatic ecosystem and biodiversity. The negative or positive values of such joint products should in principle be integrated in the project assessment. It is however difficult to value many of such impacts. The valuation is especially difficult to carry out for environmental impacts that cannot be meaningfully related to market goods. See the section A framework for integrating quantitative and qualitative impact assessment.

6.4 Sustainability

The issue of sustainability arises here because environmentalists are concerned that the policies followed should contribute to the longer term resolution of the conflicts between protection of the natural environment and economic development. The issue, which was first brought into the public domain in a significant way by the Brundtland Report (World Commission, 1987) was posed as a search for a path of development that meets the needs of present generations without compromising the abilities of future generations to meet their needs. Subsequent developments of the idea refer to the concepts of “weak” and “strong” sustainability. The notion of weak sustainability is that society should develop its resources in such a way as to ensure the passing on of a stock of wealth (including natural capital) to future generations at least as great as the one inherited by present generations. This stock is measured in money terms. The notion of strong sustainability is to ensure that critical parts of the natural capital are not degraded and that renewable resources are used in a manner that is as sustainable as possible, given other constraints on resource use and economic development. The appeal of weak sustainability depends on the degree of substitution between natural and man-made capital in the production process. There are significant difference of opinion about that among environmentalists and economists.

6.5 Measuring the benefits of reduced climate change

The assessment of benefits of reduced climate change is by nature difficult and uncertain. The current methodological framework therefore suggests not to include monetary climate change damage estimates but to focus on GHG emission reduction targets. The benefits of reduced GHG emissions vary with the time of the emission reduction, with the atmospheric GHG concentration at the reduction time, and with the total GHG concentrations more than 100 years after the emission reduction.

Reduced climate change has a benefit component and the domestic benefit should therefore in principle be included in the national project evaluation.

6.6 A framework for integrating quantitative and qualitative impact assessments

The previous sections discussed the application of cost concepts to traditional costs and benefits and to a wider range of impacts that should be included in either the cost assessment or an over-all evaluation of a mitigation action. In many cases, there will be important impacts from a project that either can not be valued in the cost assessment, due to lack of data, or should not be included in the cost assessment for sound economic accounting reasons. In the final analysis, it is important to integrate all of the cost and non-cost elements into an over-all framework that can be used to assess all of the impacts of a mitigation action.

The information collected on the impacts of a GHG limitation project or programme needs to be summarised so that different projects and programmes can be compared. There are three kinds of information to be summarised. These are:

1. Quantitative information in money terms
2. Quantitative information in physical units
3. Qualitative information

Quantitative monetary data on the project

Quantitative monetary information includes direct and indirect costs associated with the implementation of projects.

Quantitative non-monetary information

Quantitative information in non-monetary units can be available for:

1. Employment impacts.
2. Income gains and losses of different groups.
3. Associated environmental changes.
4. Sustainability indicators of the share of energy derived from renewable sources, now and at the end of the planning period.
5. Macroeconomic impacts on GDP, trade and sectoral changes in GDP.

In addition, some of the other sustainability indicators may be quantified, although that is not certain.

Qualitative information

Qualitative information on impacts is important and should not be ignored. It cannot be integrated into the summary cost effectiveness values or the multi-criteria number, but it is relevant to the selection of the project and, more crucially, to the design of the project. Once a GHG-related project has been identified, a preliminary screening should generate important qualitative information. This should then be used to modify the design of the project so that the key negative impacts are mitigated wherever justified. The revised project will still have some impacts but these will have been passed as “acceptable”. This preliminary screening of projects will avoid serious environmental damages, as well as serious political blunders where projects that seem

technically acceptable have such negative impacts on key stakeholders that they are bound to fail on political grounds.

6.7 Multi-attribute analysis

A number of methodologies consider the assessment of broader impacts. One of the most commonly applied methodology is the multi-attribute methodology. This methodology is described in the literature, one of the most important sources for further reading is Keeney & Raiffa (1993).

Multi-attribute analysis: the method

The present description is a short presentation on how a multi-attribute analysis can be used to support the assessment of climate change mitigation costs.

The basic idea of multi-attribute analysis is to base decisions upon several objectives. The focus is on identifying decision criteria specified in attributes and weights in order to measure and evaluate trade-offs between different criteria. Meier & Munasinghe (1994) outline the following five steps to be undertaken in a multi-attribute assessment:

1. Selection and definition of attributes, say A_i ($i=1, \dots, N$) selected to reflect important planning objectives.
2. Quantification of the levels A_{ij} of the i attributes estimated for each of the j alternatives.
3. Scaling of attributes, in which the level of an attribute is translated into a measure of value, $V_i(A_{ij})$ (also known as the attribute value function). This is sometimes combined with a normalisation procedure (usually on a scale of zero to one where the lowest value of the attribute is assigned to zero, the highest attribute value assigned to one).
4. Selection of weights w_i for each attribute.
5. Determination and application of a decision rule, which amalgamates the information into a single overall value or ranking of the available options, or which reduces the number of options for further consideration to a smaller number of candidate plans.

A multi-attribute decision rule can then be specified as follows:

Select the option with the highest score on $\sum_i w_i V_i(A_i)$,
where w_i is the weight and $V_i(A_i)$ is the value function of attribute A_i .

One of the most complicated elements in the design of a multi-attribute analysis is the selection of attributes. It can seem to be attractive to select and evaluate as many attributes as possible but this will not necessarily provide a good decision basis. The attributes must be selected carefully on the basis of methodological consistency and practical considerations. Some of the main methodological issues are related to double counting, value independence, proliferation of attributes, and importance of the attributes in relation to policy decisions (Meier & Munasinghe, 1994). Furthermore the attributes must also be measurable and predictable.

The use of MCA in national decisions

The MCA can be used to add broader information on social, environmental and other impacts to the cost assessment as a further development of the mitigation cost assessment.

A formal multi-criteria analysis can be integrated in the mitigation analysis through the following steps:

- construction of baseline scenario on the basis of national development plans including a macroeconomic forecast. The baseline scenario projects the scale of activities in the sectors for the most important sources and sinks. Definition of main variables to supplement the mitigation cost assessment.
- identification of mitigation options. Assessment of mitigation potential and cost of individual projects.
- assessment of mitigation potential and cost at sector level for “baskets of
- assessment of non-cost variables for projects or baskets of projects. Presentation of the cost variables and the other variables as background information for the evaluation of trade-offs, priorities, dominance, etc.
- assessment of weights connected to cost and non-cost variables in the objective function.
- formal analysis using variables and weights as input to a well-defined criteria function.
- interpretation of results as input to the national decision making framework.

This assessment will in practice be a very difficult exercise where many actors need to be involved in the setting of priorities. This can also be seen as part of the inputs to a broader national decision making process where various stakeholders and policy makers consider the outputs of the formal mitigation assessment and take the further lead in the development of national action plans.

6.8 Conclusions on decision criteria

Ultimately the decisions on which projects to undertake is a political one. The screening rules discussed above are a guide to those decisions. As has been noted these rules will not provide unique guidance on which policies or projects to choose. But they will provide a range of indicators on financial costs, full economic costs and on the other quantitative and qualitative impacts that are inputs to the decision-making process.

7 Implementation issues

Mitigation cost assessment should in principle include all costs needed to implement a given policy options. In the traditional bottom up studies employing cost-benefit analysis, it is assumed that market establishes incentives for the agents to implement the project and no specific activities are necessary to promote implementation. Therefore, implementation costs traditionally include overheads such as planning activities, administration, information, training, monitoring etc. However, in several cases including in environmental projects and mitigation projects, there are additional costs due to market imperfections, lack of institutions or their failure, externalities, lack of property rights or their enforcement etc. These factors act as barriers in

implementation and transaction costs in such projects can be significant. Therefore, implementation costs should also include these transaction costs to remove the implementation barriers, termed as *barrier removal costs*.

Barrier removal costs are costs of activities aimed at correcting market failures and reducing transaction costs. For example costs of improving institutional capacity, reducing risk and uncertainty, setting up regulatory framework to enforce policies etc. The effect of barrier removal is not limited to immediate project or strategy but reduces transaction costs for similar projects in future. The costs are incurred in a project to reduce social costs in the longer run to make regulation and policy instruments work.

Several types of barriers can be identified:

- *Market barriers*, that may be due to missing or segmented markets, monopoly, entry barriers, externalities and price distortions;
- *Inflexibility of existing technical systems* which implies capital irreversibility, economies of scale and specific learning requirements for a technology and;
- *Institutional barriers* that may be due to absence or unreliability of legal institutions, under developed financial markets, limited flow of information and administrative capacity constraints;
- *Human capacity barriers* that may be due to limited supply of skilled labour and lack of opportunities for education and training.

Barrier removal policies may thus include efforts to increase potential market through incentives, introduction of new institutions, risk reduction and specific support activities in the early market development phase. Support to renewable energy technologies by UNDP and GEF through specific projects are thus aimed at such barrier removals and develop the market (UNDP, 1996; GEF, 1994).

8 Sectoral assessment

Energy, transport, forestry, agriculture and waste sectors are major GHG emitting sectors and mitigation options for each are discussed in this section.

Energy sector: In case of energy sector, GHG emissions from production of primary fuels, transformation, and consumption by energy sector and final consumption by other sectors. Import and export of fuels as well as losses during distribution also need to be accounted for in the emission calculations. While compiling the inventory of emissions from energy sector, emissions from physical emission source are considered at each stage following the IPCC/OECD methodology (IPCC, 1997). Thus, in case of coal mines CH₄ emissions from coal bed are considered as part of fuel production process, and in case of oil and gas, CO₂ emissions from flaring of gas are also considered besides CH₄ emissions. Combustion process in both cases accounts for CO₂ emissions at point of final combustion.

Future baseline emissions from energy sector are determined through energy demand and supply projections normally using modelling approaches. A variety of modelling approaches such as simple econometric models, optimisation models, simulation models or energy-economy macro models can be used for projections. Mitigation options in case of energy sector are considered keeping in view importance of the emissions source and cost of mitigation from current as well as future perspective, magnitude of mitigation potential and ease of implementation. A recommended portfolio of mitigation project will include short-term GHG reduction projects through energy efficiency improvements and small-scale renewable, long term options involving new power supply technologies and advanced renewable technologies, and a few large scale investment projects.

Some of the mitigation options at the end use include lighting efficiency improvement through use of efficient fluorescent lamps in place of incandescent lamps, electronic ballasts and reflectors, use of high efficiency motors and variable speed drives, efficient refrigerators (that use efficient compressors), improved cooking stoves etc. Co-generation wherever possible, use of heat pumps and efficient fuels such as natural gas or renewable energy for water heating are some of the potential options for commercial and industrial facilities. Similarly, efficient options are also available for space heating and space conditioning. On supply side efficient options such as high efficiency gas turbines, combined cycle power production and advanced high efficiency measures such as integrated gasification combined cycle (IGCC) and pressurised bed combustion (PFBC) can be considered to replace existing coal and oil based systems. Renewable options for power production, such as wind power, small-scale hydro, solar systems and biomass based electric generation systems are other mitigation options on supply side.

Transport: Transport is a sub-sector of energy but discussed separately in view of its importance in emissions. It accounted for about 20-25% of global CO₂ emissions in 1990 (IEA, 1993, IPCC 1996) and expected to grow substantially. While considering mitigation options for transport sector, it is necessary to account for impacts and costs outside transport sector also for a comprehensive assessment. Mitigation options for transport consist of better demand and supply management, efficiency improvements in fuel use, and fuel switch to lower emission fuels.

The demand reduction can be achieved through increase in the cost of transport. Selective cost increase can shift the demand to more efficient mode of transport (for example, to higher capacity efficient transport from private), or to non-motorised transport. For long term, urban planning that helps reduce distance to travel and ship goods is a potential option. On supply side, increased capacity utilisation through better route planning for public transport, redesign and development of inter and intra-city mass transit system, encouraging car pooling through suitable instruments are some measures.

The efficiency of fuel usage can be increased through use of efficient vehicles. It can also be increased through better maintenance practices, training, providing good quality roads, decrease in congestion through proper traffic planning etc. For new vehicles, efficiency standards can be prescribed. Fuel switch to lower emissions fuels include use of renewable resources such as ethanol, electricity (provided emissions from electric power generation are lower), and to electricity from coal or diesel in

case of locomotives. Measures that promote shift to modes with lower emissions can also be considered. These include measures to promote walking, bicycling, public transportation and railroad relative to automobile and truck etc.

Forestry: Forest clearing is a major source of emissions in some countries. This is done either to provide land for agricultural development or fuelwood to their populations. Mitigation options for forestry sectors include reduction in rate of deforestation, afforestation (increasing forested area) and increasing stock of carbon in existing forests, increasing wood use efficiency and substitution of fossil fuels by biomass.

Deforestation can be reduced through switch to sustainable energy sources such as biomass, solar and wind energy and increasing efficiency of fuelwood use through use of efficient stoves. Measures to increase agricultural productivity can also reduce the demand for land for agriculture. The stock of carbon in the existing forests can be increased through forest protection and conservation measures, better management, agroforestry, increase in soil carbon through selective crop planting and tillage choice, and urban and community forestry.

Agriculture: Land clearing for agriculture and associated emissions from soils are the source of CO₂ emissions from agriculture. Agriculture in many countries is major source of CH₄ emissions that come from anaerobic fermentation from rice paddies and livestock, enteric fermentation from livestock. Methane is also released from burning of savannah and agriculture residues, and soil cultivation. Agriculture is also a source of nitrous oxide emissions. It also provides sinks for carbon through its absorption in soils, and short-rotation crops.

The mitigation options in agriculture in case of methane emissions from rice paddies include reduction in cultivated rice area, reduction in period of flooding (as flooding causes anaerobic conditions), introduction of new plant varieties requiring less flooding, and use of organic fertilisers that reduces emissions substantially. Methane emissions from livestock (mostly ruminant animals) can be reduced through feed processing to increase digestibility of feed, feed supplementation and use of methane reducing agents. Productivity increase of animals through genetic improvement and other methods can also decrease the number of animals needed for a given level of output from animals. Methane emissions from anaerobic fermentation of the animal waste can be reduced through production of biogas in digesters and covering lagoons to capture methane.

Carbon storage on agricultural land can be increased through crop and grazing management involving low till cultivation, rangeland rehabilitation etc., and planting windbreaks and shelterbelts. Nitrous oxide emissions from agriculture can be reduced through conservation and adoption of agronomic practices that increase efficiency of fertiliser use, better water management to reduce leaching of nitrogen.

Waste: Major GHG emissions from the waste sector are that of methane caused by disposal of solid waste on land and wastewater handling. Waste incineration of fossil based products such as plastics cause CO₂ emissions but share is small. The amount of methane produced from the solid waste disposal depends on the composition of waste and management practices with better managed landfills producing more methane due to anaerobic conditions. In case of waste water also, anaerobic treatment of municipal and industrial wastewater causes methane emissions.

Mitigation options for solid waste include recovery of methane from landfills and reduction in waste quantity through recycling or other waste management practices. For wastewater handling, aerobic processes can be used and wherever anaerobic processes are used, closed systems can be employed to recover and use methane.

9 Macroeconomic assessment

Macroeconomic assessment is concerned with the study of impacts of a mitigation project or strategy on macroeconomic variables such as GDP, employment, imports and exports, and public finances etc. The relationship between output from various sectors and emissions is brought out and analysed to estimate impact of emissions reduction on various economic activities. Macroeconomic analysis ensures that economic assumptions and projections are consistent across the sectors in formulating a mitigation strategy. Impacts at macro level provided by the analysis help in understanding consequences for economic growth, distribution and so on, depending on level of details in the analysis.

Macroeconomic analysis is data intensive and requires information on several variables such as demographic variables, national accounts data that include GDP, consumption, investment etc., public finance, land-use variables related to agriculture and forestry, foreign trade, and monetary variables such as prices, money supply and interest rates. Further dis-aggregation is done depending on level of impact analysis.

Macroeconomic assessment is carried out using a modelling approach. It can be a rough assessment or an advanced analysis depending on availability of data and model. A rough analysis is carried out when available economic data is merely in terms of economic indicators. Input-output modelling, computable general equilibrium (CGE) modelling and macroeconometric modelling are other possible assessments that require models as well as dis-aggregated data. Input-output modelling requires input-output tables for sectoral transactions. Macroeconometric models are suitable for short-term analysis, typically less than 10 years. CGE models incorporate non-linear relationships and can also account for behavioural aspects such as consumer preferences. CGE models can analyse structural changes between sectors and indicate their development potential. However it assumes market clearing and, is thus suitable for economies with market features.

A simplified macroeconomic analysis of GHG reduction policies can be carried out if CGE modelling is not feasible. Such an analysis can use the available statistics and models in a country, at the same time ensuring internal data consistency.

10 Policy instruments

Once the mitigation options have been identified, it is important to specify how the policy makers can implement this. The policy instruments can be broadly classified in two categories depending on the approach. These are:

10.1 Command and control (CAC) approach

This is a regulatory approach and examples of this are environmental regulations that have been used to achieve pollution reductions in air and water quality in many nations. For GHG emissions reductions, following CAC systems can be used:

- direct regulation of GHG emissions,
- regulation of the chemical contents of fuels,
- standards to regulate energy efficiency in buildings and energy-using durable goods in the industrial, residential, commercial, and agricultural sectors,
- regulations to mandate carbon conserving forest practices (forest practice laws), and
- automobile fuel efficiency standards.

The use of command and control systems to directly regulate GHG emissions is problematic because the technology to remove CO₂, directly from the emission stream, is quite costly compared to other indirect means such as fuel switching, conservation and use of renewable, improving transmission and distribution efficiency, etc. In addition, many of the measures that can be used to mitigate GHG emissions involve even more indirect actions, such as planting trees, switching production to less GHG intensive goods and services, and a host other types of actions that are really not very amenable to direct regulation. Therefore most plans to reduce GHG emissions envision a mixed system of regulation and economic incentives.

CAC are seen both as very expensive, requiring large bureaucracies to implement and enforce the regulations and very inefficient from an economic perspective by the developed countries. Developing countries experience with CAC is also not satisfactory for different reasons including; lack of capacity and institutions, and monitoring and enforcement problems.

10.2 Market approach

Also referred as “Economic Instruments” approach, broadly consist of the following:

- market restructuring policies in energy markets
- taxes on primary fuels, energy, and emissions including carbon taxes
- cost-based market mechanisms, such as emissions trading.

Market restructuring policies

This refers to a broad range of policies that involve removing government intervention in energy markets. These policies aim broadly at bringing the prices at which primary fuels and energy are bought and sold into line with the prices that would prevail in competitive markets.

Taxes and pollution charges: The theoretical purpose of a pollution tax is to internalise the social costs created by the pollution into the price of market goods and services. The purpose is to fix the level of output for a good at social optimum level. The externalities can be internalised through taxes on energy, on primary fuels, or through charges on pollutants. For GHG emissions, carbon taxes can be levied. This can be through direct taxation on CO₂ emissions or indirectly through taxation on energy. However, taxes on energy and primary fuels allow firms to substitute inputs that can also lead to increases in CO₂, if tax is not related to CO₂ emissions.

Cost-based market mechanisms: These are; tradable emission instruments (viz., allowances, permits, and quotas), emissions (CO₂) offsets and joint implementation. In case of these instruments pollution levels for some group of sources are fixed and they are allowed to pay other sources to reduce their emissions. The deals are made if there are cost differentials in reducing the pollution across the sources. Each is briefly discussed below.

(i) Tradable emission instruments:

Emissions trading allows regulated emissions sources facing different abatement costs to shift from their own emissions abatement marginal cost curve to an aggregate emissions abatement supply curve. For example, in case of a permit system, the government issues tradable permits based on level of emissions fixed for a pollutant. Trading of permits occurs until abatement costs are similar across the polluters.

(ii) Emissions offsets:

This system allows both regulated and unregulated entities to trade emissions reductions with regulated entities. For example, if a utility is a regulated source, an offset system may either the utility itself or another firm, NGO, or individual that was not regulated to “create” an emission offset through a tree-planting program.

(iii) Joint implementation:

Joint implementation (JI) is a mechanism that may allow nations to meet their obligations to reduce net GHG emissions by trading emissions offsets with other countries. The use of this instrument is based on the widely acknowledged fact that GHG emissions reductions/offset costs vary widely between countries.

10.3 Issues in policy implementation

Several issues need to be addressed before a market approach through introduction of economic instruments can be taken. Taxes such as carbon tax, emissions taxes and energy taxes are usually regressive, implying adverse impact on low-income groups. Therefore, before these are imposed, a compensation mechanism may have to be devised. Determining the level of taxation is one of the most complex tasks as it is difficult to establish the link between the tax base and the achievable environmental effect. Further, market based instruments require a well-developed market, which may

be a constraint in several countries, especially in developing countries. Incentives and pricing mechanisms can operate properly only in a well developed market. Since economic instruments involve changes in costs of production, adverse effect on competitiveness of the firms is a possibility.

Other issues include establishment of a suitable administrative and institutional mechanism, choice of appropriate instruments and associated implementation strategy, possibility of market distortion due to monopoly power of some big firms.

Developing countries have large non-market sectors. These may not be amenable to market policies. Even where markets exist, monitoring and enforcement may a problem due lack of skilled personnel and institutions. In many cases, political acceptance of the tax may be a major issue.

10.4 Criteria for selection of policy instruments

Given a number of issues surrounding various types of policy instruments, choice of appropriate instrument is very important. It may not be possible for a single instrument to address various issues while inducing emissions reduction. A combination of policies may have to be adopted, choice of instruments being based on importance of issues and policy planners assessment of the extent to which the instruments can address these issues. Developed countries, which have been mandated to reduce emissions by the Kyoto agreement, would look for measures that will have least effect on their economic growth. Since economic instruments offer several advantages including cost effectiveness, it may be natural to introduce them in conjunction with CAC measures. On the other hand, although developing countries have currently no obligation to reduce emissions, they are mandated by FCCC to take such appropriate measures to reduce emissions that are consistent with their development priorities. Therefore, they need to look for instruments that meet their development requirements besides reducing emissions. One of the major objectives should be to reduce emission intensity of the output without effecting the growth. For example, efficient use of energy and other resources can put developing countries on a lower energy intensive path, thereby reducing emission intensity of the development.

Of the various alternatives, restructuring of energy market is linked to broader policy of economic liberalisation since it involves reducing governmental intervention in the market. Therefore, this can be pursued as part of the liberalisation agenda in countries that are transiting to market economy.

Within developing countries, there is wide disparity in terms of current emissions and economic development. On one end of the spectrum are fairly advanced economies that are close to developed countries, while on the other yet very poor countries. Further, baseline future emissions in some cases may indicate highly emission intensive output growth resulting in high growth of their emissions, while in the others growth may be moderate and emissions well below average emissions. Some poor developing countries are also dependent on bio-fuels to meet a substantial part of their energy requirements, rendering use of some of the instruments meaningless. There is yet another group of developing countries that export energy and hence find any taxation on energy affecting their economic growth. Since emissions are due to

consumption of energy, the action for emissions reduction therefore may have to be left to energy importing countries.

Developing countries that are close to developed economies in terms of development and emissions may have option to introduce economic instruments without significant adverse impact on their economies. For other developing countries, the options may be limited in short term. In short term, their focus may be on efficient use of energy and other resources, which may help them reducing emissions besides fitting in their development priorities. Therefore policies that would encourage efficient use of energy and other resources, fuel switch to less carbon intensive fuels (wherever desirable), reduction in energy intensity of the output etc. may be desirable. It is important that barriers to this are identified and instruments selected accordingly.

In the medium and long run, developing countries may also face requirement for emissions stabilisation/reduction. The interim period can also be used to develop institutions and mechanism, build up skills and gain experience through pilot experiments.

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ISSUES RELATED TO COOPERATIVE IMPLEMENTATION MECHANISMS

Note by the secretariat

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I. INTRODUCTION

A. Mandates

1. The Kyoto Protocol provides for the establishment of three new mechanisms of cooperative implementation which may be used by Annex I Parties to supplement domestic actions to fulfil their emission limitation and reduction commitments under Article 3.⁶ Article 6 on joint implementation (JI)⁷ and Article 17 on emissions trading (IET)⁸ provide for cooperative transactions among those Parties, whose quantitative commitments are inscribed in Annex B to the Protocol. Article 12 on a clean development mechanism (CDM) extends the scope of cooperation to non-Annex I Parties, thereby contributing to their sustainable development and to the ultimate objective of the Convention. Through the CDM particularly vulnerable developing country Parties should also be assisted in meeting the costs of adaptation to the adverse effects of climate change.⁹ Article 3.12. Other articles of relevance are referred to in the attachment to this note. The term cooperative implementation is used in this note as a collective heading for the three new mechanisms established under the Kyoto Protocol as well as for activities implemented jointly (AIJ) which, under a pilot phase, have been undertaken since 1995 according to the mandate contained in decision 5/CP.1.

2. The Protocol provisions regarding the three mechanisms vary in the detail of their content and in procedures for taking decisions on implementation. Articles 6 on JI and 12 on the CDM establish frameworks to be filled out by the Conference of the Parties to the Convention serving as the meeting of the Parties to the Protocol (COP/MOP) at its first session (COP/MOP 1) or later. Article 17 is a general enabling clause that provides for the Conference of the Parties *to the Convention* (COP) to define the arrangements for IET, though it may be presumed that these will be confirmed by COP/MOP.

3. In adopting the Kyoto Protocol, the third session of the Conference of the Parties (COP 3) set in motion a process of preparatory work for a “prompt start” to the work of COP/MOP 1 (decision 1/CP.3, paragraph 6). This process encompasses the work required to give effect to the three new cooperative mechanisms. It enables the COP, supported by the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI), to prepare decisions on these mechanisms for adoption by COP/MOP 1 or, as in the case of emissions trading, decide on the matter itself. The allocation of work arising from this mandate is the

⁶“Article” means, unless otherwise indicated, an Article in the Kyoto Protocol.

⁷“Joint implementation” is suggested as a short term for the mechanism defined in Article 6.

⁸Due to possible confusion with domestic emissions trading schemes, trading under Article 17 will be referred to as “international” emissions trading (IET).

⁹ Articles 6 and 17 are to be considered in conjunction with Article 3.10 and 11; Article 12 is linked to

subject of a proposal by the Chairmen of the SBSTA and the SBI to the eighth sessions of these subsidiary bodies (document FCCC/SB/1998/1).

4. By the same decision, COP 3 also identified a number of tasks related to the three mechanisms to be undertaken by COP 4, on the basis of preparatory work by the SBSTA and the SBI, as well as by the secretariat with the guidance of the Chairmen (decision 1/CP.3, paragraph 5 (b), (c) and (e)).

5. These two related actions by COP 3 constitute the mandates for the eighth sessions of the SBSTA and SBI to carry forward the work of implementing the three mechanisms for cooperative implementation envisaged by the Kyoto Protocol.

B. Scope of the note

6. This note by the secretariat seeks to focus discussions on some key issues regarding the design and functioning of the three new mechanisms, such as issues concerning mandates, cross-cutting as well as issues concerning individual mechanisms. The note addresses each mechanism separately in view of different origins, approaches, participants and possible applications. Reference is, however, made to similarities among the mechanisms, in particular where coordination of work on methodological and institutional issues and inter-institutional collaboration are concerned. The note suggests, in its concluding part, elements of a work programme up to and, to some extent, beyond COP 4. It draws upon the views submitted by Parties (document FCCC/SB/1998/MISC.1), contains reflections by the secretariat and builds on its consultations with other organizations having activities, under way or planned, that could contribute to the design or operation of the mechanisms.

7. As a further input to the discussions, the secretariat will make available to Parties information on activities of intergovernmental and non-governmental organizations in areas of cooperative implementation and report orally on inter-institutional consultations aimed at facilitating the exchange of views on concepts and on work programmes. This information, apart from providing Parties with an overview of relevant activities, should serve the subsidiary bodies as a basis for inviting external contributions to their work on the three mechanisms.

C. Possible action by the SBI and SBSTA

8. In addition to expressing their views on the issues and questions raised below, the SBSTA and the SBI may give guidance on the organization and sequencing of work on the three mechanisms as well as in the area of AIJ, taking into consideration chapter V below containing a proposed programme of work.

II. ISSUES CONCERNING MANDATES

9. Three assumptions regarding the mandates referred to under section I.A. above require confirmation:

- While paragraphs 5(b) and (c) of decision 1/CP.3 provide broad mandates for the design of emissions trading and JI (respectively “definition of relevant principles, modalities, rules and guidelines” and “elaboration of guidelines”), the explicit mandate in paragraph 5(e) is limited to the implications of paragraph 10 of the article on the CDM (the provision for use of certified emission reductions obtained in the period 2000-2007 during the first commitment period). Nevertheless, it is assumed that the Parties will consider it prudent to undertake a comprehensive design exercise for the CDM, so that its operating procedures would be clear by the year 2000, i.e. by COP 5 in 1999.
- While the Kyoto Protocol does not make any reference to activities implemented jointly (AIJ) under the pilot phase (decision 5/CP.1), it is assumed that the technical work carried out under this mandate will be drawn upon, as appropriate, in designing the two project-based mechanisms, JI and CDM. This relates primarily to methodological issues such as determination of baselines, monitoring and reporting functions, but also to capacity-building in host and investor countries.
- Notwithstanding the differences in the provisions for taking formal decisions on the three mechanisms, it is assumed that the Parties to the Convention will seek to reach consensus on the design and operation of each of the three and that any consensus achieved before the entry into force of the Kyoto Protocol will be confirmed by the Parties to the Protocol at COP/MOP 1.

10. These assumptions affect the work programme on the design of the three mechanisms. The last also has to do with the confidence of Governments, organizations and corporations in the utility of their participation in early action to put the mechanisms into effect.

11. In addition to the core articles on cooperative implementation, several other articles in the Protocol are of relevance, if not explicitly linked, to the three new mechanisms. Any existing or future mandates related to these articles influence the scope and pace at which work on cooperative implementation proceeds. Among them are Article 18 (non-compliance), Article 4 ('bubble'), and Articles 5, 7 and 8 (in the context of JI as defined in Article 6) as well as Articles 21, 24 and 25 (on entry into force of the Protocol). Among the methodological issues to be considered in the context of project-based activities is the question of sinks (Article 3.3). Parties may wish to consider the requirements for synchronization of work in the context of the various mandates.

III. ISSUES CONCERNING INDIVIDUAL MECHANISMS

12. JI and IET provide Annex I Parties the possibility to effect transfers/acquisitions of emission reduction units (ERUs), or any part of an assigned amount, among themselves and subtract/add these to their assigned amount of greenhouse-gas emissions (GHG). Both mechanisms contain qualifications that such acquisitions shall be supplemental to domestic actions.
13. The CDM foresees that an Annex I Party investing in a sustainable development project in a non-Annex I Party may add resulting certified emission reductions (CERs) to its assigned amount. It may thus use them to contribute to compliance with part of its quantified emission limitation and reduction commitment under Article 3. As an additional function, the CDM will also assist particularly vulnerable developing country Parties in meeting the costs of adaptation to the adverse effects of climate change.
14. While recognizing the genesis and specific purpose of the CDM, it is useful to organize practical work on JI and the CDM in a manner which reflects that they are both project-based mechanisms with similarities related in particular to methodological issues (such as project baselines) as well as to institutional and capacity-building requirements. Concerning their starting dates, the specified character and type of project activities, certification procedures and their explicit linkage to funding adaptation measures there are, however, differences whose extent and implications may need to be determined.
15. IET is an inventory-related mechanism. Related methodological requirements are largely distinct from those of the other two mechanisms, being derived from those for the assessment of compliance by Annex I Parties with their commitments (accounting, monitoring and verification).
16. This Chapter addresses issues related to the design of each of the three new mechanisms under the Protocol and points at areas of relevance to more than one mechanism. Parties are invited to react to the issues presented. The mechanisms will be taken up in the sequence project based mechanisms (JI, CDM) and inventory-related mechanism (IET).

A. Project-based mechanisms (JI and CDM)

♦ General Issues

17. The secretariat's approach to the two project-based mechanisms is based on the following understandings, to which reactions are sought:
 - 1.1. Projects under JI and the CDM are subject to approval by each Party involved; in the case of the CDM, such approval would encompass that projects assist non-Annex I Parties in achieving sustainable development.
 - b. JI and the CDM are intended to be financed mainly by new private investment, attracted by the prospect of access to emission reductions "offshore" ('emission reduction units and 'certified

emission reductions', respectively) at lower cost than those available domestically. Public finance may also be engaged through these mechanisms, as appropriate.

(This presumes that domestic arrangements in Annex I Parties for meeting Article 3 commitments would provide incentives to firms, or sectors, to seek emission reductions at least cost. It also presumes that private as well as public entities would be authorized by Parties to participate in the mechanisms.)

- c. Public finance, including that of publicly-funded international and regional institutions, will be needed to facilitate the flow of private funds through the mechanisms; this role can be exercised in different forms and through diverse channels.

(Facilitating functions could include project development, financial mediation and risk management.)

- d. The credibility of the two mechanisms will depend on the quality and consistency of the measurement of emission reductions from projects.

(It is presumed that the Parties will wish to pay particular attention to the methodologies and arrangements for such measurement. It will be important to ensure the integrity of the monitoring/reporting/auditing functions by separating them from that of arranging or providing finance.)

18. As regards the work programme on JI and the CDM, the secretariat assumes that the Parties will see merit in integrating technical work on common methodological, procedural and institutional issues, as well as on capacity building. As indicated above, this work will draw upon the results of technical work under way in the pilot phase of AIJ as appropriate (see also Chapter V).

19. There are provisions in Article 6 as well as in Article 12 which can be found in one article, but not in the other. Parties may wish to express their views on these differences and their implications, so as to clarify their interpretation. Among these provisions are the following:

- a. **Starting dates:** JI does not contain a provision similar to the one under the CDM concerning the utilization during the first commitment period of CERs obtained from the year 2000 up to the beginning of the first commitment period.
- b. **Sequestration projects:** JI provisions refer explicitly to projects aimed at enhancing anthropogenic removals of GHG by sinks. This is not the case for the CDM. In considering this difference, special attention may be paid to the fact that the reduction of deforestation is a means of reducing emissions (on the issue of land use change and forestry please refer to FCCC/SBSTA/1998/INF.1).
- c. **Adaptation:** Article 12 provides for the CDM to channel some funding to assist with the costs of adapting to the adverse effects of climate change. No such provision occurs in Article 6 on JI. (The same issue may be raised in the context of international emissions trading.)

- d. On certification of emission reductions from projects: Article 12 explicitly provides for the certification of emission reductions from CDM projects. While Article 6 is silent on certification, Parties may wish to address relevant modalities for certifying emission reductions from JI projects (such as monitoring the adherence to guidelines on baselines)).

□ **Joint Implementation**

- 20. Article 6 and Article 3.10 and 3.11 set out the mechanism for which the short-term 'joint implementation' (JI) is suggested. Through this mechanism, projects which provide a reduction in emissions by sources, or an enhancement of removals by sinks, can be carried out among Annex I Parties and result in emission reduction units which can be used in meeting the commitments under Article 3 in a manner which is supplemental to domestic actions.
- 21. Decision 1/CP.3 calls for preparatory work on the elaboration of guidelines as provided for under Article 6 of the Protocol. Article 6 does indeed already spell out several provisions and contains the provision, in paragraph 2, that COP/MOP at its first session or as soon as practicable thereafter, may further elaborate guidelines, including for verification and reporting. The six elements in Article 6 guiding the design of the JI mechanism are as follows: (i) approval of project by Parties involved; (ii) additionality; (iii) compliance for acquiring Party with obligations under Articles 5 and 7 as a prerequisite for ERU acquisition; (iv) supplementarity of acquisition of ERUs to domestic actions; (v) participation of legal entities in generation, transfer and acquisition of ERUs subject to authorization by responsible Annex I Party; and, (vi) crediting limitation during resolution of Article 8 issues.

- **A Clean Development Mechanism**

- 22. A CDM has been defined in Article 12 of the Protocol and referred to in Article 3.12. It provides for an Annex I Party investing in a sustainable development project in a non-Annex I country to add CERs to its assigned amount of GHG emissions.
- 23. Whereas paragraphs 1-9 of Article 12 contain provisions to be further determined by COP/MOP (at its first session or unspecified), Article 12.10 is referred to in paragraph 5(e) of decision 1/CP.3. It calls for preparatory work by the secretariat so that COP 4 can consider the analysis of the implications of Article 12, paragraph 10, of the Protocol whereby CERs obtained during the period from 2000-2007 can be used to achieve compliance in the first commitment period. As the request does not delineate the extent of work required for the analysis of the implications of paragraph 10, it is prudent to consider design options for the CDM in a comprehensive manner at an early stage.
- 24. Design objectives: Principal functions which need to be accommodated in designing the CDM include its governance, operational functions/certification processes, potential marketing of CERs, arranging for funding of mitigation projects and providing finance for adaptation projects.

Differentiations need to be borne in mind in addressing the CDM's function of facilitating mitigation projects from its function to assist in funding adaptation as specified in paragraph 8.

25. Governance: The organs which are to fulfill the governance functions of the CDM and which are named in the Protocol are, in hierarchical order, the COP/MOP, the Executive Board (EB), and the operational entities. Actors in the CDM process can be host and investor governments (which have to approve projects in which they are involved) as well as private and/or public entities whose involvement is subject to guidance by the EB as stated in para.9.

26. The following functions to be fulfilled by COP/MOP, the supreme organ governing the CDM, are spelled out in Article 12:

- a. exercising overall authority and provides overall guidance to the CDM;
- b. playing a role in setting the scope of CDM activities through the provision that Annex I Parties may use the CERs accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by COP/MOP;
- c. designating the operational entities that certify emission reductions;
- d. ensuring that a share of the proceeds from certified project activities is used
 - 1.1.1. to cover administrative expenses, as well as
 - 1.1.2. to assist particularly vulnerable countries in meeting costs of adaptation; and,
- e. laborating - at its first session (COP/MOP 1) - modalities and procedures to ensure transparency, efficiency and accountability through independent auditing and verification of project activities

27. In particular the latter function which is specifically assigned to COP/MOP 1, i.e. the elaboration of modalities and procedures, will inform the design process through the criteria and objectives stated therein.

- a. The CDM is supervised by the Executive Board (EB). It provides guidance on the involvement of private and/or public entities. Design aspects to be considered are: Which is the relationship between COP/MOP and the EB and the character of the EB (should it be a subsidiary body possibly of limited size, linked to another existing body, or be in the form of a Board of Directors ?)? Linked to this are the options for its institutional locus which also has implications for its terms of reference. Which authority decides on the establishment, terms of reference, composition, size and tenure/rotation as well as on reporting requirements of the EB? What is the extent of involvement of COP/MOP and of delegation of

authority, respectively? Would the EB advise the COP/MOP on the functions of the operational entities? Will the EB make proposals to the COP/MOP concerning the designation of operational entities?

b. Which rules of procedure, other modalities of self-governance and methods of work need to be drawn up by the EB ('subsidiary bodies', review committees, working groups or advisory panels for handling technical/operational functions)? Which administrative support is required for the EB (in light of extent of authority, operational functions and arrangements on finance, such as handling share of proceeds) ?

29. Operational functions/certification: The operational functions and those related to certification span over the entire project cycle of mitigation projects under the CDM. The respective functions for the organs and actors of the CDM - the EB, operational entities and private and/or public entities - need to be determined and modalities/options spelled out. In doing so, it is important to clearly distinguish and separate finance and auditing functions.

30. Functions to be fulfilled by the EB in this context require further definition, in particular in response to the following questions:

- To what extent is the EB involved in the project cycle? How would priority areas be identified (e.g. in an attempt to address CDM criteria such as sustainability and additionality in an operationally feasible manner)? What are the implications of para 6 which mentions 'certified project activities' (who certifies?), i.e. how active will be the role of the EB in project identification (who identifies through which means, such as a project 'bazaar' on a Web site?), in the determination of project eligibility and, finally, a priori project certification?
- What is the process/what are the criteria (rules) for identifying and monitoring operational entities - to be designated by the COP/MOP - which are to certify emission reductions from each project (in light of 'modalities and procedures' established by COP/MOP1)?
- Would the EB fulfill the role of an auditor vis-a-vis the operational entities or would another body be charged with this function (ensuring adherence to 'modalities and procedures')?
- What is the role of the EB in the process of certification of projects (such as 'stamping'/ issuing of final certificate)?
- What are the elements of the 'guidance on the involvement of private and/or public entities' (link to operational functions)?

31. Issues to be addressed concerning operational entities include the extent and procedures of their certifying operations and, importantly, the provisions built into the system for assuring the adherence to standards. This leads to questions such as:

- a. In light of the rules established, what are the prerequisites to be met on the part of operational entities to qualify (application, nomination, reporting procedures)?
- b. What are the routines of certification (link to para.7 of Article 12)?
- c. Which are the self-control and external control, liability mechanisms of operational entities?
- d. What is the appeal process (on the part of the Parties involved in the project/ on the part of the EB as representative of the Parties)?
- e. How will fees for certification be set (costs determined)?

32. In defining the role of private and/or public entities (host and investor Party(ies)), the following issues need to be addressed:

- What are the procedural and functional requirements for the entities to participate in project activities resulting in certified emission reductions and acquisition of such reductions?
- b. How is ownership - public or private - of CERs defined? Could host countries or their legal entities be owners and for which purpose?
- c. What is the relationship between private entities and the State in the host country of the project and in the investor country (impact on pursuit of policies and programmes in light of national priorities; accountability)?
- d. How does the duration of projects and/or their life cycle relate to CERs (annual issuing/certification)?
- e. How will the risk from non-performing projects be taken into account?
- f. What kind of capacity-building is required regarding these entities on the part of hosts and investors (development of a guide to successful CDM projects, code-of conduct provisions)?
- f. Which institutions are most suitable for carrying out activities facilitating capacity-building?

33. If the CDM is to have a function in the potential marketing of CERs which non-Annex I Parties may hold, several issues need to be addressed which concern the investor and the host country of a project:

- 1.1. What would be modalities for a host country of a CDM project to have CERs and what options are there for their use?
- b. Which are possible arrangements between investor and host countries for sharing the CERs (model agreements)?
- c. Will there be monetarization of the CERs and how will it be effected?

d. How could host/investor countries reduce risks associated with a potential oversupply of/lack of demand for CERs during the first commitment period (e.g. servicing of debts incurred)?

34. According to paragraph 6, the CDM is to assist in arranging funding for mitigation projects. In the design of the finance structures of the CDM, the following questions need to be addressed:

- 1.1. What is meant by para.6, which provides that the CDM ‘shall assist in arranging funding of certified project activities as necessary’ (e.g. importance of institutional separation of certification and arranging of funding)?
- b. How is such assistance for mitigation projects to be effected?
- c. Who would carry out this function?
- d. What are the respective roles of private and public finance?

35. Another aspect concerns the shares of proceeds from certified project activities which are to be used for covering administrative costs and for funding adaptation measures (paragraph 8). Questions in this context include:

- 1.1. What are ‘proceeds from certified project activities’?
- b. What are the implications of the provisions in para.8 related to ‘meet the costs of adaptation’ (relationship between Art. 4.4. of the Convention and para.8; definition of particular vulnerability ‘to the adverse effects of climate change’ and determination of eligibility for funding (role of IPCC); nature of support (grants, technical assistance), institutional arrangements (from pre-feasibility to final evaluation))?
- c. What is the scope of administrative expenses in light of the functions to be fulfilled (including start-up costs)? Whose administrative expenses are to be covered?

□ **The AIJ pilot phase**

36. COP 1 had established AIJ under the pilot phase through decision 5/CP.1. Since its inception in 1995, this has given rise to 75 projects in 17 host and by 5 investor countries (as of March 1998). While the pilot phase has allowed for valuable experience to be built up in host and investor countries alike - ranging from the approval process (ensuring that national development and environment priorities are met), methodological questions such as the determination of baselines to capacity-building and related research activities - the core issue of crediting was, however, absent. The range of features which are common to AIJ, JI and CDM and experiences from the AIJ under the pilot phase could be usefully employed in the design process of the project-based activities for which credits can be obtained.

B. Inventory-related mechanism: International emissions trading (IET)

37. A framework for IET among Annex I Parties is contained in Articles 17, 3.10 and 3.11. Article 17 further calls on the COP to define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability. Decision 1/CP.3, paragraph 5, assigns this task to COP4 for consideration.

38. In its most basic form, IET could consist of the exchange of parts of assigned amounts between eligible Parties, through a simple system of "double-entry book-keeping" as envisaged in Article 3.10 and 3.11. This could be supplemented by purely domestic emissions trading (DET) schemes where the Party devolves part of its assigned amount to sub-national entities, for example to industrial sectors or directly to private companies. An adequate national monitoring and reporting system would need to ensure that the international reporting obligations of a Party can be fully met.

39. More sophisticated, market-based, trading arrangements would be required if Parties wish to explore arrangements whereby private entities would be able to engage in cross-border IET. Also, if IET is to be possible at an early date and under uncertainty concerning eventual compliance on the part of the transferring Party (seller), a trading scheme may need to be backed through insurance provisions to be defined.

40. In the period towards and during the first commitment period, knowledge will emerge on several issues which may have a bearing on the scope and credibility of the IET mechanism. On the one hand, the impact of policies and measures of Annex I Parties on their GHG emissions will become increasingly apparent, and, by the year 2005, demonstrable progress will be assessed. On the other hand, provisions may be devised which affect the costs of non-compliance - and thus of measures to achieve compliance, such as IET - to these Parties.

41. Participation (eligible participants): Article 17, referring to Article 3, defines participation in ET as including Annex I Parties which have agreed to limit their GHG emissions to the assigned amount as specified in Annex B for the purposes of fulfilling their commitment under Article 3. The participation of

actors other than Parties, such as private companies and legal entities, has not been mentioned in Articles 17 and 3.10 and 3.11. While domestic emissions trading rules could be set by sovereign States, it will need to be determined whether and to which extent there should be a certain compatibility of rules between the domestic and international trading systems. Also, no Parties other than Annex I Parties are included. Questions in this context are:

- 1.1. Which provisions are needed related to the participation of private or public legal entities in IET?
- 1.1. If compatibility of national and international rules is pursued, which modalities and possibly schedules for its achievement would be needed (e.g. concerning the ‘passing down’ of obligations from Parties to the legal entities for which they are responsible)?
- 1.1. What might be the consequences of non-Annex I Parties introducing shares of CERs which they may possess as a result of successful CDM projects?

42. Volume: The provisions in Article 3.10 and 3.11 specify that any ERUs, or any part of an assigned amount, which a Party acquires/transfers shall be added to/subtracted from the assigned amount for the acquiring/transferring Party. Transferable amounts (TA) are limited to a certain portion (supplementarity) of assigned amounts (possibly adjusted through ERUs and CERs) minus actual emissions, provided that this difference is positive. Questions arising in this context are as follows:

- 1.1. How is the volume of transfer/acquisition of parts of assigned amount affected by the acquisition and transfer of ERUs (as defined by Article 6) and the acquisition of CERs (as defined by Article 12)?
- b. How will this influence market parameters?
- c. While Article 17 qualifies that ‘any such trading system shall be supplemental to domestic actions’, a quantitative definition would require a specification on which basis supplementarity should be calculated.

43. Variations in TAs may be influenced through the attractiveness/credibility of the product on the IET market and/or through rules. Two angles, which are complementary and could be mutually reinforcing, are prominent in the discussion. One is focussing on the need to resolve methodological aspects, while the second one addresses issues related to trading prior to the date when compliance is ascertained. In the latter context, questions concerning seller and/or buyer liability will need to be considered. Related questions are as follows:

- 1.1. *Methodological angle:* How can uncertainty concerning compliance by a Party be assessed? At which point in time could credible forecasting be undertaken? This angle establishes close links between work on the IET system and on the establishment of

credible national systems for compliance monitoring (including the resolution of methodological issues such as those related to sinks and the six gases), the assessment of compliance and the determination of consequences of non-compliance. Paragraph 2 of Article 3 which calls for each Annex I Party to show, by 2005, 'demonstrable progress' in achieving its commitments could in this context be seen as providing an indicator in a process of lessening uncertainty.

- b. *Economic/market angle related to ex ante trading:* How can a market be established which strikes a balance between the uncertainties of compliance and the interest to achieve emission reductions at lowest cost. Which risk mitigation strategies can be employed which are compatible with the principles established for IET? How can uncertainties concerning a selling Party's compliance be compensated for? This angle emphasizes, on the one hand, the potential corrections brought about by a functioning, transparent market (with appropriate discounting depending on probability of compliance or differentiating by seller and/or sector) and, on the other hand, measures which can be introduced to compensate for market imperfections and to enable trading in spite of risks. The issue of insurance against the risks of non-validity of acquisitions, in case of non-compliance of the seller, is one option for consideration. This could be related to a scheme of buyer liability (see also liability below). Further options include the definition of caps within caps, trading within safe margins, i.e. limitations of the market size/scope/ traders.
- c. *Liability options:* The determination of whether liability in the case of non-compliance is with the seller or the buyer may shape the character of the IET system. The options can be seen along a continuum which progresses from a high-certainty to a low-certainty scenario regarding compliance or compliance expectations. A high-certainty scenario would mean that maximum assurance exists once the compliance of an Annex I Party with its commitments has been ascertained. Over-compliance may then result in banking or trading (e.g through a clearing-house) if buyers are available. In this case, seller's liability would be the implied option as the validity of the product has been established prior to trading (liability is quasi obsolete). Low-certainty scenario: least assurance of the validity of acquisitions is available as a result of various factors (or combinations thereof). An important one is the possible lapse of time between the trade and the assessment of compliance. It is essentially linked to the margins of error in systems of accounting, of projections of GHG emissions of Parties as well as uncertainties as to the impact of policies and measures. In this case, the type of liability requires careful attention. The questions arising are:

- Will there be seller's or buyer's liability, or could there be shared liability?
- Which will be the associated risk mitigation modalities in each case?
- Which schemes for insuring against risks may be envisaged?

44. Parties may wish to pronounce themselves on the linkages in work schedules between the design process of IET and methodological work aimed at improving accounting and national systems as well as work on compliance. Parties may further wish to indicate how the balance between allowing for a flexible market mechanism and the need for rules and regulations is to be struck in the design of a credible IET. In this context, the issue of transaction costs could be addressed. If an IET market is to function with as much information, transparency and a calculable risk concerning compliance as possible, confidence in accounting systems will be essential. The desired sophistication of such systems may imply additional direct and indirect transaction costs.

45. Concerning linkages to other mechanisms, Parties may wish to clarify whether there is a need for a separate role in IET for accommodating project-based emissions reductions (JI and CDM), such as intermediate stages/transfers, or whether reductions thus obtained are simply 'merged' into the accounting system through which Parties monitor performance and compliance with assigned amounts.

IV. CROSS-CUTTING ISSUES

46. Ultimately, the three new cooperative implementation mechanisms provide for transactions in units of GHG. On the assumption that these transactions will be market-based, there will be tendency for the unit value of reductions to be equalized under the three schemes. It is envisaged that the Parties may wish to anticipate such trends in their design of the three mechanisms.

47. Guidance is particularly required where provisions may or may not apply to more than one mechanism and an indication should be given whether differentiation should be maintained or an effort be made at harmonization. Certain specific assumptions and questions to be addressed are as follows:

- 1.1. **Principles:** Since the Protocol is guided by the principles set out in Article 3 of the Convention, it is assumed that any discussion of principles for one or more cooperative mechanisms will be grounded in that Article. Article 3 of the Convention covers the issues of equity, environmental efficiency and economic efficacy, and provides that *efforts to address climate change may be carried out cooperatively by interested Parties*. Paragraph 5 of Article 3 of the Convention also contains principles which could inform modalities and rules relating to the three mechanisms, in particular

concerning international emissions trading (Article 17 explicitly calling for the definition of 'principles' for IET)

- b. **Supplementarity:** Transactions under each of the three mechanisms are to supplement domestic actions by Annex I Parties to meet their commitments under Article 3 of the Protocol ('contribute to compliance with part of their quantified emission limitation and reduction commitments' under the CDM). Will there be a determination of the overall extent of supplementarity? What should be the basis of calculation (1990 levels, targets as contained in Annex B)? Will shares be attributed to the various mechanisms? Will there be a differentiation by mechanisms?
- c. **Participation of private entities:** What arrangements will be needed to ensure the accountability of individual Parties for transactions undertaken by private entities, including transnational corporations, under their authority?

V. PROPOSED WORK PROGRAMME

48. Parties may wish to review the proposed work to be undertaken by the secretariat before COP4. Elements of work on each mechanism are outlined below. In each case, the subsidiary bodies are invited to indicate the timing and sequencing of work, the priorities to be addressed in preparation for COP4 and what work may need to continue beyond that. They are also invited to determine which elements of work they will undertake themselves, in formal sessions or informal frameworks, and on which they seek inputs and/or support activities from the secretariat or from other organizations. In the latter case, they may also indicate whether, in certain instances, information and proposals should be submitted directly or compiled and synthesised.

The Chairmen of the two Subsidiary Bodies, and representatives of Parties consulted by them, have expressed interest in receiving information on activities and plans of inter-governmental and non-governmental organizations with particular expertise and/or interest in relation to the three mechanism. The secretariat will consult with such institutions and provide the Parties with a document synthesizing the results of such consultations and provide an oral report at the June session. Collaboration and exchange of experiences will be further strengthened with relevant UN bodies, inter-governmental and non-governmental organizations through participation in workshops, the organization of forums on cooperative implementation mechanisms, and the ongoing improvement of the Web site.

Much of this work may be undertaken within the existing resources of the secretariat and other organizations. The secretariat has given priority to this area of work in its proposal for deploying "post-Kyoto" resources. FCCC/SBI/1998/3 However, given the scale of the work and the need to undertake it expeditiously, supplementary funding needs are likely to arise, for the secretariat and for other organizations.

49. **Work related to joint implementation:**

- Implications of decision 1/CP.3, para. 5(c) need to be determined and the scope of work on further guidelines, including a time-table reflecting options for the implementation of Article 6 provisions, should be delineated. Linkages with work schedules on Articles 5, 7 and 8 need to be borne in mind.
- Methodological issues: In the design of guidelines, practical options on several issues need to be developed. The following is proposed:
 - i. concerning the determining of baselines (such as the development of a list of feasible technologies, e.g. in a regional context) and on topics such as monitoring and reporting, work undertaken during the AIJ pilot phase could be drawn upon and suitably expanded;
 - ii. Concerning issues related to the certification/crediting of ERUs obtained through JI projects, this new area of work needs to be developed and experience gained in collaboration with other institutions which are anticipating to undertake efforts; and,
 - iii. work on sinks (Article 3.3) and on Articles 5, 7 and 8 needs to be reflected upon as it evolves.
 - c. Institutional and related issues: Capacity-building experiences gained during the ongoing AIJ pilot phase need to be further monitored and evaluated. This could provide a basis for designing relevant provisions in the guidelines on JI. Additional work is needed to identify new and expanded institutional, technical, legal and human resource requirements arising from monitoring, verification and the certification process. Parallels to similar work carried out in the context of the CDM may be explored. Activities which are useful in this context include the exchange of experiences and national/regional specificities through workshops which elaborate on practical options (leading to the identification of 'best practices') which are found to be most suitable to the needs of both host and investor countries. Of particular interest are the definition of and guidelines for the operation of legal entities.

50. Work related to the clean development mechanism:

- 1.1. Implications of decision 1/CP.3, para. 5(e) need to be determined and the scope of work on the CDM, including a time-table reflecting options for its implementation by the year 2000, should be delineated.
- b. Methodological issues: In the design of the CDM, practical options on several issues need to be developed. The following is proposed:

- i. concerning the determining of baselines (such as the development of a list of feasible technologies, e.g. in a regional context) - in particular in regard of the sustainable development provision - and on topics such as monitoring and reporting, work undertaken during the AIJ pilot phase could be drawn upon and suitably expanded;
- ii. concerning issues related to certification/crediting of CERs obtained through CDM projects, approaches need to be developed and experience gained in collaboration with other institutions which are anticipating to undertake related efforts;
- c. Institutional and related issues: Modalities for capacity-building for successfully carrying out CDM projects need to be worked out (also the linkages to conceptual work under AIJ and JI), bearing in mind the experiences gathered through the AIJ pilot phase. In addition, new needs as they emerge from intensified monitoring, reporting and verification as well as from the various certification requirements would need to be reflected in a capacity-building strategy related to CDM. The respective list of issues and questions in Chapter III.A would guide the detailed work.

51. Work related to the AIJ pilot phase:

- 1.1. Continuation of work begun under AIJ pilot phase, such as the monitoring of projects, the provision of a document to the eighth and ninth sessions of the subsidiary bodies with updates on activities by Parties;
- b. Preparation of the second Synthesis Report on the AIJ Pilot Phase (in accordance with decision 5/CP.1); given the larger number of projects now reported upon in accordance with the Uniform Reporting Format (URF) and the longer duration of projects, the second Synthesis Report is likely to generate a significant body of knowledge and experience with AIJ. Based on more empirical data and improved reporting by Parties, valuable information can be derived, for example on the refinement of descriptors, and other URF elements;
- c. Work on at least four substantive areas which commenced during the pilot phase but which will remain of continued relevance for JI and CDM under the Protocol will be advanced before COP4 (through technical papers and workshops):
 - i. capacity-building for cooperative implementation,
 - ii. definition of terminology (such as verification, reporting etc),
 - iii. determination of GHG reductions attributable to a project, and
 - iv. monitoring and verification of projects.

52. Work related to international emissions trading:

- Determining the implications of decision 1/CP.3, para.5(b) and identifying related work;
- Methodological issues:
 - i. Application of *principles* of Article 3 of the Convention in the context of IET; identification of additional principles if so required;
 - ii. Linked to the *modality* of ET contained in Article 3.10 and 3.11, there are several issues which require consideration, such as the timing of trade and liability as highlighted above.
 - iii. Concerning *rules*: Article 17 calls for verification, reporting and accountability provisions to be elaborated. In light of the modalities established in Article 3.10 and 3.11, rules concerning the validity of acquisitions (both in terms of quantity and quality) will need to be addressed in the context of determining the process leading to assessing compliance.
 - iv. Concerning *guidelines* for verification and accounting, links to work by the secretariat on monitoring and assessing of compliance, and on the provisions established in Articles 5, 7 and 8 as well as in Article 18 need to be borne in mind and elaborated upon.

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CLIMATE CHANGE MITIGATION IN ASIA
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GOA, India, 4 to 6 May 1998

PRESENTATION

THE UNFCCC SECRETARIAT

**THE KYOTO PROTOCOL TO THE UNITED
NATIONS FRAMEWORK CONVENTION ON
CLIMATE CHANGE (UNFCCC):**

**THE CLEAN DEVELOPMENT MECHANISM IN THE
CONTEXT OF COOPERATIVE IMPLEMENTATION**

**PRESENTATION BY THE UNFCCC SECRETARIAT
April 1998**

INTRODUCTION

Mandates

☞ The **Kyoto Protocol** adopted on 11 December 1997

☞ three mechanisms of **cooperative implementation**

Annex I Parties can supplement domestic actions to fulfil their emission limitation and reduction commitments under Article 3 through

☞ **Article 6 on joint implementation (JI)** and

☞ **Article 17 on international emissions trading (IET)** which provide for cooperative transactions among those Parties, whose quantitative commitments are inscribed in Annex B to the Protocol

☞ **Article 12 on a clean development mechanism (CDM)** which extends the scope of cooperation to non-Annex I Parties

☞ Conference of the Parties to the Convention serving as the meeting of the Parties to the Protocol (COP/MOP) at its first session (**COP/MOP 1**) **or later is to decide on modalities**

☞ Article 17 is a general enabling clause that provides for the Conference of the Parties *to the Convention (COP) to define the arrangements for IET*

☞ **“prompt start” provision** to the work of COP/MOP 1 (decision 1/CP.3)

Work in progress

- ☞ **Key issues for discussion** are
 - ☞ issues concerning mandates
 - ☞ cross-cutting issues among mechanisms
 - ☞ issues related to individual mechanisms

- ☞ **Proposals on work** reflect
 - ☞ views submitted by Parties
 - ☞ reflections by the secretariat
 - ☞ consultations with organizations

- ☞ **Further guidance required** on
 - ☞ What should the Parties do when? How would Parties like to organize the work (informal consultations, workshops)?
 - ☞ What inputs do they need from the Convention secretariat and when should these be available? What support activities should the secretariat organize (information dissemination, e.g. through a web site? forums/workshops)?
 - ☞ What inputs do they need from other organizations and when should these be available?
 - ☞ General issues.

ISSUES CONCERNING MANDATES

Assumptions to be considered

- ↳ **comprehensive design exercise** for the CDM - conclusion by COP 5 in 1999?
- ↳ **link to technical work under AIJ** desirable - such as on baselines, methodology and reporting and capacity-building?
- ↳ **consensus** to be achieved before the entry into force of the Kyoto Protocol - to be confirmed by the Parties to the Protocol at COP/MOP 1?
- ↳ **link to work on other Articles**, such as Article 18 (non-compliance), Article 4 ('bubble'), and Articles 5, 7 and 8 (in the context of JI as defined in Article 6) as well as Articles 21, 24 and 25 (on entry into force of the Protocol) and on sinks (Art.3.3): requirements for sequencing of work and synchronization?

CI MECHANISMS

✍ **JI and IET**

- ✍ provide Annex I Parties the possibility to effect transfers/acquisitions of emission reduction units (ERUs), or any part of an assigned amount, among themselves and subtract/add these to their assigned amount of GHG
- ✍ are to be supplemental to domestic actions

CDM

- foresees that an Annex I Party investing in a sustainable development project in a non-Annex I Party may add resulting certified emission reductions (CERs) to its assigned amount. It may thus use them to contribute to compliance with part of its quantified emission limitation and reduction commitment under Article 3. As an additional function, the CDM will also assist particularly vulnerable developing country Parties in meeting the costs of adaptation to the adverse effects of climate change

JI and the CDM

-  both project-based mechanisms
-  similarities: related in particular to methodological issues (such as project baselines) as well as to institutional and capacity-building requirements
-  differences: starting dates, the specified character and type of project activities, certification procedures and their explicit linkage to funding adaptation measures

IET

- inventory-based mechanism.
-  methodological requirements largely distinct from those of the other two mechanisms
-  strong link to assessment of compliance by Annex I Parties with their commitments (accounting, monitoring and verification).

Project-based mechanisms (JI and CDM)

Similarities

- both are subject to **approval by each Party** involved; with CDM approval encompassing that projects assist non-Annex I Parties in achieving **sustainable development**.
- financed mainly by **new private investment**, attracted by the prospect of access to emission reductions “offshore” at lower cost than those available domestically; not precluding public sector engagement
- essential **role of public finance**, including that of publicly-funded international and regional institutions, for facilitating the flow of private as well as public funds.
- credibility** - to be ensured through quality and consistency of the measurement of emission reductions
- link to **AIJ** work

Differences

- Starting dates**
- Sequestration projects**
- Adaptation**
- Certification**
- A Clean Development Mechanism**

- CDM has been **defined** in Article 12 of the Protocol and referred to in Article 3.12.
- ✎ provides for an Annex I Party investing in a sustainable development project in a non-Annex I country to add CERs to its assigned amount of GHG emissions.

✎ **featuring:**

- ✎ contribution to sustainable development
- ✎ potential for technology transfer
- ✎ assisting in achieving ultimate objective of the Convention
- ✎ share of proceeds is to assist in meeting the costs of adaptation

✎ **prudent to consider design** options for the CDM in a comprehensive manner at an early stage if early start is to materialize

✎ **Design objectives**

- ↳ Principal functions
- ↳ governance
- ↳ operational functions/certification processes
- ↳ potential marketing of CERs
- ↳ arranging for funding of mitigation projects
- ↳ providing finance for adaptation projects.

✎ **Governance:**

- ↳ COP/MOP
- ↳ Executive Board (EB)
- ↳ operational entities
- ↳ Actors: hosts investors
- ↳ private and/or public entities whose involvement is subject to guidance by the EB

Functions of COP/MOP

- exercising overall authority and provides overall guidance to the CDM;
- playing a role in setting the scope of CDM activities through the provision that Annex I Parties may use the CERs accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by COP/MOP;
- designating the operational entities that certify emission reductions;
- ensuring that a share of the proceeds from certified project activities is used
 - 1.1.1.to cover administrative expenses, as well as
 - 1.1.2.to assist particularly vulnerable countries in meeting costs of adaptation; and,

(e) elaborating - at its first session (COP/MOP 1) - modalities and procedures to ensure transparency, efficiency and accountability through independent auditing and verification of project activities.

- ☞ **CDM is supervised by the Executive Board (EB).**
- ☞ provides guidance on the involvement of private and/or public entities
- ☞ **Clusters of questions:**
 - ☞ Which is the relationship between COP/MOP and the EB and the character of the EB (should it be a subsidiary body possibly of limited size, linked to another existing body, or be in the form of a Board of Directors ?)? Linked to this are the options for its institutional locus which also has implications for its terms of reference. Which authority decides on the establishment, terms of reference, composition, size and tenure/rotation as well as on reporting requirements of the EB? What is the extent of involvement of COP/MOP and of delegation of authority, respectively? Would the EB advise the COP/MOP on the functions of the operational entities? Will the EB make proposals to the COP/MOP concerning the designation of operational entities?
 - ☞ Which rules of procedure, other modalities of self-governance and methods of work need to be drawn up by the EB ('subsidiary bodies', review committees, working groups or advisory panels for handling technical/operational functions)? Which administrative support is required for the EB (in light of extent of authority, operational functions and arrangements on finance, such as handling share of proceeds) ?



Operational functions/certification

- ✍ Clear distinction and separation of finance and auditing functions.
- ✍ **Role** of EB: clusters of questions:
 - ✍ To what extent is the EB involved in the project cycle? How would priority areas be identified (e.g. in an attempt to address CDM criteria such as sustainability and additionality in an operationally feasible manner)? What are the implications of para 6 which mentions 'certified project activities' (who certifies?), i.e. how active will be the role of the EB in project identification (who identifies through which means, such as a project 'bazaar' on a Web site?), in the determination of project eligibility and, finally, a priori project certification?
 - ✍ What is the process/what are the criteria (rules) for identifying and monitoring operational entities - to be designated by the COP/MOP - which are to certify ERs from each project (in light of 'modalities and procedures' established by COP/MOP1)?
 - ✍ Would the EB fulfill the role of an auditor vis-a-vis the operational entities or would another body be charged with this function (ensuring adherence to 'modalities and procedures')?
 - ✍ What is the role of the EB in the process of certification of projects (such as 'stamping'/ issuing of final certificate)?

- ✍ What are the elements of the ‘guidance on the involvement of private and/or public entities’ (link to operational functions)?

✍ **Operational entities**

- ✍ extent and procedures of their certifying operations

- ✍ provisions built into the system for assuring the adherence to standards

- ✍ Cluster of questions:

- ✍ In light of the rules established, what are the prerequisites to be met on the part of operational entities to qualify?

- ✍ What are the routines of certification?

- ✍ Which are the self-control and external control, liability mechanisms of operational entities?

- ✍ What is the appeal process?

- ✍ How will fees for certification be set?



Private and/or public entities (host and investor Party(ies))

- What are the procedural and functional requirements for the entities to participate in project activities resulting in certified emission reductions and acquisition of such reductions?
- How is ownership - public or private - of CERs defined? Could host countries or their legal entities be owners and for which purpose?
- What is the relationship between private entities and the State in the host country of the project and in the investor country?
- How does the duration of projects and/or their life cycle relate to CERs?
- How will the risk from non-performing projects be taken into account?
- What kind of capacity-building is required regarding these entities on the part of hosts and investors?
- Which institutions are most suitable for carrying out activities facilitating capacity-building?



Potential marketing of CERs which non-Annex I Parties may hold

- ☞ What would be modalities for a host country of a CDM project to have CERs and what options are there for their use?
- ☞ Which are possible arrangements between investor and host countries for sharing the CERs (model agreements)?
- ☞ Will there be monetarization of the CERs and how will it be effected?
- ☞ How could host/investor countries reduce risks associated with a potential oversupply of/lack of demand for CERs during the first commitment period (e.g. servicing of debts incurred)?



CDM is to assist in arranging funding for mitigation projects

- ☞ What is meant by para.6, which provides that the CDM ‘shall assist in arranging funding of certified project activities as necessary’?
- ☞ How is such assistance for mitigation projects to be effected?
- ☞ Who would carry out this function?
- ☞ What are the respective roles of private and public finance?

✎ **Shares of proceeds from certified project activities**

- ✎ which are to be used for covering administrative costs and
- ✎ for funding adaptation measures
- ✎ What are 'proceeds from certified project activities'?
- ✎ What are the implications of the provisions in para.8 related to 'meet the costs of adaptation'?
- ✎ What is the scope of administrative expenses in light of the functions to be fulfilled? Whose administrative expenses are to be covered?

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PAPER

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THE INDIRECT COSTS AND BENEFITS OF GREENHOUSE GAS MITIGATION.

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1. INTRODUCTION

There has been a considerable amount of work on the appraisal of different projects and programmes that reduce greenhouse gases (GHGs) (Haines and Rose, 1996; IPCC, 1996). The focus of these studies has been on the proper methodologies for the estimation of the costs of GHG limitation, and on the correct methods for measuring the amount of GHGs reduced. Clearly, these are some of the central issues that need to be addressed in arriving at a policy for GHG mitigation; ideally one would choose those actions that reduce GHGs at least cost, and a measure of that is the cost per ton of carbon (or carbon equivalent) eliminated.

Although the cost (correctly measured) is one key component of the decision on which policies to select, it is not the only consideration. Other factors will enter the decision, such as the impacts of the policies on different social groups in society, particularly the vulnerable groups, the benefits of the GHG limitation in other spheres, such as reduced air pollution, and the impacts of the policies on broader concerns such as sustainability. In developing countries these other factors are even more important than they are in the industrialised countries. GHG limitation does not have as high a priority relative to other goals, such as poverty alleviation, reductions in employment, etc. as it does in the wealthier countries. Indeed, one can argue that the major focus of policy will be development, poverty alleviation etc. and that GHG limitation will be an *addendum* to a programme designed to meet those needs. Taking account of the GHG component may change the detailed design of a policy or programme, rather than being the main issue that determines the policy¹⁰.

This paper summarises the results of a larger project, the purpose of which was to evaluate GHG limitation issues in a broader context (Markandya, 1997). These include the impacts of projects on vulnerable groups, the impacts on the environment more generally and the impacts on sustainability in a wider sense. It also offers some advice on how a decision-making framework can bring together these different dimensions.

2. A FRAMEWORK FOR ALL IMPACTS OF GHG LIMITATION PROJECTS

¹⁰ The World Bank recognises this different focus in many developing countries and has prepared guidelines for the valuation of GHG 'overlays' to projects in the energy and forestry sector (World Bank, 1997). Although useful in terms of putting GHG projects in a wider context, it does not address the kind of broader social and environmental issues that arise in such projects. It is these that are central to this paper.

GHG limitation projects can relate to many sectors of the economy and can have a wide range of effects. In Table 1 a qualitative indication is given of the main impacts that need to be looked at for typical projects in the areas of: energy, forestry, agriculture, land use etc. Discussed below¹¹ are some of the reasons for the judgements made in Table 1.

2.1 Energy

2.2.1 Fossil Fuels

There are many projects that deal with measures to reduce emissions from fossil fuel use through increased efficiency (e.g. repowering of electric generating units), or through fuel switching (e.g. conversion from coal to gas), etc. The employment effects of such projects are not likely to be large in general, although there could be major impacts if a country followed a policy of switching from domestic coal to gas, for example. Likewise, the income distribution and poverty impacts of fossil fuel efficiency/switching policies will not be significant, in most cases. The associated environmental benefits will, however, be important as there will be implied changes in emissions of SO_x, particulates and other pollutants. These can be quantified. Adjustments to financial costs will be required when prices of capital goods are out of line with the true economic costs of these goods, and when fossil fuel inputs carry significant taxes and subsidies. Macroeconomic impacts of fuel switching will arise when there are trade effects from the switching policy, or when the substitute fuels are more expensive for industry and households than the original fuels. Finally, the sustainability concerns relate to how long the new fuel regime can last and whether adequate substitutes can be developed in the time period before it becomes too costly to use an alternative fossil fuel (or more generally how the costs of the substitutes will evolve over time).

2.2.2 Renewable Energy

There is a wide range of renewable energy projects that can be introduced to limit GHG emissions. The options of biomass, solar, wind, hydro and nuclear as a substitute for fossil fuels will result in reduced GHG emissions. In developing countries, increased efficiency in the use of fuel wood, the development of biogas and other rural energy sources could result in reduced GHG emissions. In this case the employment impacts are potentially important and should be analysed, as should the impacts on the poor and the vulnerable income groups. There will be associated environmental benefits in the form of reduced polluting emissions as well as reduced damage to the natural environment (if biogas replaces open access fuel wood collection, for example).

With renewable energy in developing countries the financial costs will diverge significantly from the economic costs. For example, the provision of regular energy supplies to rural consumers will reduce the time spent collecting fuel wood. This time

¹¹ This discussion is only intended to point to the directions where impacts are likely to be important. A more full discussion of the effects and their measurement is given in Sections 3-7.

has a value, although there is no direct financial flow associated with it. Hence, it should be valued and included in the analysis as a benefit or reduction in cost.

Macroeconomic impacts from renewable energy programmes are likely to be small. Sustainability issues, on the other hand, will be important in that the move from the existing use of energy to a more sustainable renewable source will entail a benefit in terms of sustainability. These effects also need to be accounted for.

2.2.3 Energy Conservation

Energy conservation programmes are envisaged here as end-use energy efficiency programmes, such as better insulation, better heating and refrigeration and lighting equipment that allows for more efficient energy use, waste heat recovery etc. These measures have an impact on firms and households and can generate some impacts outside the area of main concern to them. These are unlikely, however, to include significant effects on employment and income distribution, although the acceptability of household schemes for energy conservation will depend on there not being any adverse income effects.

The main associated benefits/costs of energy conservation programmes will arise in relation to the pollution saving, which results from the increased efficiency, and from the sustainability implications of the increased levels of conservation.

2.2.4 Market Based Instruments

The above policies have been assumed generally to be ‘technologically’ oriented, in that the measures are introduced with a direct requirement for producers, manufacturers and users to comply. It is possible, however, to use more indirect instruments, such as energy or carbon taxes, to achieve across the board reductions in energy use in general, and in carbon based energy in particular.

The impacts of such policies can only be effectively gauged through models that estimate the effects across sectors, allowing for important inter-sectoral linkages. Such studies (which are also referred to as ‘top down’ studies) look at different policies for reducing GHG emissions and compare the impacts of these policies with a scenario where the policies have not been implemented. Examples are and Ekins (1994) for the UK, Jorgensen and Wilcoxen (1993), Nordhaus and Popp (1997) for the US, and Capros et al. (1996) for the EU. IPCC (1996) cites more than two hundred such studies. The analysis is conducted using sophisticated models of the economy, which incorporate the linkages between the different sectors, and which allow for the responses of supply and baseline demand in different markets to changes in prices, taxes and other control parameters.

The analysis at the macroeconomic level provides the policy-maker with information on the likely impacts of different policies. These impacts are measured in terms of changes to parameters such as the rate of growth of GDP, the level of *per capita* GDP, employment and the trade balance. *Other impacts can, however, be estimated and reported.* In almost all cases such an analysis does not include the costs of adaptation to climate change. The models may or may not specify a target reduction in emissions. Unfortunately the models that have been developed do not provide a consensus on the impacts of the kinds of policies that are the focus of this paper. This has been shown clearly in IPCC (1996). It should also be emphasised that, even if agreement could be reached on the underlying model to be used, differences would arise because many of the parameters on which the answers depend are not ones for which we have adequate empirical estimates.

Macroeconomic analysis is a necessary accompaniment to the analysis of the impacts of a market based instrument. The models discussed above can be designed to provide information on a number of impacts of the policy, including employment, income distribution, environmental benefits, as well as macroeconomic factors such as GDP, GDP growth etc. It is recommended that the models are oriented to provide such information. Admittedly, there will be a range of estimates obtained, depending on which model is used and what parameter values are taken, but this should not preclude the reporting of a range of impact values.

2.3 Forestry

In the case of forestry projects, employment effects could be important, as could the impacts of using land for re-plantation on peasants and other potential users. These effects have to be estimated and reported in the broader analysis.

Associated environmental benefits of forestry projects could be changes in the conservation of biodiversity, reduced soil erosion etc. There could be associated benefits from secondary forest products that result from any re-plantation programme. On the other hand large mono-cultural plantations have often had negative environmental impacts, which have to be accounted for. The design of the forestry programme should be such as to minimise these costs.

The adjustment to financial costs arises primarily because of a limited market in land that is used for the purpose of reforestation and for the secondary forest products. These items do not have adequate market values that can be used in the analysis, and hence an alternative method of valuation has to be used. Details are discussed in Section 6.

From the experience so far, reforestation programmes are not expected to have significant macroeconomic impacts.

Sustainability issues that arise from forestry projects relate to the long-term plans for the areas replanted. If the expectation is that the forest will be managed sustainably (i.e. replanted after eventual cutting), the impact will be different compared to a situation where the planting is a 'one-off' exercise.

2.4 Transport

For transport a number of options are available that will reduce GHG emissions. These include:

- reducing energy intensity in transport through measures such as vehicle downsizing, changes in transport mode etc.
- reducing the emissions of carbon monoxide, NM volatile organic compounds (NMVOCs), nitrous oxide (N_2O), and methane (CH_4).
- switching to energy sources with lower greenhouse gas emissions (e.g. natural gas)
- reducing the use of motorised vehicles through switches to non-motorised transport modes, substitution of transport services with telecommunications etc.

The employment effects of most of the practical options in these areas are not likely to be large, although one should check carefully for each option proposed. The income distribution effects are potentially significant. Some measures to reduce emissions will require increased strict controls on older vehicles, two-wheelers etc. Others will raise the cost of transport generally. The costs of these are likely to fall on urban groups, which, while not at the bottom of the income distribution, are among the lower middle income earners. The impacts on these groups are, however, of considerable significance both in social and political terms. From the practical viewpoint of the implementation of the policies, it is not enough to have an idea of the impacts by broad income category. Much more details are needed, on key groups impacted and on the spatial and other dimensions of the impacts. This is still lacking, both in developing countries, and industrialised countries. In the latter it has been argued that the distributional impacts of most environmental policies are not large; as a percentage of income the gains and losses are indeed small. But that is misleading in relation to the possible objections that can arise over such measures, as recent attempts to increase energy prices in the US and UK have shown. A better understanding of the distributional effects of different measures is required across a wide range of environmental policies.

The associated environmental benefits of transport policies are of considerable importance. Reductions in emissions will generate benefits in terms of health, reduced materials damage, reduced damage to ecosystems and amenities. These in themselves could justify many of the policies.

The financial costs of transport are often a poor guide to the true economic costs because many transport services are not priced. In particular, the use of roads is not subject to direct pricing, so that the effects of changes in traffic flows on travel time have to be estimated separately and included in the costs of the measures. Taxes on fuels and on vehicles also result in financial costs diverging from economic costs.

There are some potentially important macroeconomic impacts of transport policies. Unlike market based instruments, where the effects are more on GDP, trade etc., in the case of transport the effects will be more spatial and sectoral. These include changes in the value of land, relocation of economic activity etc. Modelling these is difficult and, to date, there is very little empirical work available, particularly for developing countries. In most cases one will have to rely on *ad hoc* discussions of potential macroeconomic impacts of this kind.

The sustainability issues concerning transport relate to how the policies will influence the long-term use of resources and land. A policy of reduced transport investment could, for example, reduce the conversion of non-urban land to urban land, thereby maintaining the stock of natural capital in a better state than it would be with present policies. This is a potentially important impact that needs to be looked at, although, as with the macroeconomic impacts, there are few tools available for doing so.

2.5 Land Use and Agriculture

Policies aimed at changing land use and agricultural practices to limit GHGs are few. The ones that have been identified relate to the use of agricultural residues for energy generation (co-generation), the production of ethanol for use in existing fleets of motor vehicles., and reductions of methane emissions from livestock. These examples all show how the agricultural/land use issues are linked to energy, transport and other categories of GHG mitigation considered in this report.

The employment effects of programmes that use agricultural land to generate raw materials for energy could be significant. The impact of interest is, of course, the net effect of changing from one form of land use to another. In addition, the processing of the agricultural products will also have an employment effect, which has to be accounted for. The same measures will often generate income among low-income households and thereby contribute to the reduction in poverty. This also needs to be taken into account.

There are a number of associated environmental impacts that need to be looked at. Increased use of agricultural inputs, water resource implications and soil mining are all factors that have impacts that need to be evaluated. The planting of areas with monocultures may have impacts on biodiversity that will also need to be estimated. In some cases, such as agro-forestry planting of trees, the projects may actually enhance food production, and reduce run-off, which may be significant impacts.

As with the case of forestry, financial costs will not always reflect the economic costs of the land used for planting, or the agricultural residues, which may have alternative uses that are not valued through the market place.

The macroeconomic impacts of agricultural projects are mainly through their effects on food production. If the land used for biomass production is degraded or surplus, then the impact on food should be small, but account should be taken of the use of water and other inputs for the biomass and its knock-on effects on food production.

The contribution of agricultural projects to sustainability will depend on how the new pattern of land use can be maintained over time, compared to previous uses of the same land. An index of sustainability of land use based on the maintenance of land productivity over time can be used to estimate this.

3. QUANTIFICATION OF THE INDIRECT IMPACTS

In Markandya (1997) a number of indirect impacts of GHG gases have been analysed further. The key ones relate to employment, income distribution/poverty,

environmental impacts, social pricing issues, macroeconomic impacts and sustainability.

3.1 Employment Benefits

Employment benefits arise because the persons involved in GHG projects may not otherwise be employed. Markandya, 1997, Chapter 3, provides a methodology for estimating the benefits of such employment and presents an illustration in the case of Egypt for the benefits of employment. These arise because of the loss of output in moving an unemployed person to employment is less than the wage paid to that person, and because there are social costs to unemployment that are alleviated, principally health related. All these benefits can be quantified and included in a broader analysis of the effects of GHG limitation projects. Some guidance on the quantitative values to be attached to the benefits is offered.

Although it is possible to estimate the health consequences of unemployment, it is by no means clear that such valuations will be accepted by policy-makers. The ‘transfer’ of method and values from the OECD countries may not be appropriate. Further research is needed to establish whether or not this is the case. Until such research has been carried out, analysts may prefer simply to report the health consequences qualitatively.

3.2 Income Distribution Effects

Income distribution impacts should be reported for all GHG related projects that have significant distributional effects. In addition, these impacts can be converted into money terms by weighting the transfers of costs and benefits to different groups by their income status. Markandya, 1997, Chapter 4, provides a methodology for doing that and provides some estimates of weights for different inequality aversion parameters. It is quite easy to use these weights, as is shown in some case studies discussed at the end of this paper.

3.3 Environmental Impacts

Environmental impacts of GHG related projects are discussed under the categories of changes in fossil fuel use on health, materials and agriculture; and changes in ecosystems and amenities. The former can be quantified in money terms whereas the latter generally cannot. Chapter 5 provides estimates ranges of damage per tonne of pollutant for SO₂, NO_x and particulates. This is done for different countries based on benefit transfers of damages estimates in the EU and the US. For other impacts a qualitative description is required. Some suggestions on how this might be framed are offered.

3.4 Financial Cost Adjustments

The adjustments to financial costs to obtain economic costs are discussed in Chapter 6. A clear understanding of the term economic cost and its role in the analysis is critical to the correct and consistent estimation of the costs of mitigation and adaptation to climate change. The main points to note are:

- I. The key concept of cost in evaluating mitigation programmes is the *economic opportunity cost*. This may not be equal to the financial flows arising from the programmes.

- II. To estimate the *economic opportunity cost* of a programme it is necessary to adjust the data received from market transactions. One set of adjustments is to add any *external costs or benefits* that arise.
- III. A second set of adjustments is to correct for distortions in the market prices. Such distortions arise because of government taxes and subsidies, because markets do not always clear, or function with money transactions, and because of monopoly or other factors.
- IV. The full set of corrections described above can provide an estimate of the *social cost* of the programme.
- V. Conventionally, the main corrections that arise are in relation to the value of capital, the exchange rate and taxes or subsidies. Methods for making such adjustments are discussed. In addition many projects fail to value changes in time, which often does not have a direct financial counterpart. This is particularly important in developing countries where the projects deal with rural energy. Again some guidance is offered on the valuation of time in this context.
- VI. Finally there is the issue of implementation, or hidden, costs. Many GHG related projects have such costs, arising from the inertia to change and the need for training and experience in order to implement the project. The estimation of such costs is discussed in this chapter. The chapter concludes with an example of the estimation of shadow prices and related costs.

3.5 Macroeconomic Impacts

The macroeconomic impacts of GHG limitation policies are on national output (GDP), employment, trade, and the sectoral/regional breakdown of output and employment. They are important considerations for many mitigation policies. In particular, they are important for market based policies that affect a large number of individuals or on wholesale changes in energy sources and land use. For these policies some such assessment is desirable. The problem is that the answers depend considerably on what assumptions one makes, and there is little guidance on what these assumptions should be. Consequently, it is important to provide a range of estimates of the macroeconomic impacts. The analysis should be carried out under the most realistic assumptions of what would be situation without the policy (the baseline) and what would be the case with the policy. Exploiting the opportunities of GHG policies to affect other changes such as changes in the tax structure, should not be built into the analysis unless there is clear evidence that these changes can in fact be implemented.

3.6 Sustainability Issues

A key indicator of sustainability is the impact the project or policy has for the share of total energy that will come from renewable sources at the beginning and at the end of the planning period. This applies to almost all interventions that are likely to be considered, and could, in fact, be reported for **all** interventions, even those that will not impact on the use of renewable resources.

For fossil fuel policies it is important to look at how long such policies will last. This is not mainly a physical consideration, but an economic one. At some time the fossil energy source may be so depleted that the costs of extraction will rise above those of the renewable source. That is the point at which the fossil fuel is effectively depleted. An idea of when that is likely to happen will provide useful information on the length of time for which the present project (and its successors) can last.

For projects that impact on the natural resource base directly -- forestry and biomass production -- an assessment of the impacts on key forms of natural capital, particularly biodiversity related, should be provided. This information will probably not be quantitative, but rather a qualitative description of what impacts are expected.

For biomass projects it is important to monitor how agricultural land use will affect yields in the medium to long term. Placing a reporting requirement on this will ensure that estimates are prepared. A range will typically need to be reported to allow for the uncertainty arising from the estimation procedures.

Finally, some projects involving transport will have impacts on urbanisation and on land available for agriculture. One sustainability concern is that the trends in land use are not sustainable; that as more and more land is taken into urban and suburban use, there is a loss of amenity and of biodiversity. A proxy for that is the change in the percentage of urban/suburban land. Policies in the transport sector that reduce energy use could reverse present trends and cause a fall in the areas of suburban land (or at least arrest the rate of growth of such land).

The above measures of sustainability are useful complements to the monetary measures of the costs of GHG limitation projects.

3.7 Quantitative Criteria for Selecting Projects

Given the above information, what criteria should we use to rank and select projects? It is proposed that the financial cost information should be summarised in the form of a cost per tonne of GHG gas removed as a result of the project. There are quite precise rules to follow in developing such estimates and these are outlined in UNCEE, 1997 and Markandya, 1997. At the same time, however, an economic cost measure should also be computed, including the monetary information on the broader impacts. Both these measures should be accompanied by information on the data that have only a physical quantification and data that have no quantification. Methods for analysing a mixture of quantified monetary and non-monetary data are available, such as multi-criteria methods. These are discussed further in UNCEE, 1997.

Ultimately the decisions on which projects to undertake is a political one. The screening rules discussed above are a guide to those decisions. These rules will not provide unique guidance on which policies or projects to choose. But they will provide a range of indicators on financial costs, full economic costs and on the other quantitative and qualitative impacts that are inputs to the decision-making process.

3.8 Some Case Studies of the Indirect Costs of GHG Projects

Markandya, 1997 offers some examples, based on actual projects, of how such techniques can be implemented and what the implications of their application are. The cases are, however, only loosely based on actual data, which have been added to,

so that the value of the different techniques can be demonstrated. The first case looks at a biogas plant in Tanzania and is based on some data from a GEF Project Document (UNDP, 1994). The second is based on a forestry project proposed for the Russian Federation prepared by the Environmental Defense Fund. The third is an energy efficiency project in Thailand, based on another GEF project document (World Bank, 1993). In each case the basic objectives of the projects are discussed and the conventional analysis presented alongside the broader analysis. Some comments on the implications of the broader analysis for project selection and project design are offered.

The cases show that the economic analysis is sometimes (but not always) substantially different from the financial analysis. Both are important sources of information for the decision-maker. In addition, however, there are other types of information, about key parameters, about sustainability and about socio-economic impacts that need to be included in the impacts 'portfolio'. Project rankings and design can be substantially affected by these wider considerations.

4. CONCLUSIONS

The indirect costs of GHG projects are very important in the evaluation of such projects. In many cases they are more important than the direct costs. This paper has shown what such costs consist of and how they may be estimated. A more full discussion of these issues is available in Markandya, 1997.

As countries prepare their mitigation strategies, it is very important that they develop tools for the assessment of these indirect costs and use these tools in the appropriate manner. Hopefully, this paper will point them in the right direction.

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PAPER

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Climate Change Mitigation in the Energy Sector of Developing Countries

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1. INTRODUCTION

The earth's fragile atmosphere is changing with the continuing release of greenhouse gases (GHGs) around the world. At increasing atmospheric concentrations, GHGs are projected to raise the average world temperature, lead to a rise in sea level, and change seasonal and geographic precipitation patterns (1). These changes are expected to severely impact agriculture, ecosystems, water resources, coastal areas, and human health. Concern about such impacts led more than 160 nations to ratify the United Nations Framework Convention on Climate Change (UNFCCC), which was adopted in Rio de Janeiro in 1992 (2). The nations include those from the Organization for Economic Cooperation and Development (OECD) along with Russia and the Eastern European countries, known together as the Annex 1 countries; and a group, most of which are developing countries, referred to as the non-Annex 1 countries.

Developing countries today have lower income per capita and use fuel less efficiently than industrialized countries. This less efficient use of fuels stems from both a lack of state-of-the-art technology, and proportionally higher use of coal and biomass, which produce more of the greenhouse gas carbon dioxide (CO₂), per unit of energy than do petroleum products and natural gas. In addition, developing countries are net emitters of GHGs from the burning of forests for land clearing and the burning of nonrenewable biomass for cooking and other uses (3). Commensurate with the high economic and population growth in developing countries, GHG emissions there are expected to increase rapidly to match those from industrialized countries around 2018 (4).

There is much debate about the extent of each country's responsibility for stabilizing global climate change. The 1997 meeting in Kyoto, Japan of the Third Conference of the Parties to the UNFCCC (5) illustrated the sharp division between the 130 or so developing countries on the one hand and the industrialized countries on the other. The Annex 1 countries (which, except Belarus and Turkey, are listed as Annex B in the Kyoto Protocol) agreed to cap their emissions averaged over the period 2008 to 2012 at levels ranging from 7% below to 10% above their 1990 levels. The developing countries, often referred to as the "G77+China," resisted commitments to limit the growth of their GHG emissions on the grounds that these emissions have thus far been generated mainly by industrialized countries. Why, developing nations ask, should they assume responsibility for a problem they did not cause? The industrialized countries do not contest this position but point out that many emerging low-cost opportunities for reducing GHG emissions are found in developing countries. Can these opportunities be secured without affecting the economic growth and social fabric in these countries, particularly in view of their perennial shortage of capital for investment in new technologies and hard currency for the purchase of imported goods?

Climate change mitigation analysis, which is the process of projecting future GHG emissions growth and evaluating strategies for reducing this growth, is a valuable tool for addressing this question and resolving the debate between industrialized and developing nations on the extent to which developing countries could reduce their emissions. Using mitigation analysis, developing countries can discover how far and how fast they can go in reducing GHG emissions within their borders without jeopardizing, and even enhancing, their aspirations for sustainable development. Options for reducing GHG emissions growth, such as more efficient motors and appliances or increased use of wind and solar energy, are compatible with the policies and programs currently being implemented by developing countries in their pursuit of greater economic growth; in fact, most of these countries are already pursuing options to slow the growth of GHG emissions for good reasons other than the need to prevent global warming.

2. BACKGROUND

Climate change country studies may be categorized into three types, 1) inventory-of-GHG-emissions studies, 2) mitigation studies and 3) vulnerability and adaptation (V & A) studies. Inventory studies quantify, for a given year, the level of GHG emissions and sequestration of carbon from all sources in a country. Mitigation studies project future GHG emissions and the economic and other implications of limiting their

growth. V&A studies estimate the impacts of climate change on a region or country and evaluate strategies to reduce or adapt to these impacts. This article focuses on mitigation studies in developing countries.

A handful of major multi-country efforts have studied opportunities for climate change mitigation in the developing world since 1989. A unique feature of most of the studies discussed below is that the work was carried out by institutions within each country, rather than by consultants or experts from abroad. Institutions in industrialized countries provided technical assistance and training on methods and tools for analysis. The results thus present perspectives of analysts from the country being analyzed.

Precursors to today's mitigation studies were led by research groups; the first effort was coordinated by the Lawrence Berkeley National Laboratory (LBNL) of the United States (6). The main focus of these studies was the preparation of long-term (through the year 2025) energy and carbon scenarios using a detailed end-use approach for 12 countries/groups of countries. A more ambitious effort, which included the estimation of costs of mitigation options, was initiated by the United Nations Environment Programme's Collaborating Centre for Energy and Environment (UNEP/CCEE) at the Riso National Laboratory in Denmark (7, 8). In parallel, the Asian Development Bank (ADB) completed a broad climate change study that evaluated mitigation as well as vulnerability and adaptation options in several Asian countries (9).

A parallel research effort was coordinated by LBNL on mitigation options in the forestry sector. Its main focus was on developing methods to estimate carbon emissions from land-use change and to evaluate mitigation options to reduce net emissions; seven tropical countries with significant deforestation problems were studied along with China (10, 11).

In the early 1990s, governments in several industrialized countries, notably the U.S., Germany, the Netherlands and Denmark, initiated climate change studies in collaboration with developing countries. The U.S. undertook the U.S. Country Studies Program (CSP), in which 12 U.S. government agencies participate, to support climate change studies in 56 developing and transitional-economy countries in order to assist them in meeting their reporting requirements to the UNFCCC (12). A unique feature of the German and Danish efforts is their attention to regional mitigation options that may be pursued jointly by neighboring countries, such as the use of hydro power across southern Africa. Together, the bilateral efforts have spent more than US \$50 million on country studies, with the largest contribution from the US, about \$35 million. Two other multi-country efforts supported by the Global Environment Facility (GEF) are also under way. One, administered by United Nations Development Programme (UNDP)/ADB, focuses on 12 Asian countries and is called the Asia Least-Cost Greenhouse Gas Abatement Study (ALGAS); the other is administered by UNEP/CCEE and involves eight countries worldwide.

3. MITIGATION STUDIES METHODOLOGY

A mitigation assessment prioritizes, for a given situation, technologies and practices that combat climate change by reducing GHG emissions or sequestering carbon. Options are generally prioritized by cost and occasionally by other criteria, such as ancillary social benefits. Conducting a mitigation assessment requires defining: the time frame for the proposed mitigation scenarios, the geographic area and economic sectors to be targeted, a range of results that will form part of a national action plan to reduce emissions growth, and approaches appropriate to the data and expertise available in the country where mitigation is proposed. In keeping with UNFCCC, mitigation options should be consistent with a country's development objectives (13).

Two primarily different approaches, "*bottom up*" and "*top down*," have been used for mitigation analysis, particularly in the energy sector. The bottom-up approach is more engineering oriented and begins by characterizing technologies and processes, combinations of which are then evaluated to assess their aggregate GHG emissions and costs. In order to evaluate and rank options with respect to multiple criteria in addition to costs, some studies have used a "*multi criteria approach*." The top-down approach primarily evaluates the impact on a nation's Gross Domestic Product (GDP) of policy instruments, such as changes in carbon or fuel taxes. These approaches are described in detail in their respective sections below. For the forestry sector, mitigation analysis typically involves assessing mitigation options in relation to the land available for emissions reduction or carbon sequestration, and then exploring the costs and benefits of each option as well as policies and other means to encourage implementation of options.

Most mitigation analyses include the development of a "baseline" scenario, a projection of potential future emissions growth in the absence of mitigation activities. Development of a baseline scenario involves both analysis and judgment about the future. As a consequence, baseline scenarios can be quite different and

depend a great deal on an analyst's individual perspective, which may be guided by ulterior motives; for example, a country may deliberately increase its baseline emissions in order to show that extraordinary external resources are needed to reduce its future emissions.

4. CO₂ EMISSIONS FROM THE ENERGY SECTOR

The energy sector contributes to the bulk of carbon dioxide emissions worldwide. A recent estimate places global CO₂ emissions from fossil fuel combustion and natural gas flaring at 6.0 Gt C in 1996 (14) up from 5.8 in 1990 (Table 1). The 1992 IPCC scenarios included in Table 1 show the emissions increasing to between 7 and 12.1 Gt C by 2020, with a mid-range estimate of 9.91Gt C. The scenarios show a slowing of growth in the developing countries, but a much higher growth rate in the Eastern Europe/former Soviet Union region, primarily because the decline in demand past 1990 was not anticipated when the scenarios were made in 1992. Studies completed almost 10 years ago emphasized that it would not be possible to stabilize climate change without reducing the rapid growth of emissions from the developing countries (15); CO₂ emissions growth from developing countries between 1990 and 1996 supports this thesis, increasing at an annual rate of 4.4%, from 1.73 to 2.26 Gt C. China, India, South Korea, South Africa, and Mexico rank as the second, sixth, tenth, thirteenth and fourteenth largest contributors, respectively. Should China's emissions continue to increase at the 4.4% rate that was estimated for the period from 1990 to 1996, they would reach the 1996 U.S. emissions level of 1,466 Mt C by 2010. India's emissions, growing at 6.7% annually, will exceed the 1996 U.S. figure by 2025.

Table 1. Emissions of carbon dioxide from fossil fuel combustion and natural gas flaring^a

Country	1990 ^b	1996 ^b (AAGR)	Baseline Projections/AAGR/Final year/Source
China	620	805 (4.4%)	1855 (3.5%) (2030) Ref. 19 1671(3.0%) (2020) Ref. 16
India	155	232 (6.7%)	960 (5.9%) (2025) Ref. 16 630 (4.2%) (2020) Ref. 17
S. Korea	61	113 (10.3%)	284 (3.8%) (2020) Ref. 17
S. Africa	81	96 (2.8%)	
Mexico	79	86 (1.4%)	134 (4.9%) (2005) Ref. 18 164 (4.6%) (2010) Ref. 18
Other developing Countries	735	1332 (9.9%)	
Total Developing Countries	1731	2260 (4.4%)	4050 (2.4%) (2020) Ref. 4
OECD	2804	2943 (0.8%)	3570 (0.8%) (2020) Ref. 4
E. Europe/FSU	1296	833 (-7.4%)	2300 (4.2%) (2020) Ref. 4
Total World	5831	6036 (0.6%)	9910 (2.0%) (7000-12100) ^d (2020) Ref. 4

a. In million tons of carbon. AAGR, Average annual growth rate; OECD, Organization for Economic Cooperation and Development; FSU, former Soviet Union.

b. Reference 14.

c. Intergovernmental Panel on Climate Change range of projections for scenarios 1992a through 1992f.

5. KEY FINDINGS FROM ENERGY SECTOR MITIGATION STUDIES

Is it possible to slow the growth of emissions from developing countries? Future country-specific emissions scenarios reported in Table 1 project lower growth rates than historically observed. These and other studies that we have reviewed as well (Tables 2 and 3) suggest that future energy/GDP growth rates may be lower than historical ones. This decline would result from an anticipated change in economic structure as service industries begin to dominate and also as rapid stock turnover and energy efficiency programs and policies motivate efficiency gains.

The result is a lower energy/GDP ratio than has been observed historically. The fuel mix, however, gets more carbon-intensive in the baseline scenario of many countries as the share of coal and oil increases by 2020. Some smaller countries, Ghana and Nepal for example, have CO₂/GDP elasticity well in excess of 1. The higher elasticity is a result of switching from biomass, which is assumed to have no net CO₂ emissions, to modern fuels like kerosene and LPG. India, South Korea, and China, which are among the three largest contributors to CO₂ emissions, have CO₂/GDP elasticities less than 1. In China's case, the fuel mix becomes marginally more carbon intensive, which is more than offset by an energy/GDP elasticity of 0.5. Future carbon emissions increase at annual rates of 3.6% for China, 4.9% for India, and 2.7% for South Korea compared to the much higher recent growth rates of 4.4%, 6.7%, and 10.3% respectively.

Is it possible to reduce emissions beyond baseline scenarios, and how much would this cost? The studies show a potential to reduce emissions beyond the baseline scenario ranging from a low of 12% for South Korea to more than 50% for Brazil. Generally, the countries most endowed with natural energy resources have the largest potential for further reductions using renewable energy sources. Between a quarter to a third of the carbon emissions in the baseline scenarios in China and India could be reduced in the mitigation scenario in the target year (Table 2). Each study investigated dozens of individual options to improve energy efficiency and substitute fuels. The reduction amount for China in the ALGAS study in 2020 is as high as 430 MtC; for India it is around 330 MtC in 2025. The average cost of reducing emissions by this magnitude is negative for India as both energy efficiency improvement and fuel switching are cost effective, whereas it is positive for China and South Korea. This negative cost implies that, leaving aside barriers to market penetration and the transaction costs of overcoming them, it would be cost effective for India to pursue a carbon-friendly strategy as a baseline scenario. An important caveat here is that the extent of emissions reduction and the corresponding costs in the mitigation scenario are estimated relative to the baseline, whose definition is open to interpretation and judgement about a country's future. If reforms in India capture the full energy efficiency potential and fuel allocation is least-cost, then a mitigation scenario for India would also show positive cost.

Although the annualized or life-cycle cost may be negative for India, it would be difficult for the country to raise the necessary capital or hard currency to pay for renewable energy sources or imported natural gas. On the other hand, it may cost more for China and South Korea to reduce their emissions beyond the baseline scenario, but as a proportion of GDP, the increased capital and hard currency requirements for these countries would still be modest and affordable.

Table 2. Growth rates of population, gross domestic product (GDP), primary energy consumption and CO₂ emissions

	Population	GDP	Primary Energy		CO ₂ Emissions			Type of Model	Sources
Country ^a			Baseline	Mitigation	Baseline	Mitigation	% reduction in target yr.		Ref. Number
Africa									
Ghana (1987-2025)*	2.90%	4.00%	3.6%	3.00%	5.4%	5.00%	14%	Accounting	6
Senegal (1990-2020)	3.00%	3.20%	3.2%	2.4%	3.5%	2.60%	24%	Accounting	7
Sierra Leone(1987-2025)	2.30%	3.00%	2.2%	1.70%	3.5%	3.00%	17%	Accounting	6
Nigeria (1990-2030)	2.80%	2.00%	1.80%	1.4%	2.00%	1.4%	20%	Optimization	20
	2.40%	3.00%	2.00%	1.6%	2.60%	2.0%	20%	Optimization	20
	2.00%	5.00%	2.60%	2.1%	3.20%	2.7%	19%	Optimization	20
Latin America									
Argentina (1990-2025)	1.10%	2.00%	1.80%	1.1%	1.80%	1.1%	22%	Accounting	6
Brazil (1985-2025)	1.20%	3.20%	2.50%	1.0%	2.80%	0.8%	55%	Accounting	6
Brazil (1990-2025)	1.40%	4.70%	3.50%	3.7%	5.30%	3.2%	52%	Optimization	7
Brazil (1985-2025)	1.35%	4.30%	3.60%	3.70%	4.30%	2.50%	51%	Optimization	16
Mexico (1987-2025)	1.70%	4.40%	2.7%	2.0%	2.9%	2.0%	30%	Accounting	6
Venezuela (1984-2025)	1.70%	4.00%	3.40%	3.2%	2.50%	1.9%	22%	Accounting	6
Venezuela (1990-2025)	2.10%	3.80%	2.50%	1.9%	3.10%	2.1%	30%	Accounting	7
Venezuela (1990-2025)	2.25%	4.00%	3.2%		2.3%			Iterative	21
Asia									
China (1990-2020)	0.70%	4.90%	3.30%	2.90%	3.10%	2.20%	24%	Optimization	16
China (1990-2020)-I	0.9%	7.2%	3.6%	3.2%	3.7%	2.7%	26%	Optimization	17
China (1990-2020)-II	0.9%	7.2%	3.6%	3.0%	3.7%	2.1%	38%	Optimization	17
China (1990-2030)	0.8%	7.2%	3.2%		2.9%			Optimization	19
India (1985-2025)-I	1.25%	4.90%	5.40%	4.70%	5.30%	4.30%	33%	Optimization	16
India (1990-2020)	1.5%	5.7%	4.9%		4.9%			Optimization	17
Indonesia (1990-2020)		7.00%	5.7%	5.5%	7.1%	6.3%	20%	Optimization	22
Nepal (1990-2030)	1.60%	4.50%	1.3%		5.7%			Optimization	18
S. Korea (1995-2020)-I	0.5%	3.8%	2.7%	2.3%	3.6%	3.1%	12%	Optimization	17
S. Korea (1995-2020)-II	0.5%	3.8%	2.7%	2.1%	3.6%	2.9%	17%	Optimization	17

a. Numbers in parenthesis indicate the scenario time period.

Table 3. Key elasticities in baseline and mitigation scenarios^a

Country ^b	Baseline			Mitigation			Sources Ref. Number
	E/GDP	CO ² /E	CO ² /GDP	E/GDP	CO ² /E	CO ² /GDP	
Africa							
Ghana (1987-2025)	0.90	1.50	1.35	0.75	1.67	1.25	6
Senegal (1990-2020)	1.00	1.09	1.09	0.75	1.08	0.81	7
Sierra Leone(1987-2025)	0.73	1.59	1.17	0.57	1.76	1.00	6
Nigeria (1990-2030)	0.90	1.11	1.00	0.70	1.02	0.71	20
	0.67	1.30	0.87	0.52	1.31	0.68	20
	0.52	1.23	0.64	0.43	1.25	0.53	20
Latin America							
Argentina (1990-2025)*	0.90	1.00	0.90	0.55	1.00	0.55	6
Brazil (1985-2025)	0.78	1.12	0.88	0.31	0.80	0.25	6
Brazil (1990-2025)	0.74	1.51	1.13	0.79	0.86	0.68	7
Brazil (1985-2025)	0.84	1.19	1.00	0.86	0.68	0.58	16
Mexico (1987-2025)	0.61	1.07	0.66	0.46	0.96	0.45	6
Venezuela (1984-2025)	0.85	0.74	0.63	0.80	0.59	0.48	6
Venezuela (1990-2025)	0.66	1.24	0.82	0.50	1.11	0.55	7
Venezuela (1990-2025)	0.81	0.71	0.57				21
Asia							
China (1990-2020)	0.67	0.94	0.63	0.59	0.76	0.45	16
China (1990-2020)-I	0.50	1.01	0.51	0.45	0.83	0.37	17
China (1990-2020)-II	0.50	1.01	0.51	0.42	0.69	0.29	17
China (1990-2030)	0.44	0.89	0.40				19
India (1985-2025)	1.10	0.98	1.08	0.96	0.91	0.88	16
India (1990-2020)	0.87	1.00	0.86				17
Indonesia (1990-2020)	0.81	1.25	1.01	0.79	1.15	0.91	22
Nepal (1990-2030)	0.29	4.40	1.27			0.00	18
S. Korea (1995-2020)-I	0.70	1.36	0.96	0.60	1.36	0.82	17
S. Korea (1995-2020)-II	0.70	1.36	0.96	0.56	1.38	0.77	17

a. E, Energy; GDP, gross national product; CO², carbon dioxide emissions.

b. Numbers in parenthesis indicate scenario time period.

Implementation of the mitigation scenarios in Brazil, China, and India (16) will lead to a reduction in the demand for oil by a small percentage in the target year but would substantially increase the demand for natural gas. The study scenarios suggest that natural gas demand in India, China and Brazil in the mitigation scenario would amount to 15.9 mbpd compared to 10.7 mbpd in 2025 period (16). Additional demand from other countries pursuing mitigation would require much more natural gas than the 4.5 mbpd being traded today.

Are carbon taxes a feasible alternative for reducing emissions? There have been only a handful of studies which have evaluated this question (for China, Egypt, India, Nigeria, and Venezuela); for each country the GDP growth rate slows with carbon taxes. The Nigeria study shows, however, that the decline can be offset by improving productivity of energy use. The policy prescription would then be to implement initiatives to improve energy efficiency along with an increase in carbon taxes.

6. IMPLEMENTATION OF MITIGATION OPTIONS IN DEVELOPING COUNTRIES

At the Third session of the Conference of the Parties to the UNFCCC in Kyoto, Japan in December 1997 (3b), industrialized countries agreed to varying degrees of reduction to their 1990 base year emissions by the period 2008-2012. Developing countries, however, remained reluctant to commit to limiting the growth of their GHG emissions. This reluctance stems in part from their view that the industrialized countries are largely responsible for the historical emissions of greenhouse gases, and, in part, due to concerns about how emissions limits may affect their prospects for economic growth. Global climate change, however, cannot be stabilized unless both industrialized and developing countries cooperate (15). Different solutions have been proposed, including letting developing countries 1) increase their GHG emissions or emissions/per capita until they reach some future "industrialized-country average" (23, 24, 25); and 2) increase emissions as industrialized countries decrease theirs until each country's contribution to atmospheric temperature increase is effectively equal, taking into account both past and future emissions (26). None of the proposed approaches to joint responsibility for limiting GHG emissions has so far been accepted by governments signatory to the UNFCCC.

However, despite the political rhetoric and apparent reluctance, developing countries, for reasons other than climate change, are pursuing many energy and forestry programs and projects that are slowing their net GHG emissions growth. They have also reduced energy price subsidies. From 1990-91 and 1995-96, total fossil fuel subsidies declined 45 percent, from \$60 billion to about \$33 billion in 14 developing countries that account for 25 percent of global carbon emissions from energy and industrial sources (27).

Our survey of mitigation studies highlights the fact that developing countries could pursue many additional, cost-effective GHG mitigation options in the energy and forestry sectors. Pursuit of these cost-effective options would reduce the rate of increase in carbon emissions from developing countries without jeopardizing, and in some cases enhancing, the countries' economic growth. Although the estimated GHG emissions reduction from a mitigation option depends on the baseline scenario that is somewhat subjectively defined for each country, experts from all the countries we have cited

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The mix of these options and their impact on emissions reduction differs across countries. Energy-efficiency and renewable energy options that displace grid connected electricity will not reduce emissions as much in Brazil where electricity is largely generated using hydropower as in China or India where coal-based electricity generation predominates. Further, studies show a higher potential for renewable energy options in countries rich in natural resources.

¹² Potential for negative-cost options is not unique to developing countries; a recent U.S. DOE study conducted by five national laboratories estimates a 7% reduction in GHG emissions is possible by 2010 at negative cost in the U.S. This study considered both energy-efficiency and renewable energy options, including nuclear power and supports developing country contentions that industrialized countries should start reducing GHG emissions at home before seeking low-cost GHG mitigation projects outside their borders (32a).

However, many market barriers prevent adoption of cost-effective mitigation options in developing countries. In the energy sector, these barriers include the high first cost of equipment, a lack of information on new technologies, the presence of subsidies for electricity and fuels and high tariffs on import of energy technologies. An absence of appropriate methods and institutions to monitor and verify carbon flows also deters investors from pursuing climate change projects (28).

In addition, implementation of GHG mitigation options involves many actors from the political, governmental, business/corporate, financial, institutional, environmental, and other sectors (29), who want their interests to be taken into account and who want to be adequately compensated for participating. A substantial body of literature discusses market barriers to the implementation of energy options (30, 31, 32).

Studies show that GHG mitigation projects that have been jointly implemented, or designed, thus far under the UNFCCC benefit local communities and host countries. Such projects should be pursued aggressively under the Clean Development Mechanism (CDM) proposed for the Kyoto protocol. However, monitoring and verification of the carbon benefits of such projects, and the acceptance of emissions caps on national emissions are necessary to encourage large-scale implementation of climate mitigation projects under the CDM.

Mitigation options face barriers at the macro, sector, and project levels. Removal of these barriers will improve developing countries' access to financing and advanced technologies, both of which are perennial concerns for developing country governments. Policy reforms to encourage environmental sustainability, increased productivity, improved infrastructure and planning, and carbon-project monitoring are essential for large-scale implementation of mitigation options. A large national and international financial commitment is also necessary (33).

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