I

Policymakers Summary of The Response Strategies Working Group of the Intergovernmental Panel on Climate Change (Working Group III)

Contents
Policymakers Summary
Formulation of Response Strategies

CHAIRMAN'S INTRODUCTION

The First Plenary meeting of Working Group III of the IPCC, the Response Strategies Working Group (RSWG), was held in Washington, January 30–February 2, 1989. This meeting was largely organizational, and it was not until after a subsequent RSWG Officers Meeting in Geneva, May 8–12, 1989, that the real work by the four RSWG subgroups, the Emissions Scenarios Task Force (Task A), and "Implementation Measures" Topic Coordinators (Task B) began.

The Second RSWG Plenary Session was held in Geneva, from October 2–6, 1989, to discuss the implementation measures: (1) public education and information; (2) technology development and transfer; (3) financial measures; (4) economic measures; and (5) legal measures, including elements of a framework climate convention. A consensus was reached on five topical papers dealing with these measures, with the understanding that they would be "living documents" subject to further modification as new information and developments might require.

The Third Plenary Meeting of RSWG, held in Geneva, June 5–9, 1990, achieved three objectives:

1) It reached consensus on the attached "policymakers summary," the first interim report of the RSWG.

2) It completed final editing and accepted the reports of the four RSWG subgroups, of the coordinators of Task A, and of the coordinators of the five Task B topical papers. These documents comprise the underlying material for the consensus report of this meeting, the policymakers summary; they are not themselves the product of a RSWG plenary consensus, although many governments participated in their formulation.

Finally,

3) The Working Group agreed to submit comments on its suggested future work programme to the RSWG Chairman by July 1, 1990, for transmission to the Chair of the IPCC. There was general agreement that the work of the RSWG should continue.

The primary task of the RSWG was, in the broad sense, technical, not political. The charge of IPCC to RSWG was to lay out as fully and fairly as possible a set of response policy options and the factual basis for those options.

Consistent with that charge, it was *not* the purpose of the RSWG to select or recommend political actions, much less to carry out a negotiation on the many difficult policy questions that attach to the climate change issue, although clearly the information might tend to suggest one or another option. Selection of options for implementation is appropriately left to the policymakers of governments and/or negotiation of a convention.

The work of RSWG continues. The Energy and Industry Subgroup has, since the June RSWG Plenary Meeting, held additional meetings in London (June 1990) and Paris (September 1990), the results of which are not reflected in this report.

It should be noted that quantitative estimates provided in the report regarding CFCs, including those in Scenario A ("Business as Usual"), generally do not reflect decisions made in June 1990 by the

Parties to the Montreal Protocol. Those decisions accelerate the timetable to phase out production and consumption of CFCs, halons, carbon tetrachloride, and methyl chloroform.

It should further be noted that quantitative estimates of forestry activities (e.g., deforestation, biomass burning, including fuel wood, and other changes in land-use practices), as well as agricultural and other activities provided in the Report continue to be reviewed by experts.

Two specific items of unfinished business submitted to RSWG by the Ministers at the November 1989 meeting in Noordwijk are the consideration of the feasibility of achieving: (1) targets to limit or reduce CO_2 emissions, including, e.g., a 20 percent reduction of CO_2 emission levels by the year 2005; (2) a world net forest growth of 12 million hectares a year in the beginning of the next century.

The subgroup chairs and topic coordinators took the responsibility for completing their individual reports and, along with their respective governments, contributed generously of their time and resources to that end.

The RSWG Policymakers Summary is the culmination of the first year of effort by this body. The RSWG has gone to considerable lengths to ensure that the summary accurately reflects the work of the various subgroups and tasks. Given the very strict time schedule under which the RSWG was asked to work, this first report can be only a beginning.

—FREDERICK M. BERNTHAL
Chairman
Response Strategies Working Group
Intergovernmental Panel on
Climate Change

EXECUTIVE SUMMARY

Working Group III (Response Strategies Working Group) was tasked to formulate appropriate response strategies to global climate change. This was to be done in the context of the work of Working Group I (Science) and Working Group II (Impacts), which concluded that:

> We are certain emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluoro-carbons (CFCs), and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface.
>
> The longer emissions continue at present-day rates, the greater reductions would have to be for concentrations to stabilize at a given level.
>
> The long-lived gases would require immediate reductions in emissions from human activities of over 60 percent to stabilize their concentrations at today's levels.
>
> Based on current model results, we predict under the IPCC "Business-as-Usual" emissions of greenhouse gases, a rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2°C to 0.5°C per decade), greater than that seen over the past 10,000 years; under the same scenario, we also predict an average rate of global mean sea level rise of about 6 cm per decade over the next century (with an uncertainty range of 3–10 cm per decade).
>
> There are many uncertainties in our predictions particularly with regard to the timing, magnitude, and regional patterns of climate change.
>
> Ecosystems affect climate, and will be affected by a changing climate and by increasing carbon dioxide concentrations. Rapid changes in climate will change the composition of ecosystems; some species will benefit while others will be unable to migrate or adapt fast enough and may become extinct. Enhanced levels of carbon dioxide may increase productivity and efficiency of water use of vegetation.
>
> In many cases, the impacts will be felt most severely in regions already under stress, mainly the developing countries.
>
> The most vulnerable human settlements are those especially exposed to natural hazards, e.g., coastal or river flooding, severe drought, landslides, severe storms and tropical cyclones.

Any responses will have to take into account the great diversity of different countries' situations and responsibilities and the negative impacts on different countries, which consequently would require a wide variety of responses. Developing countries, for example, are at widely varying levels of development and face a broad range of different problems. They account for 75 percent of the world population and their primary resource bases differ widely. Nevertheless, they are most vulnerable to the adverse consequences of climate change because of limited access to the necessary information, infrastructure, and human and financial resources.

MAIN FINDINGS

1) Climate change is a global issue; effective responses would require a global effort that may have a considerable impact on humankind and individual societies.

2) Industrialized countries and developing countries have a common responsibility in dealing with problems arising from climate change.

3) Industrialized countries have specific responsiblities on two levels:
   (a) a major part of emissions affecting the atmosphere at present originates in industrialized countries where the scope for change is greatest. Industrialized countries should adopt domestic measures to limit climate change by adapting their own economies in line with future agreements to limit emissions;
   (b) to cooperate with developing countries in international action, without standing in the way of the latter's development, by contributing additional financial resources, by appropriate transfer of technology, by engaging in close cooperation concerning scientific observation, by analysis and research, and finally by means of technical cooperation geared to forestalling and managing environmental problems.

4) Emissions from developing countries are growing and may need to grow in order to meet their development requirements and thus, over time, are likely to represent an increasingly significant percentage of global emissions. Developing countries have the responsibility, within the limits feasible, to take measures to suitably adapt their economies.

5) Sustainable development requires the proper concern for environmental protection as the necessary basis for continuing economic growth. Continuing economic development will increasingly have to take into account the issue of climate change. It is imperative that the right balance between economic and environmental objectives be struck.

6) Limitation and adaptation strategies must be considered as an integrated package and should complement each other to minimize net costs. Strategies that limit greenhouse gas emissions also make it easier to adapt to climate change.

7) The potentially serious consequences of climate change on the global environment give sufficient reasons to begin by adopting response strategies that can be justified immediately even in the face of significant uncertainties.

8) A well-informed population is essential to promote awareness of the issues and provide guidance on positive practices. The social, economic, and cultural diversity of nations will require tailored approaches.

A FLEXIBLE AND PROGRESSIVE APPROACH

Greenhouse gas emissions from most sources are likely to increase significantly in the future if no response measures are taken. Although some controls have been put in place under the Montreal Protocol for CFCs and halons, emissions of CO_2, CH_4, N_2O, and other gases such as several CFC substitutes will grow. Under these scenarios, it is estimated that CO_2 emissions will increase from approximately 7 billion* tonnes carbon (BTC) in 1985 to between 11–15 BTC by 2025. Similarly, man-made methane emissions are estimated to increase from about 300 teragrams (Tg) to over 500 Tg by the year 2025. Based on these projections, Working Group I estimated that global warming of 0.3°C/decade could occur.

The climate scenario studies of Working Group I further suggest that control policies on emissions can indeed slow global warming, perhaps from 0.3°C/decade to 0.1°C/decade. The social, economic, and environmental costs and benefits of these control policies have not been fully assessed. It must be emphasized that implementation of measures to reduce global emissions is very difficult, as

* 1 billion = 1000 million

energy use, forestry, and land use patterns are primary factors in the global economy. To take maximum advantage of our increasing understanding of scientific and socio-economic aspects of the issue, a flexible and progressive approach is required. Subject to their particular circumstances, individual nations may wish to consider taking steps now to attempt to limit, stabilize, or reduce the emission of greenhouse gases resulting from human activities and prevent the destruction and improve the effectiveness of sinks. One option that governments may wish to consider is the setting of targets for CO_2 and other greenhouse gases.

Because a large, projected increase in world population will be a major factor in causing the projected increase in global greenhouse gases, it is essential that global climate change strategies include strategies and measures to deal with the rate of growth of the world population.

Shorter-Term

The Working Group has identified measures at the national, regional, and international levels as applicable, which, while helping to tackle climate change, can yield other benefits.

Limitation

- *Improved energy efficiency* reduces emissions of carbon dioxide, the most significant greenhouse gas, while improving overall economic performance and reducing other pollutant emissions and increasing energy security.
- *Use of cleaner energy sources and technologies* reduces carbon dioxide emissions, while reducing other pollutant emissions that give rise to acid rain and other damaging effects.
- *Improved forest management* and, where feasible, *expansion of forest areas* as possible reservoirs of carbon.
- *Phasing out of CFCs under the Montreal Protocol,* thus removing some of the most powerful and long-lived greenhouse gases, while also protecting the stratospheric ozone layer.
- Agriculture, forestry, and other human activities are also responsible for substantial quantities of greenhouse gas emissions. In the short term, reductions can be achieved through *improved livestock waste management, altered use and formulation of fertilizers,* and other *changes to agricultural land use,* without affecting food security, as well as through improved management in landfill and wastewater treatment.

Adaptation

- Developing *emergency and disaster preparedness* policies and programmes.
- Assessing areas at risk from sea level rise and developing *comprehensive management plans* to reduce future vulnerability of populations and coastal developments and ecosystems as part of coastal zone management plans.
- Improving the *efficiency of natural resource use,* research on control measures for desertification and enhancing adaptability of crops to saline regimes.

Longer-Term

Governments should prepare for more intensive action, which is detailed in the report. To do so, they should undertake now:

- *Accelerated and coordinated research programmes* to reduce scientific and socio-economic uncertainties with a view toward improving the basis for response strategies and measures.
- Development of *new technologies* in the fields of energy, industry, and agriculture.
- Review planning in the fields of energy, industry, transportation, urban areas, coastal zones, and resource use and management.
- Encourage beneficial behavioral and structural (e.g., transportation and housing infrastructure) changes.
- Expand the global ocean observing and monitoring systems.

It should be noted that no detailed assessments have been made as of yet of the economic costs and benefits, technological feasibility, or market potential of the underlying policy assumptions.

INTERNATIONAL COOPERATION

The measures noted above require a high degree of international cooperation, with due respect for national sovereignty of states. The international negotiation on a framework convention should start as quickly as possible after the completion of the IPCC First Assessment Report. This, together with any additional protocols that might be agreed upon, would provide a firm basis for effective cooperation to act on greenhouse gas emissions and adapt to any adverse effects of climate change. The convention should, at a minimum, contain general principles and obligations. It should be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced range of countries, while permitting timely action to be taken.

Key issues for negotiation will include the criteria, timing, legal form and incidence of any obligations to control the net emissions of greenhouse gases, how to address equitably the consequences for all, any institutional mechanisms that may be required, the need for research and monitoring, and in particular, the request of the developing countries for additional financial resources and for the transfer of technology on a preferential basis.

FURTHER CONSIDERATION

The issues, options, and strategies presented in this document are intended to assist policymakers and future negotiators in their respective tasks. Further consideration of the summary and the underlying reports of Working Group III should be given by every government, as they cut across different sectors in all countries. It should be noted that the scientific and technical information contained in the policymakers summary and the underlying reports of Working Group III do not necessarily represent the official views of all governments, particularly those that could not participate fully in all Working Groups.

FORMULATION OF RESPONSE STRATEGIES

BY WORKING GROUP III

1. SOURCES OF ANTHROPOGENIC GREENHOUSE GASES

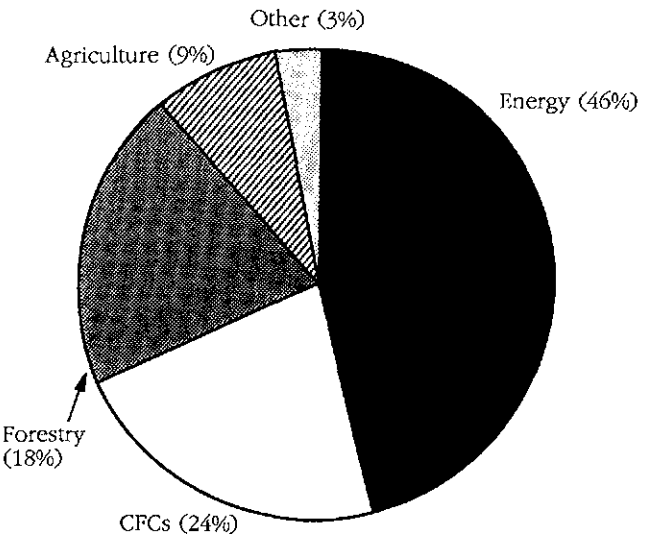
A wide range of human activities result in the release of greenhouse gases, particularly CO_2, CH_4, CFCs, and N_2O, into the atmosphere. Anthropogenic emissions can be categorized as arising from energy production and use, non-energy industrial activities (primarily the production and use of CFCs), agricultural systems, and changes in land-use patterns (including deforestation and biomass burning). The relative contributions of these activities to radiative forcing during the 1980s are discussed in the text and shown in Figure 1 (see Working Group I report for further explanation of the radiative forcing of the various greenhouse gases; see also the Chairman's introduction regarding the quantitative estimates of the contributions to radiative forcing from these activities).

IPCC Working Group I calculated that the observed increases in the atmospheric concentrations of CO_2, CH_4, CFCs, and N_2O during the 1980s, which resulted from human activities, contributed to the enhanced radiative forcing by 56 percent, 15 percent, 24 percent, and 5 percent, respectively.

ENERGY

The single largest anthropogenic source of radiative forcing is energy production and use. The consumption of energy from fossil fuels (coal, petroleum, and natural gas, excluding fuelwood) for industrial, commercial, residential, transportation, and other purposes results in large emissions of CO_2 accompanied by much smaller emissions of CH_4 from coal mining and the venting of natural

FIGURE 1: **Estimated Contribution of Different Human Activities to the Change in Radiative Forcing During the Decade from 1980 to 1990***



* Percentages derived from estimated greenhouse gas concentrations in the atmosphere and the Global Warming Potentials of these greenhouse gases given by Working Group I on pages 11 and 12 of that group's Policymakers Summary.

gas; the energy sector accounts for an estimated 46 percent (with an uncertainty range of 38–54 percent) of the enhanced radiative forcing resulting from human activities.

Natural fluxes of CO_2 into the atmosphere are large (200 Bt/yr*), but inputs from man-made sources are large enough to significantly disturb the atmospheric balance.

INDUSTRY

The production and use of CFCs and other halocarbons in various industrial processes comprise about 24 percent of the enhanced radiative forcing.

FORESTRY

Deforestation, biomass burning including fuelwood, and other changes in land-use practices release CO_2, CH_4, and N_2O into the atmosphere and together comprise about 18 percent (with an uncertainty range of 9–26 percent) of the enhanced radiative forcing.

AGRICULTURE

Methane releases from rice cultivation and from livestock systems, and nitrous oxide released during the use of nitrogenous fertilizers together comprise about 9 percent (with an uncertainty range of 4–13 percent) of the enhanced radiative forcing.

OTHER SOURCES

Carbon dioxide from cement manufacturing and methane from landfills together comprise about 3 percent (with an uncertainty range of 1–4 percent) of the enhanced radiative forcing.

Estimates of current greenhouse gas emissions are not precise because of uncertainties regarding both total emissions and emissions from individual sources. Global emissions from certain sources are particularly difficult to determine, e.g., CO_2 emission from deforestation, CH_4 emission from rice cultivation, livestock systems, biomass burning, coal mining and venting of natural gas, and N_2O emissions from all sources. The range of such estimates can be quite large, typically, a factor of 1.5 for methane from livestock, a factor of 4 for CO_2 from deforestation, and up to a factor of 7 for rice cultivation.

* Billion (or 1000 million) tons per year

2. FUTURE EMISSIONS OF GREENHOUSE GASES

Greenhouse gas emissions from most sources are likely to increase significantly in the future if no policy measures are taken. As economic and population growth continues, in particular in the developing countries, there is expected to be an increase in energy use, industrial and agricultural activity, deforestation, and other activities which result in a net increase of greenhouse gas emissions. Although some controls have been put in place under the Montreal Protocol for certain CFCs and halons, emissions of CO_2, methane, nitrous oxide, and other greenhouse gases are likely to increase under current patterns of economic activity and growth.

However, because of the inherent limitations in our ability to estimate future rates of population and economic growth, etc., there is some uncertainty in the projections of greenhouse gas emissions, individual behavior, technological innovation, and other factors that are crucial for determining emission rates over the course of the next century. This lends uncertainty to projections of greenhouse gas emissions over several decades or longer. Reflecting these inherent difficulties, the RSWG's work on emissions scenarios are the best estimates at this time covering emissions over the next century, but further work needs to be done.

The RSWG used two methods to develop scenarios of future emissions as discussed in Sections 2.1 and 2.2. One method used global models to develop four scenarios which were subsequently used by Working Group I to develop estimates of future warming. The second method used studies of the energy and agriculture sectors submitted by over 21 countries and international organizations to estimate emissions. These latter studies were aggregated into a reference scenario. Both approaches show that emissions of CO_2 and CH_4 will increase in the future. Both approaches indicate that CO_2

emissions will grow from approximately 7 BTC to between 11 and 15 BTC by the year 2025.

2.1 Emissions Scenarios

One of the RSWG's first tasks was to prepare some initial scenarios of possible future greenhouse gas emissions for the use of the three IPCC Working Groups. An experts' group was formed that looked at four hypothetical future patterns of greenhouse gas emissions and their effect on the atmosphere. The cumulative effect of these emissions was calculated using the concept of equivalent CO_2 concentrations (e.g., the contributions of all greenhouse gases to radiative forcing are converted into their equivalent in terms of CO_2 concentrations). Global economic growth rates were taken from World Bank projections, and population estimates were taken from United Nations (UN) studies, and assumed equal for all scenarios.

The first of the scenarios, called the "Business as Usual" or the 2030 High Emissions Scenario, assumes that few or no steps are taken to limit greenhouse gas emissions. Energy use and clearing of tropical forests continue and fossil fuels, in particular coal, remain the world's primary energy source. The Montreal Protocol comes into effect, but without strengthening, and with less than 100 percent compliance. Under this scenario, the equivalent of a doubling of pre-industrial CO_2 levels occurs, according to Working Group I, by around 2025.

The predicted anthropogenic contributions to greenhouse gas emissions in 2025 are shown in Table 1. The RSWG attempted to synthesize and compare the results of the AFOS/EIS Reference Scenario and the Task A "Business as Usual" (or "2030 High Emissions") Scenario (see Figure 2). The figure shows the equivalent CO_2 concentrations for the Task A "Business as Usual" Scenario and the AFOS/EIS Reference Scenario with its higher CO_2 emissions and the CFC phase-out agreed to by the Parties to the Montreal Protocol. The results indicate that the CO_2 equivalent concentrations and thus the effect on the global climate are similar for both scenarios.

The second of the scenarios, the 2060 Low Emissions Scenario, assumes that a number of environmental and economic concerns result in steps to reduce the growth of greenhouse gas emissions. Energy efficiency measures, which might only be possible with government intervention, are implemented, emissions controls are adopted globally, and the share of the world's primary energy provided by natural gas increases. Full compliance with the Montreal Protocol is achieved and tropical deforestation is halted and reversed. Under this scenario, the cumulative effect of such measures is a CO_2 equivalent doubling around 2060.

The remaining two scenarios reflect futures where steps in addition to those in the 2060 Low Emissions Scenario are taken to reduce greenhouse gas emissions. These steps include rapid utilization of renewable energy sources, strengthening of the Montreal Protocol, and adoption of agricultural policies to reduce emissions from livestock systems, rice paddies, and fertilizers.

All of the above scenarios provide a conceptual basis for considering possible future patterns of emissions and the broad responses that might affect those patterns. However, they represent assumptions rather than cases derived from specific studies. In addition, no full assessment was made as yet of the total economic costs and benefits, technological feasibility, or market potential of the underlying policy assumptions.

FIGURE 2: EIS/AFOS Reference Scenario—Task A "Business as Usual" CO_2 Equivalent Concentrations

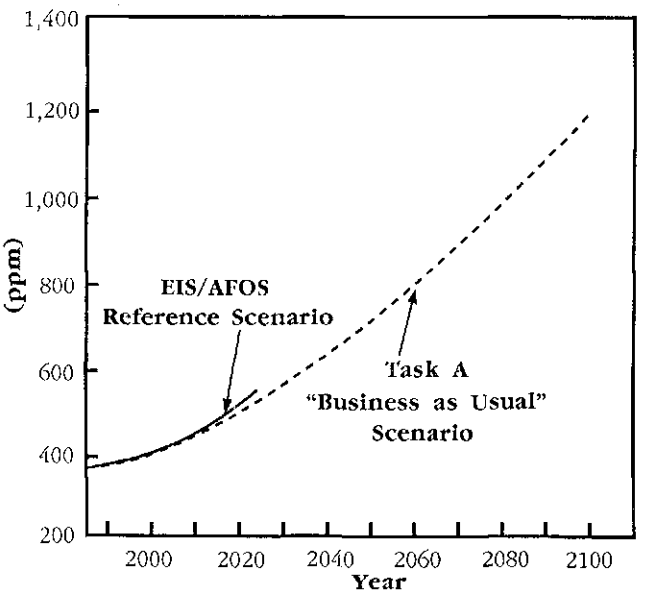


TABLE 1: **Anthropogenic Greenhouse Gas Emissions From Working Group III Scenarios**

	AFOS/EIS Reference Scenario Modified to Include CFC Phase-out[a]		Task A "Business as Usual" Scenario	
	1985	2025	1985	2025
CO_2 Emissions (BTC)				
Energy	5.1	12.4	5.1	9.9
Deforestation	1.7[b]	2.6	0.7[c]	1.4
Cement	0.1	0.2	0.1	0.2
Total	**6.9**	**15.2**	**5.9**	**11.5**
CH_4 Emissions ($TgCH_4$)[d]				
Coal Mining	44.0	126.0	35.0	85.0
Natural Gas	22.0	59.0	45.0	74.0
Rice	110.0	149.0	110.0	149.0
Enteric Ferm.	75.0	125.0	74.0	125.0
Animal Waste	37.0	59.0	–	–
Landfills	30.0	60.0	40.0	71.0
Biomass Burning	53.0	73.0	53.0	73.0
Total	**371.0**	**651.0**	**357.0**	**577.0**
N_2O (TgN)[d]	4.6	8.7	4.4	8.3
CO (TgC)[d]	473.0	820.0	443.0	682.0
NO_X (TgN)[d]	38.0	69.0	29.0	47.0
CFCs (Gg)				
CFC-11	278.0	11.0	278.0	245.0
CFC-12	362.0	10.0	362.0	303.0
HCFC-22	97.0	1572.0	97.0	1340.0
CFC-113	151.0	0.0	151.0	122.0
CFC-114	15.0	0.0	15.0	9.0
CFC-115	5.0	0.0	5.0	5.0
CCl_4	87.0	110.0	87.0	300.0
CH_3CCl_3	814.0	664.0	814.0	1841.0
Halon 1301	2.1	1.8	2.1	7.4

[a] The estimates for emissions of CFCs in 1985 and 2025 reflect the decisions taken at the meeting of the Parties to the Montreal Protocol in London in June 1990. At that meeting, the Parties agreed to accelerate the phase-out of the production and consumption of CFCs, halons, carbon tetrachloride and methyl chloroform.

[b] Midrange estimates for deforestation and biomass consistent with preferred value from Working Group I.

[c] Assuming low biomass per hectare and deforestation rates.

[d] Differences in the 1985 emissions figures are due to differences in definitions and qualifying the emissions from these particular sources.

2.2 Reference Scenario

Table 2 shows the results of the EIS Reference Scenario (for CO_2 emissions from the energy sector only) divided by region. The table is incomplete and does not include CO_2 emissions from non-energy sources or other greenhouse gases and sinks. While it is not directly a measure of a region's climate forcing contribution, this table does portray a future where, in the absence of specific policy measures, global emissions of one major gas, CO_2, grow from 5.15 BTC in 1985, to 7.30 BTC in 2000 and 12.43 BTC in 2025. Primary energy demand more than doubles between 1985 and 2025, an average annual growth rate of 2.1 percent.

The annual rate of growth in CO_2 emissions

TABLE 2: Gross CO_2 Emissions from the Energy Sector* (From the Reference Scenario)

	CO_2 Emissions in Billion Tonnes Carbon					
	1985	%	2000	%	2025	%
Global Totals	**5.15**	**(100)**	**7.30**	**(100)**	**12.43**	**(100)**
Industralized	3.83	(74)	4.95	(68)	6.95	(56)
North America	1.34	(26)	1.71	(23)	2.37	(19)
Western Europe	0.85	(16)	0.98	(13)	1.19	(10)
OECD Pacific	0.31	(6)	0.48	(7)	0.62	(5)
Centrally Planned Europe	1.33	(26)	1.78	(24)	2.77	(22)
Developing	1.33	(26)	2.35	(32)	5.48	(44)
Africa	0.17	(3)	0.28	(4)	0.80	(6)
Centrally Planned Asia	0.54	(10)	0.88	(12)	1.80	(14)
Latin America	0.22	(4)	0.31	(4)	0.65	(5)
Middle East	0.13	(3)	0.31	(4)	0.67	(5)
South and East Asia	0.27	(5)	0.56	(8)	1.55	(12)

	CO_2 Emissions in Tonnes Carbon per Captia and by Carbon Intensity					
	1985		2000		2025	
	PC[a]	CI[b]	PC	CI	PC	CI
Global	**1.06**	**15.7**	**1.22**	**15.8**	**1.56**	**16.0**
Industralized	3.12	16.3	3.65	16.1	4.65	16.0
North America	5.08	15.7	5.75	15.8	7.12	16.6
Western Europe	2.14	15.6	2.29	15.1	2.69	14.6
OECD Pacific	2.14	16.1	3.01	16.1	3.68	14.8
Non-OECD Europe	3.19	17.5	3.78	16.9	5.02	16.4
Developing	0.36	14.2	0.51	15.2	0.84	16.0
Africa	0.29	12.3	0.32	13.2	0.54	15.2
Centrally Planned Asia	0.47	17.3	0.68	18.8	1.15	19.6
Latin America	0.55	11.5	0.61	11.4	0.91	11.8
Middle East	1.20	16.7	1.79	16.1	2.41	15.5
South and East Asia	0.19	12.3	0.32	14.3	0.64	15.6

* This table presents regional CO_2 emissions and does not include CFCs, CH_4, O_3, N_2O, or sinks. Climate change critically depends on all GHG from all economic sectors. Totals and subtotals reflect rounding. *This table should be interpreted with care.*

[a] PC–Per capita carbon emissions in tonnes carbon per person.

[b] CI–Carbon intensity in kilograms carbon per gigajoule.

varies from 0.7 percent in Western Europe, 1.3 percent in North America and the Pacific OECD Countries, to 3.6 percent in developing countries. The share of emissions between regions varies over time.

Under this scenario, the per capita emissions in the industrialized countries increase from 3.1 tonnes carbon (TC) per capita in 1985 to 4.7 TC per capita in 2025. For the developing countries, the per capita emissions rise from 0.4 TC per capita in 1985 to 0.8 TC per capita in 2025.

The Reference Scenario sets out an example of the scope of the reductions in total global emissions that might be necessary to stabilize or reduce CO_2 emissions. The stabilization of global emissions at 1985 levels would require reductions of 29 percent by

2000 and 50 percent by 2025. A reduction of global emissions to 20 percent below 1985 levels would require reductions of 44 percent in 2000 and 67 percent by 2025.

The carbon intensity figures show, for each region, the amount of carbon emitted per unit of energy consumed. The contribution of energy consumption in a region to global warming is largely a function of its carbon intensity, total fuel use, and of the efficiency with which it consumes fossil fuels. Carbon intensity for industrialized countries changes from 16.3 tonnes carbon per gigajoule (TC-GJ) in 1985 to 15.5 in 2025. In the developing world the change is from 14.2 TC-GJ to 15.6.

3. RESPONSE STRATEGIES FOR ADDRESSING GLOBAL CLIMATE CHANGE

Because climate change could potentially result in significant impacts on the global environment and human activities, it is important to begin considering now what measures might be taken in response. Working Group I found that under a "Business as Usual" Scenario global average temperature could rise by 0.3 degrees centigrade per decade; it also found that under the Accelerated Control Policies Scenario (Scenario D) with extremely stringent emissions reductions the temperature rise could perhaps be reduced to 0.1 degree centigrade per decade. The RSWG identified a wide range of options for the international community to consider. These include measures both to limit net greenhouse gas emissions and to increase the ability of society and managed ecosystems to adapt to a changing climate.

Strategies that focus only on one group of emissions sources, one type of abatement option, or one particular greenhouse gas will not achieve this. Policy responses, should, therefore, be balanced against alternative abatement options among the energy, industry, forestry, and agricultural sectors, and adaptation options and other policy goals where applicable at both national and international levels. Ways should be sought to account for other countries, and for intergenerational issues, when making policy decisions.

The consideration of climate change response strategies, however, presents formidable difficulties for policymakes. On the one hand, the information available to make sound policy analyses is inadequate because of: (a) remaining scientific uncertainties regarding the magnitude, timing, rate, and regional consequences of potential climate change; (b) uncertainty with respect to how effective specific response options or groups of options would be in actually averting potential climate change; and (c) uncertainty with respect to the costs, effects on economic growth, and other economic and social implications of specific response options or groups of options. The potentially serious consequences of climate change on the global environment, however, give sufficient reasons to begin by adopting response strategies that can be justified immediately even in the face of such significant uncertainties.

Recognizing these factors, a large number of options were preliminarily assessed. It appears that some of these options may be economically and socially feasible for implementation in the near term while others, because they are not yet technically or economically viable, may be more appropriate for implementation in the longer term. In general, the RSWG found that the most effective response strategies, especially in the short term, are those which are:

- beneficial for reasons other than climate change and justifiable in their own right—for example, increased energy efficiency and lower greenhouse gas emission technologies, better management of forests and other natural resources, and reductions in emissions of CFCs and other ozone-depleting substances that are also radiatively important gases;
- economically efficient and cost effective, in particular those that use market-based mechanisms;
- able to serve multiple social, economic, and environmental purposes;
- flexible and phased, so that they can be easily modified to respond to increased understanding of scientific, technological, and economic aspects of climate change;
- compatible with economic growth and the concept of sustainable development;
- administratively practical and effective in terms of application, monitoring, and enforcement; and

- reflecting obligations of both industrialized and developing countries in addressing this issue, while recognizing the special needs of developing countries, in particular in the areas of financing and technology.

The degree to which options are viable will also vary considerably depending on the region or country involved. For each country, the implications of specific options will depend on its social, environmental, and economic context. Only through careful analysis of all available options will it be possible to determine which are best suited to the circumstances of a particular country or region. Initially, the highest priority should be to review existing policies with a view to minimizing conflicts with the goals of climate change strategies. New policies will be required.

4. OPTIONS FOR LIMITING GREENHOUSE GAS EMISSIONS

The RSWG reviewed potential measures for mitigating climate change by limiting net emissions of greenhouse gases from the energy, industry, transportation, housing and building, forestry, agriculture, and other sectors. These measure include those that limit emissions from greenhouse gas sources (such as energy production and use), those that increase the use of natural sinks (such as immature forests and other biomass) for sequestering greenhouse gases, as well as those measures aimed at protecting reservoirs such as existing forests. While the RSWG was not mandated to consider the role of the oceans, Working Group I noted that oceans also play an equally important role as sinks and reservoirs for carbon dioxide. A discussion of both short- and long-term options for each major emissions sector is provided below.

It also should be recognized that the large projected increase in the world population, to as much as ten billion people during the next century, will be a major factor in causing the projected increase in global greenhouse gases. This is because larger populations will be accompanied by increased consumption of energy and of food, more land clearing, and other activities, all of which will cause an increase in net greenhouse gas emission. It is essential, therefore, that policies designed to deal effectively with the issue of potential global climate change include strategies and measures to reduce the rate of growth of the world population.

4.1 Limitation of Net Emissions from the Energy Sector

The energy sector plays a vitally important role in economic well-being and development for all nations. At the same time, because energy production and use account for approximately one half of the radiative forcing from human activities, energy policies need to ensure that continued economic growth occurs in a manner that, globally, conserves the environment for future generations. However, there is no single, quick-fix technological option for limiting greenhouse gas emissions from energy sources. A comprehensive strategy is necessary that deals with improving efficiency on both the demand and supply sides as a priority and emphasizes technological research, development, and deployment.

The RSWG recognizes the particular difficulties that will be faced by countries, particularly developing countries whose economy is heavily dependent on the production and/or export of fossil fuels, as a consequence of actions taken by other countries to limit or reduce energy-related greenhouse gas emissions. These difficulties should be taken into account when elaborating international strategies.

Various potential options have been identified for reducing greenhouse gas emissions from energy systems. The most relevant categories of options appear to be:

- efficiency improvements and conservation in energy supply, conversion, and end use;
- fuel substitution by energy sources that have lower or no greenhouse gas emissions;
- reduction of greenhouse gas emissions by removal, recirculation, or fixation; and
- management and behavioral changes (e.g., increased work in homes through information technology) and structural changes (e.g., modal shift in transport).

From an analysis of the technologies in these categories, it appears that some technologies are

TABLE 3: Examples of Short-Term Options

I. Improve Efficiency in the Production, Conversion, and Use of Energy

Electricity Generation	Industry Sector	Transport Sector	Building Sector
· Improved efficiency in electricity generation: –repowering of existing facilities with high efficiency systems; –introduction of integrated gasification combined cycle systems; –introduction of atmospheric fluidized bed combustion; –introduction of pressurized fluidized bed combustion with combined cycle power systems; –improvements of boiler efficiency.	· Promotion of further efficiency improvements in production process.	· Improved fuel efficiency of road vehicles: –electronic engine management and transmission control systems; –advanced vehicle design: reduced size and weight, with use of lightweight composite materials and structural ceramics; improved aerodynamics, combustion chamber components, better lubricants and tire design, etc. –regular vehicle maintenance; –higher capacity trucks; –improved efficiency in transport facilities; –regenerating units.	· Improved heating and cooling equipment and systems: –improvement of energy efficiency of air conditioning; –promotion of introduction of area heating and cooling including use of heat pumps; –improved burner efficiency; –use of heat pumps in buildings; –use of advanced electronic energy management control systems.
· Improved system for cogeneration of electricity and steam.	· Materials recycling (particularly energy-intensive materials).	· Technology development in public transportation: –intra-city modal shift (e.g., car to bus or metro); –advanced train control system to increase traffic density on urban rail lines; –high-speed inter-city trains; –better intermodal integration.	· Improved space conditioning efficiency in house/building: –improved heat efficiency through highly efficient insulating materials; –better building design (orientation, window, building, envelope, etc.); –improved air-to-air heat exchangers.
· Improved operation and maintenance.	· Substitution with lower energy intensity materials.	· Improved driver behavior, traffic management, and vehicle maintenance.	· Improved lighting efficiency.
· Introduction of photovoltaics, especially for local electricity generation.	· Improved electro-mechanical drives and motors.		· Improved appliance efficiency.
· Introduction of fuel cells.	· Thermal process optimization, including energy cascading and cogeneration.		· Improved operation and maintenance.
	· Improved operation and maintenance.		· Improved efficiency of cook stoves (in developing countries).

TABLE 3 (*continued*): Examples of Short-Term Options

II. NON FOSSIL AND LOW EMISSION ENERGY SOURCES

ELECTRICITY GENERATION	OTHER SECTORS
· Construction of small-scale and large-scale hydro projects. · Expansion of conventional nuclear power plants. · Construction of gas-fired power plants. · Standardized design of nuclear power plants to improve economics and safety. · Development of geothermal energy projects. · Introduction of wind turbines. · Expansion of sustainable biomass combustion. · Replacement of scrubbers and other energy-consuming control technology with more energy efficient emission control.	· Substitution of natural gas and biomass for heating oil and coal. · Solar heating. · Technologies for producing and utilizing alternative fuels: –improved storage and combustion systems for natural gas; –introduction of flexible-fuel and alcohol fuel vehicles.

III. REMOVAL, RECIRCULATION, OR FIXATION

ENERGY/INDUSTRY	LANDFILLS
· Recovery and use of leaked or released CH_4 from fossil fuel storage, coal mining. · Improved maintenance of oil and natural gas and oil production and distribution systems to reduce CH_4 leakage. · Improved emission control of CO, SO_X, NO_X and VOCs to protect sinks of greenhouse gases.	· Recycle and incineration of waste materials to reduce CH_4 emissions. · Use or flaring of CH_4 emissions. · Improved maintenance of landfill to decrease CH_4 emissions.

available now or in the short term while others need further development to lower costs or to improve their environmental characteristics.

Tables 3 and 4 provide various examples of technological options within each of the broad categories defined above, and their possible application in the short, medium, and longer term. This distinction among time frames is used in order to reflect the remaining technological needs in each category and to assist in formulating technological strategies. Short-term technologies are those that apparently are or will be both technically and economically ready for introduction and/or demonstration by the year 2005. Mid-term technologies are those that while technically available now, are not yet economic and thus may not be implemented until the period from 2005 to 2030. Longer-term technologies are not yet available but may emerge after 2030 as a result of research and development. Such time frames could be influenced by such factors as the pace of the technological changes and economic conditions.

The technical, economic, and market potential of technological options will vary depending upon the sector in which they are to be applied. The technical potential of an energy technology is its capacity to reduce potential emissions, irrespective of the costs involved, and is largely a function of technical feasibility and resource availability. Economic potential refers to whether the application of the options is economically efficient and cost-effective—it may be significantly less than technical potential where there are positive resource costs. Market potential refers to whether the consumer or user is likely to adopt the option—it might be even less than economic potential due to market imperfections, attitudes to risk, and the presence of non-monetary costs.

There is, in general, extensive information available on the technical potential of the many technological options listed. For example:

- in the Transportation sector, vehicle efficiency improvements have very high technical

TABLE 4: Examples of Medium-/Long-Term Options

I. Improve Efficiency in the Production, Conversion, and Use of Energy

Electricity Generation	Industry Sector	Transport Sector	Building Sector
· Advanced technologies for storage of intermittent energy. · Advanced batteries. · Compressed air energy storage. · Superconducting energy storage.	· Increased use of less energy-intensive materials. · Advanced process technologies. · Use of biological phenomena in processes. · Localized process energy conversion. · Use of fuel cells for cogeneration.	· Improved fuel efficiency of road vehicles. · Improvements in aircraft and ship design: –advanced propulsion concepts; –ultra high-bypass aircraft engines; –contra rotating ship propulsion.	· Improved energy storage systems: –use of information technology to anticipate and satisfy energy needs; –use of hydrogen to store energy for use in buildings. · Improved building systems: –new building materials for better insulation at reduced cost; –windows which adjust opacity to maximize solar gain. · New food storage systems which eliminate refrigeration requirements.

II. Non Fossil and Low Emission Energy Sources

Electricity Generation	Other Sectors
· Nuclear power plants: –passive safety features to improve reliability and acceptability. · Solar power technologies: –solar thermal; –solar photovoltaic (especially for local electricity generation). · Advanced fuel cell technologies.	· Other technologies for producing and utilizing alternative fuels: –improved storage and combustion systems for hydrogen. –control of gases boiled off from cryogenic fuels. –improvements in performance of metal hydrides. –high-yield processes to convert ligno-cellulosic biomass into alcohol fuels. –introduction of electric and hybrid vehicles. –reduced re-charging time for advanced batteries.

III. Removal, Recirculation, or Fixation

· Improved combustion conditions to reduce N_2O emissions.

· Treatment of exhaust gas to reduce N_2O emissions.

· CO_2 separation and geological and marine disposal.

potential (e.g., 50 percent improvement from the average vehicle on the road in some countries);
- in the Electricity Generation sector, efficiency improvements of 15 to 20 percent could be achieved for retrofits of coal plants and up to 65 percent of new generation versus average existing coal plants; fuel substitution could achieve 30 percent (for oil to natural gas) to 40 percent (for coal to natural gas) reduction in emissions of CO_2;
- in the Building sector, new homes could be roughly twice as energy efficient and new commercial buildings up to 75 percent more energy efficient than existing buildings; retrofitting existing homes could average 25 percent improvement and existing commercial buildings around 50 percent.
- in the Industry sector, the technical potential for efficiency improvements ranges from around 15 percent in some sub-sectors to over 40 percent in others (i.e., the best available technology versus the stock average).

The constraints to achieving the technical potential in these sectors can be generally categorized as:

- capital costs of more efficient technologies vis-à-vis the cost of energy;
- relative prices of fuels (for fuel substitution);
- lack of infrastructure;
- remaining performance drawbacks of alternative technologies;
- replacement rates;
- reaching the large number of individual decision makers involved.

Each of these constraints may be more or less significant depending on the sector in question. While not a constraint, behavioral changes (e.g., improved driver behavior, better vehicle maintenance, and turning off unused lights) can make significant contributions to emissions reduction in all sectors. Achieving such changes requires the engagement of both the energy supplier and the consumer. Likewise, improvements in operational practices on the part of industry and government (e.g., better traffic management or boiler operation) offer significant potential but require increased attention. Transport and housing policies (e.g., promotion of public transport, home insulation) could also reduce greenhouse gas emissions. A more comprehensive assessment of the measures to overcome these constraints is contained in section 7 of this policymakers summary.

Factors external to the energy sector also significantly constrain potential. These include the difficulty of:

- making basic changes in the structure of economies (e.g., development of new transportation and housing infrastructure);
- making fundamental changes in attitudinal and social factors (e.g., preferences for smaller and higher-efficiency vehicles).

The challenge to policymakers is to enhance the market uptake of technological options and behavioral and operational changes as well as to address the broader issues outside the energy sector in order to capture more of the potential that exists.

Options and Strategies

Tables 3 and 4 summarize the technological, regulatory, and institutional approaches that could form elements of strategies to control greenhouse gases.

A list of options recommended by EIS as measures for addressing greenhouse gas emissions is given below. Countries are encouraged to evaluate the social, economic, and environmental consequences of these options:

- taking steps now* to attempt to limit, stabilize, or reduce the emission of energy-related greenhouse gases and prevent the destruction and improve the effectiveness of sinks (one option that governments may wish to consider is the setting of targets for CO_2 and other greenhouse gases);
- adopting a flexible progressive approach, based on the best available scientific, economic, and technological knowledge, to action needed to respond to climate change;
- drawing up specific policies and implementing wide-ranging comprehensive programmes that cover all energy-related greenhouse gases;

* There was significant concern expressed at the RSWG meeting about the immediacy implied by the word "now" in option one, when implementation could only be considered at a rate consistent with countries' level of knowledge and particular circumstances.

- starting with implementing strategies that have multiple social, economic, and environmental benefits, are cost effective, are compatible with sustainable development, and make use of market forces in the best way possible;
- intensifying international, multilateral, and bilateral cooperation in developing new energy strategies to cope with climate change. In this context, industrialized countries are encouraged to promote the development and transfer of energy-efficient and clean technologies to other countries;
- increasing public awareness of the need for external environmental costs to be reflected in energy prices, markets, and policy decisions to the extent that they can be determined;
- increasing public awareness of energy-efficient technologies and products and alternatives, through public education and information (e.g., labeling);
- strengthening research and development and international collaboration in energy technologies, and economic and energy policy analysis, which are relevant for climate change;
- encouraging the participation of industry, the general public, and NGOs in the development and implementation of strategies to limit greenhouse gas emissions.

Short-Term Strategy Options

Short-term strategies for all individual nations include:

- improving diffusion of energy-efficient and alternative energy technologies that are technically and commercially proven;
- improving energy efficiency of mass-produced goods, including motor vehicles and electrical appliances, and equipment and buildings (e.g., through improved standards);
- developing, diffusing, and transferring technologies to limit energy-related greenhouse gas emissions;
- reviewing energy-related price and tariff systems and policy decisions on energy planning to better reflect environmental costs.

Long-Term Strategy Options

Over the longer term, sustainable development will remain a central theme of policies and strategies. Specific approaches within a sustainable development policy framework will evolve as our understanding of climate change and its implications improves.

Long-term strategies for all individual nations include:

- accelerating work to improve the long-term potential of efficiency in the production and use of energy; encouraging a relatively greater reliance on no or lower greenhouse gas emissions energy sources and technologies; and enhancing natural and man-made means to sequester greenhouse gases;
- further reviewing, developing, and deploying policy instruments, which may include public information, standards, taxes and incentives, tradeable permits, and environmental impact assessments, which will induce sustainable energy choices by producers and consumers without jeopardizing energy security and economic growth;
- developing methodologies to evaluate the trade-off between limitation and adaptation strategies and establishing changes in infrastructure (e.g., pipelines, electrical grids, dams) needed to limit or adapt to climate change.

4.2 LIMITATION OF NET EMISSIONS FROM THE INDUSTRY SECTOR

The most significant source of greenhouse gases associated with industrial activity not related to energy use is the production and use of CFCs and other halocarbons. CFCs represent a very important source of greenhouse gas emissions and account for about 24 percent of the total contributions to the enhanced radiative forcing for the period of the 1980s. While the RSWG did not consider control strategies for these gases, since the issue is already addressed under the Montreal Protocol on Substances that Deplete the Ozone Layer, it noted that the review of the Montreal Protocol now under way should take into account the global warming potential of potential CFC substitutes.

The RSWG did develop future emission scenarios

for CFCs and HCFC-22 (HCFC-22 was used as a surrogate for a potential mix of HCFCs and HFCs substitutes). The potential impact of such substitutes on radiative forcing was assessed by Working Group I. For a given emission rate, HCFCs and HFCs are less effective greenhouse gases than the CFCs because of their shorter lifetimes. The growth rates assumed in the IPCC scenarios will result in the atmospheric concentrations of HFCs and HCFCs becoming comparable to the CFCs during the next several decades, assuming that the CFCs had continued to be used at current rates. Assuming the IPCC scenarios for HFCs and HCFCs, Working Group I calculated that these gases would contribute up to 10 percent of the total additional radiative forcing for the period 2000–50.

4.3 Limitation of Net Emissions from the Agriculture Sector

About 9 percent of anthropogenic greenhouse gas emissions can be attributed to the agricultural sector—in particular, livestock systems, rice cultivation, and the use of nitrogenous fertilizers. Limitation of emissions from this sector presents a challenge because the processes by which greenhouse gases—in particular, methane and nitrous oxide—are released in agricultural activities are not well understood. In addition, response options in the agricultural sector must be designed to ensure maintenance of food supply. There appear, however, to be a number of short-term response options, some economically beneficial in their own right, that could contribute to a limitation of net emissions from agricultural sources. Where appropriate, the removal of subsidies, incentives, and regulatory barriers that encourage greenhouse gas emissions from the agricultural sector would be both environmentally and economically beneficial. In addition, there are a number of promising technologies and practices that, in the longer term, could significantly reduce greenhouse gas emissions.

Short-Term Options

Livestock systems: Methane emissions could be reduced through improved management of livestock wastes, expansion of supplemental feeding practices, and increased use of production- and growth-enhancing agents, with safeguards for human health.

Fertilizer use: Nitrous oxide emissions may be reduced by using existing improved fertilizer formulations, judicious use of animal manures and compost, and improved application technology and practices.

Marginal lands: Areas marginally suitable for annual cropping systems may be shifted to perennial cover crops for fodder, pastoral land use, or forests if soils are suitable. Such actions would increase carbon uptake, both in the vegetation and soil, and would yield other benefits.

Sustainable agricultural practices: Where possible, minimum or no-till systems should be introduced for those countries currently using tillage as part of the annual cropping sequence, thus maintaining and increasing soil organic matter.

Longer-Term Options

Rice cultivation: A comprehensive approach, including management of water regimes, improvement of cultivars, efficient use of fertilizers, and other management practices, could lead to a 10 to 30 percent reduction in methane emissions from flooded rice cultivation, although substantial research is necessary to develop and demonstrate these practices. It is estimated that at least twenty years would be needed to introduce such practices. Adaptable alternative crops research is needed to provide a more diverse crop base for rice-growing regions.

Livestock: Through a number of technologies it appears that methane emissions may be reduced from livestock systems by up to 25–75 percent per unit of product in dairy and meat production, although many uncertainties exist.

Fertilizers: Fertilizer-derived emissions of nitrous oxide potentially can be reduced (although to what extent is uncertain) through changes in practices, such as using fertilizers with controlled nitrogen conversion rates, improving fertilizer-use efficiency, and adopting alternative agricultural systems where possible.

Desertification: Enhanced research on control measures.

4.4 LIMITATION OF NET EMISSIONS FROM FORESTRY AND OTHER ACTIVITIES

Forestry and related aspects of land use cannot be considered in isolation, and solutions must be based on an integrated approach that links forestry to other policies, such as those concerned with poverty and land resources, which should be supported by strong institutions in order to enhance overall forest management. The forest crisis is rooted in the agricultural sector and in people's needs for employment and income. Deforestation will be stopped only when the natural forest is economically more valuable for the people who live in and around the forests than alternative uses for the same land.

Forestry practices and other human activities associated with land use, such as biomass burning and landfills, account for about 18 percent of anthropogenic greenhouse gas emissions. A number of short- and long-term response options for limiting net emissions from these sectors have been identified.

Short-Term Options

1) Improvement of forest-management and reduction of deforestation and forest degradation, which should be supported by:
   - reduction of air pollution, which contributes to forest degradation;
   - elimination of inappropriate economic incentives and subsidies that contribute to forest loss, where appropriate;
   - integration of forest conservation requirements and sustainable development in all relevant sectors of national development planning and policy, taking account of the interests of local communities;
   - coordinated remote sensing, data collection, and analyses to provide the required data;
   - a meeting of interested countries from the developing and the industrialized worlds and of appropriate international agencies to identify possible key elements of a world forest conservation protocol in the context of a climate convention process that also addresses energy supply and use, and practical means of implementing it. Such a meeting should also develop a framework and methodology for analyzing the feasibility of the Noordwijk remit, including alternative targets, as well as the full range of costs and benefits;
   - strengthening Tropical Forestry Action Plan (TFAP) and, in the light of the independent review that is being undertaken, the International Tropical Timber Organization (ITTO), and other international organizations whose objective is to help developing countries in achieving conservation and sustainable development and management of forests;
   - an assessment of incentives and disincentives for sustainable forest management—for example, the feasibility of labeling;
   - introduction of sustainable forest harvesting and management;
   - development of enhanced regeneration methods;
   - development and implementation of (large-scale) national afforestation and forest conservation plans, where feasible.
2) Where appropriate, expand forest areas, especially by afforestation, agroforestry, and regreening of available surplus agricultural, urban, and marginal lands.
3) Where appropriate, strengthen and improve the use of forest products and wood through measures such as substituting a portion of fossil energy sources by wood or other sustainable managed biomass; partial replacement of high energy input materials by wood; further recycling of forest products; and improved efficiency of use of fuelwood.
4) Development of methane recovery systems for landfill and wastewater treatment facilities and their use, in particular, in industrialized countries.

Longer-Term Options

1) Maintain the health and the continuance of existing forests as major natural carbon reser-

voirs, especially through the development and implementation of:
- silvicultural adjustment and stress management strategies;
- special forest protection strategies (developed under climate change scenarios);
- environmentally sound treatment practices for peatlands;
- standardization of methods of forest inventory and bio-monitoring to facilitate global forest management.

2) Expand forest biomass, especially of intensively managed temperate forests, by silviculture measures and genetically improved trees.

3) With regard to waste management, use of gas collection and flaring to reduce methane emissions from landfills and development of biogas plants to reduce methane emissions from wastewater treatment. Demonstration, training, and technology transfer are necessary to realize these potentials, which may range from 30 to 90 percent for landfills and up to 100 percent for wastewater treatment.

5. FURTHER WORK ON GREENHOUSE GAS EMISSION LIMITATION GOALS

There has been considerable international discussion of targets for specific greenhouse gas emissions, in particular, CO_2, which is the most abundant of the greenhouse gases. The final declaration at the November 1989 Noordwijk Conference on Atmospheric Pollution and Climate Change encouraged the IPCC to include in its First Assessment Report an analysis of quantitative targets to limit or reduce CO_2 emissions, and urged all industrialized countries to investigate the feasibility of achieving such targets, including, for example, a 20 percent reduction of CO_2 emissions by the year 2005. The Conference also called for assessing the feasibility of increasing net global forest growth by 12 million hectares per year. During its Third Plenary, the IPCC accepted the mandate.

Although the feasibility of quantitative targets on greenhouse gas emissions fell within the RSWG's original mandate through its Energy and Industry Subgroup (EIS), it was agreed that these new, specific tasks would require more time, data, and analyses in order to be dealt with properly. It was decided, therefore, that the results of the deliberation of the EIS on these remits could not be fully included in its report but only treated in an incomplete and preliminary way. A progress report is to be presented to the fourth IPCC Plenary following an international workshop to be hosted by the United Kingdom in June 1990. As for the Noordwijk remit on global forest growth, the RSWG through its Agriculture, Forestry, and Other Human Activities Subgroup (AFOS) noted that a framework and methodology for analyzing its feasibility should be developed.

While the technical potential of a number of options has been demonstrated, there is very little information available on the actual economic and social feasibility associated with implementation of such options. An adequate understanding of the benefits, in terms of changes in climate variables that are avoided, is also seriously lacking. It is imperative that further work on the cost and benefit implications of response strategies be undertaken. These issues have been identified as one of the most important areas for future research by the RSWG, concerned international organizations, and individual countries.

The material available to the EIS demonstrates the important role emissions of industrialized countries play in total global emissions in the near term. The material also indicates that the technical potential for reduction is large, and differs greatly between regions and countries. Therefore, in the near term, no significant progress in limiting global emissions will occur without actions by the industrialized countries. Some countries have already decided to stabilize or reduce their emissions.

6. MEASURES FOR ADAPTING TO GLOBAL CLIMATE CHANGE

In addition to the limitation options discussed above, the RSWG reviewed measures for adapting to potential climate change. The consideration of adaptation options is critical for a number of reasons. First, because it is believed that there is likely

to be a lag time between emissions and subsequent climate change, the climate may already be committed to a certain degree of change. Implementation of adaptation measures may thus be necessary regardless of any limitation actions that may be taken. Second, natural climate variability itself necessitates adaptation.

Furthermore, should significant adverse climate change occur, it would be necessary to consider limitation and adaptation strategies as part of an integrated package in which policies adopted in the two areas complement each other so as to minimize costs. Limitation and adaptation options should be developed and analyzed recognizing the relationship between the timing and costs of limitation and adaptation. For example, the more net emissions are reduced and the rate of climate change potentially slowed, the easier it would be to adapt. A truly comprehensive approach should recognize that controlling the different gases might have different effects on the adaptive capacity of natural resources.

The RWSG explored two broad categories of adaptation options:

- *Coastal zone management*, or options that maximize the ability of coastal regions to adapt to the projected sea level rise and to reduce vulnerability to storms; and
- *Resource use and management*, or options that address the potential impacts of global climate change on food security, water availability, natural and managed ecosystems, land, and biodiversity.

6.1 COASTAL ZONE MANAGEMENT

Under the 2030 High Emissions Scenario, global climate change is predicted to raise global mean sea level 65 cm (with an uncertainty range of 30 to 110 cm) by the year 2100. If sea level rises by 1 meter, hundreds of thousands of square kilometers of coastal wetlands and other lowlands could be inundated, while ocean beaches could erode as much as a few hundred meters over the next century. Flooding would threaten lives, agriculture, livestock, and structures, while salt water would advance inland into aquifers, estuaries, and soils, thus threatening water supplies and agriculture in some areas. Loss of coastal ecosystems would threaten fishery resources.

Some nations would be particularly vulnerable to such changes. Eight to ten million people live within one meter of high tide in each of the unprotected river deltas of Bangladesh, Egypt, and Vietnam. Half a million people live in coral atoll nations that lie almost entirely within three meters of sea level, such as the Maldives, the Marshall Islands, Tuvalu, Kiribati, and Tokelau. Other states with coastal areas, archipelagos, and island nations in the Pacific and Indian Oceans and the Caribbean could lose much of their beaches and arable lands, which would cause severe economic and social disruption.

Available responses to sea level rise fall broadly into three categories:

- *Retreat:* Under this option no actions would be taken to protect the land from the sea—the focus would instead be on providing for people and ecosystems to shift landward in an optimal fashion. This choice could be motivated by either excessive costs of protection or by a desire to maintain ecosystems.
- *Accommodation:* Under this strategy, while no attempt would be made to protect the land at risk, measures would be taken to allow for continued habitation of the area. Specific responses under this option would include erecting flood shelters, elevating buildings on pilings, converting agriculture to fish farming, or growing flood- or salt-tolerant species.
- *Protection:* A protection strategy uses site-specific features such as seawalls, dikes, dunes, and vegetation to protect the land from the sea so that existing land uses can be retained.

There are various environmental, economic, social, cultural, legal, institutional, and technological implications for each of these options. Retreat could lead to a loss of property, potentially costly resettlement of populations, and, in some notable cases, refugee problems. Accommodation could result in declining property values and costs for modifying infrastructure. Protecting existing development from a one-meter sea level rise would require about 360,000 kilometers of coastal defenses at a total cost of U.S.$500 billion, over the next one hundred years. The annual cost of protection represents, on average, 0.04 percent of total gross national product (GNP), and ranges from zero to 20 percent for

individual countries. The estimate is not discounted and does not reflect present coastal defense needs or impacts of salt water intrusion or flooding of unprotected lands. Further, the protection could have negative impacts on fisheries, wildlife, and recreation. The loss of traditional environments could potentially disrupt family life and create social instability.

Actions to Prepare for Possible Sea Level Rise

A number of response options are available which not only enhance the ability of coastal nations to adapt to sea level rise, but are also beneficial in their own right. Implementation of such options would be most effective if undertaken in the short term, not because there is an impending catastrophe, but because there are opportunities to avoid adverse impacts by acting now—opportunities that may not be as effective if the process is delayed. These options include:

National Coastal Planning

- *Development and implementation in the short term of comprehensive national coastal zone management plans*, which (a) deal with both sea level rise and other impacts of global climate change and (b) ensure that risks to populations are minimized while recognizing the need to protect and maintain important coastal ecosystems.
- *Identification of coastal areas at risk*. National efforts are needed to (a) identify functions and resources at risk from a one-meter rise in sea level and (b) assess the implications of adaptive response measures on them.
- *Provisions to ensure that coastal development does not increase vulnerability to sea level rise*. Actions in particular need of review include river levees and dams, conversions of mangroves and other wetlands for agriculture and human habitation, harvesting of coral, and increased settlement in low-lying areas. In addition, while structural measures to prepare for sea level rise are not yet warranted, the design and location of coastal infrastructure and coastal defenses should include consideration of sea level rise and other coastal impacts of climate change. It is sometimes less expensive to design a structure today, incorporating these factors, than to rebuild it later.
- *Review and strengthening of emergency preparedness and coastal zone response mechanisms*. Efforts are needed to develop emergency preparedness plans for reducing vulnerability to coastal storms through better evacuation planning and the development of coastal defense mechanisms that recognize the impact of sea level rise.

International Cooperation

- *Maintenance of a continuing international focus on the impacts of sea level rise*. Existing international organizations should be augmented with new mechanisms to focus attention and awareness on sea level change and to encourage the nations of the world to develop appropriate responses.
- *Provision of technical assistance and cooperation to developing nations*. Institutions offering financial support should take into account the need for technical assistance and cooperation in developing coastal management plans, assessing coastal resources at risk, and increasing a nation's ability—through education, training, and technology transfer—to address sea level rise.
- *Support by international organizations for national efforts to limit population growth in coastal areas*. In the final analysis, rapid population growth is the underlying problem with the greatest impact on both the efficacy of coastal zone management and the success of adaptive response options.

Research, Data, and Information

- *Strengthening of research on the impacts of global climate change on sea level rise*. International and national climate research programmes need to be directed at understanding and predicting changes in sea level, extreme events, precipitation, and other impacts of global climate change on coastal areas.
- *Development and implementation of a global ocean-observing network* — for example, through the efforts of the IOC, WMO, and UNEP—to establish a coordinated international ocean-observing network that will allow for accurate assessment and continuous mon-

itoring of changes in the world's oceans and coastal areas, particularly sea level changes and coastal erosion.

- *Dissemination of data and information on sea level change and adaptive options.* An international mechanism could be identified with the participation of the parties concerned for collecting and exchanging data and information on climate change and its impact on sea level and the coastal zone and on various adaptive options. Sharing this information with developing countries is critically important for preparation of coastal management plans.

A programme could begin now to enable developing countries to implement coastal zone management plans by the year 2000. The programme would provide for training of country experts, data collection, and technical assistance and cooperation. Estimated funding to provide the necessary support over the next five years is U.S.$10,000,000. It is suggested that international organizations such as UNEP and WMO consider coordinating this programme in consultation with interested nations.

6.2 RESOURCE USE AND MANAGEMENT

The reports of Working Groups I and II indicate significant and unavoidable impacts, both positive and negative, upon the very resources that humans and other species rely on to live. These resources include water, agriculture, livestock, fisheries, land, forests, and wildlife. The RSWG addressed these resource issues in the context of considering options for ensuring food security; conserving biological diversity; maintaining water supplies; and using land rationally for managed and unmanaged ecosystems.

The potential impacts of climate change on natural resources and human activities are poorly understood. First, credible regional estimates of changes in critical climatic factors—such as temperature, soil moisture, annual and seasonal variability, and frequencies of droughts, floods, and storms—are simply not available. For many of these critical climate factors even the direction of change is uncertain. Second, methods for translating these changes into effects on the quantity and quality of resources are generally lacking. While it is clear that some of the impacts of climate change on resources could be negative and others positive, a more specific quantification of those impacts is not possible at this time. Nevertheless, these uncertainties do not preclude taking appropriate actions, especially if they are worthwhile for other, non-climate related, reasons. However, it can be said that: (a) those resources that are managed by humans (e.g., agriculture, forestry) are more suited to successful adaptation than unmanaged ecosystems; and (b) the faster the rate of change, the greater the impact. In that regard, it is very important to realize that some species will not be able to survive rapid climate changes.

Through the ages societies and living things have developed the capability to adapt to the climate's natural variability and to extreme events. Several climatic zones span the globe, and resource use and management is an ongoing challenge in each of these zones. Therefore, society could borrow from this existing large reservoir of experience and knowledge in developing policies to adapt to possible climate change. In addition, expected future economic and technological progress would provide the financial and technical resources required to better adapt to a changing climate. Nevertheless, significant costs and legal, institutional, and cultural adjustments may be necessary to implement adaptation measures.

In recognition of the uncertainties regarding the impacts of climate change on resource use and management, the following sections provide general, rather than specific, options in three categories. The appropriateness of these options for individual countries may vary depending on the specific social, environmental, and economic context.

Short-Term Research Related Options

There are a number of actions that would augment our knowledge base for making reasoned judgments about response strategies. These include:

- developing inventories, data bases, monitoring systems, and catalogues of the current state of resources and resource use and management practices;
- improving our scientific understanding of and predictive tools for critical climatic factors,

their impacts on natural resources, and their socioeconomic consequences;
- undertaking studies and assessments to gauge the resilience and adaptability of resources and their vulnerability to climate change;
- encouraging research and development by both public and private enterprises directed toward more efficient resource use and biotechnological innovation (with adequate safeguards for health, safety, and the environment), including allowing innovators to benefit from their work;
- continuing existing research and development of methods to cope with the potentially worst consequences of climate change, such as developing more drought- or salinity-resistant cultivars or using classical and modern breeding techniques to help keep farming and forestry options open, and research on agrometeorology or agroclimatology;
- increasing research on the preservation of biological resources *in situ* and *ex situ*, including investigations into the size and location of protected natural areas and conservation corridors.

Short-Term Policy Options

Some response strategies are available that are probably economically justified under present-day conditions and that could be undertaken for sound resource management reasons, even in the absence of climate change. In general, these relate to improving the efficiency of natural resource use, fuller utilization of the "harvested" component of resources, and waste reduction. Measures that could be implemented in the short term include:

- increased emphasis on the development and adoption of technologies that may increase the productivity or efficiency (per unit of land or water) of crops, forests, livestock, fisheries, and human settlements, consistent with the principles of sustainable development. Such efficiencies reduce the demand for land for human activities and could also help reduce emissions of greenhouse gases. Examples of specific options include more efficient milk and meat production, improved food storage and distribution, and better water management practices;
- increased promotion and strengthening of resource conservation and sustainable resource use—especially in highly vulnerable areas. Various initiatives could be explored for conserving the most sensitive and valuable resources, including strengthening conservation measures, managing development of highly vulnerable resources, and promoting reforestation and afforestation;
- acceleration of economic development efforts in developing countries. Because these countries often have largely resource-based economies, efforts at improving agriculture and natural resource use would be particularly beneficial. Such efforts would also promote capital formation, which would generally make adaptation to climate change and sustainable development more feasible;
- developing methods whereby local populations and resource users gain a stake in conservation and sustainable resource use—for example, by investing resource users with clear property rights and long-term tenure, and allowing voluntary water transfer or other market mechanisms;
- decentralizing, as practicable, decision making on resource use and management.

Longer-Term Options

There are also a number of other possible responses that are costly or otherwise appear to be more appropriate for consideration in the longer term, once uncertainties regarding climate change impacts are reduced. Options in this category include:

- building large capital structures (such as dams) to provide for enhanced availability of water and other resources;
- strengthening and enlarging protected natural areas and examining the feasibility of establishing conservation corridors to enhance the adaptation prospects for unmanaged ecosystems;
- as appropriate, reviewing and eliminating direct and indirect subsidies and incentives for inefficient resource use, and other institutional barriers to efficient resource use.

7. MECHANISMS FOR IMPLEMENTING RESPONSE STRATEGIES

The RSWG also considered several priority areas that must be addressed in order to adequately implement limitation or adaptation responses. These "implementation mechanisms" represent the primary vehicles through which national, regional, and international responses to climate can be brought into force. The specific implementation mechanisms considered were:

- public education and information;
- technology development and transfer;
- economic (market) mechanisms;
- financial mechanisms; and
- legal and institutional mechanisms, including possible elements of a framework convention on climate change.

The results of the RSWG's deliberations on these issues are provided below.

7.1 PUBLIC EDUCATION AND INFORMATION

A well-informed global population is essential for addressing and coping with an issue as complex as climate change. Because climate change would affect, either directly or indirectly, almost every sector of society, broad global understanding of the issue will facilitate the adoption and implementation of such response options as deemed necessary and appropriate. The dissemination of information also represents a powerful economic instrument for ensuring that markets accurately take into account potential consequences and/or opportunities of climate change.

The core aims of public education and information programmes are to:

- promote awareness and knowledge of climate change issues;
- provide guidance for positive practices to limit and/or adapt to climate change;
- encourage wide participation of all sectors of the population of all countries, both developed and developing, in addressing climate change issues and developing appropriate responses; and
- especially emphasize key target groups, such as children and youth, as well as individuals at household levels, policymakers and leaders, media, educational institutions, scientists, business and agricultural sectors.

Given the importance of a well-informed population, the RSWG developed suggestions and approaches for improving international awareness of the potential causes and impacts of climate change. In this process it was recognized that, while broad-based understanding is essential, no single mechanism can work for every group or in every culture or country. The social, economic, and cultural diversity of nations will likely require educational approaches and information tailored to the specific requirements and resources of particular locales, countries, or regions. The importance of education and information for developing countries cannot be overemphasized.

A number of national and international actions should be taken to disseminate broadly information on climate change. These include the:

- establishment of national committees or clearinghouses to collect, develop, and disseminate objective materials on climate change issues. This could help provide focal points for information on issues such as energy efficiency, energy savings, forestry, agriculture, etc.;
- use by international organizations (UNESCO, UNEP, WMO, etc.) and non-governmental organizations of IPCC and other relevant reports in developing and providing to all countries an adequate understanding for future actions;
- use of an existing international institution, or development of a new institution, if necessary, to serve as a clearinghouse for informational and educational materials;
- upon completion of the IPCC reports, or earlier, arranging a series of short seminars targeted to inform high-priority decision makers, world leaders, and others of causes and effects of climate change.

7.2 Technology Development and Transfer

The development and transfer of technologies are vital to any effort to address global climate change. The development of new technologies may provide the means by which societies can meet their energy, food, and other needs in the face of changes in global climate, while at the same time minimizing emissions of greenhouse gases. Prompt transfer of technologies, especially to developing countries, is likewise an important aspect of any effort to limit or adapt to climate change.

Technology Research and Development

Technological development, including improvement and reassessment of existing technologies, is needed to limit or reduce anthropogenic greenhouse gas emissions; absorb such gases by protecting and increasing sinks; adapt human activities and resource use and management to the impacts of climate change; and detect, monitor, and predict climate change and its impacts. Technological development could be pursued in a wide range of activities such as energy, industry, agriculture, transport, water supply, coastal protection, management of natural resources, and housing and building construction.

Adequate and trained human resources are a prerequisite for development and transfer of technologies, and technological actions, founded on a sound scientific basis, must be consistent with the concept of sustainable development.

Criteria for selecting technologies include such factors as the existence of economic and social benefits in addition to environmental benefits, economic efficiency taking into account all the external costs, suitability to local needs, ease of administration, information needs, and acceptability to the public.

Appropriate pricing policies where applicable, information exchange on the state of development of technologies, and the support of governments are important measures that can promote technology development. Also of importance are international collaborative efforts, especially between the industrialized and the developing countries in the bilateral and multilateral context.

Technology Transfer

There is a need for the rapid transfer to the developing countries, on a preferential basis, of technologies for addressing climate change. Developing countries are of the view that transfer of technologies on a noncommercial basis is necessary and that specific bilateral and multilateral arrangements should be established to promote this. Some other countries where technologies are not owned by the government believe that transfer of technologies would be a function of commercial negotiations. The issue of intellectual property rights also presents a case where international opinion is mixed.

A number of impediments also exist that hinder the effective transfer of technologies to developing countries. These include lack of financial resources, necessary institutions, and trained human resources. Existing institutions could be strengthened, or new mechanisms established, where appropriate, to finance technology transfers, train human resources, and evaluate, introduce, and operate existing or new technologies. Legal barriers and restrictive trade practices are also impeding factors.

It has not been possible to bridge the difference on views on some of the questions mentioned above. It is extremely important to reach early international agreement on these issues in order to promote effective flow of technologies to monitor, limit, or adapt to climate change. One area where international agreement may be possible is the promotion of CFC substitutes and provision of assistance and cooperation to the developing countries in the acquisition and manufacture of such substitutes.

Several countries have suggested that the issue of technology transfer to Eastern European countries be addressed.

7.3 Economic Mechanisms

It is important that any potential measures to limit or adapt to global climate change be as economically efficient and cost-effective as possible, while taking into account important social implications. In general, environmental objectives can be achieved either through regulations requiring the use of a

specific technology or attainment of specific goals, or economic instruments such as emissions fees, subsidies, tradeable permits, or sanctions.

Economic instruments, through their encouragement of flexible selection of abatement measures, frequently offer the possibility of achieving environmental improvements at lower cost than regulatory mechanisms. Unlike many regulations, they tend to encourage innovation and the development of improved technologies and practices for reducing emissions. Economic mechanisms also have the potential to provide the signals necessary for more environmentally sensitive operation of markets. It is unlikely, however, that economic instruments will be applicable to all circumstances.

Three factors are considered as potential barriers to the operation of markets and/or the achievement of environmental objectives through market mechanisms. These are: *information problems*, which can often cause markets to produce less effective or unfavorable environmental outcomes; *existing measures and institutions*, which can encourage individuals to behave in environmentally damaging ways; and *balancing competing objectives* (social, environmental, and economic). An initial response strategy may therefore be to address information problems directly and to review existing measures that may be barriers. For example, prior to possible adoption of a system of emission charges, countries should examine existing subsidies and tax incentives on energy and other relevant greenhouse gas producing sectors.

A general advantage of market based *economic instruments* is that they encourage limitations or reductions in emissions by those who can achieve them at least cost. They also provide an ongoing incentive for industry and individual consumers to apply the most efficient limitation/reduction measures through, for example, more efficient and cleaner technologies. Such incentives may be lacking in the case of regulations.

Regulations are the customary means of controlling pollution in both market and centrally planned economies. An advantage of regulations is that, in certain circumstances, they create more certainty as to desired outcomes, whereas major disadvantages are that they may discourage innovation, introduce inflexibilities in meeting objectives, can discourage resource use efficiency, and offer few or no incentives to reduce emissions below specified levels.

It is evident that the question of adoption of any form of economic instrument, whether domestically or internationally, raises many complex and difficult issues. Careful and substantive analysis of all implications of such instruments that have been identified for consideration include:

- *A system of tradeable emissions permits:* An emission permit system is based on the concept that the economic costs of attaining a given environmental goal can be minimized by allowing for the trading of emissions rights. Once an overall limit on emissions has been set, emissions entitlements amounting to that limit could be provided to emitting sources and free trading of such entitlements allowed. This would reduce the costs of meeting a given emission target because: (a) as in trade, comparative advantages between trading entities would be maximized; and (b) economic incentives would be created for the development of improved greenhouse gas limitation technologies, sink enhancement, and resource use efficiency (energy conservation). Concerns with this approach include the limited experience with this instrument, the potential scope and size of trading markets, and the need for the development of an administrative structure not currently in place.
- *A system of emission charges:* Emission charges are levied on specified emissions depending on their level of contribution to climate change. Such changes may provide a means of encouraging emitters to limit or reduce emissions and provide an incentive for diverse parties to implement efficient means of limiting or reducing emissions. Another advantage of charges is that they generate revenue that could provide a funding base for further pollution abatement, research, and administration, or allow other taxes to be lowered. Concerns with this approach include the difficulty of deciding on the basis and size of the tax, and the lack of certainty that the tax will achieve the agreed emission reduction target.
- *Subsidies:* Subsidies are aimed at encouraging environmentally sound actions by lowering their costs. Subsidies could be used, *inter alia*, to encourage the use of energy-efficient equipment and non-fossil energy sources, and the

development and greater use of environmentally sound technologies. Concerns with subsidies include the possible size of the required financial commitment of governments, the need for careful design, the need for review, and the international trade aspects of such measures.

- *Sanctions.* A final type of economic instrument is the use of economic sanctions for the enforcement of international agreements. This would require an international convention to establish a system of agreed trade or financial sanctions to be imposed on countries not adhering to agreed regimes. Many contributors expressed considerable reservations about applying this approach to greenhouse gas emissions because of the complexity of the situation. The concerns include a belief that sanctions could appear to be arbitrary, could create confusion and resentment, and could be used as a pretext to impose new non-tariff trade barriers.

It has also been suggested that environmental protection could be advanced and the economic costs of meeting greenhouse gas limitation targets, if any, minimized by addressing, to the extent feasible, all greenhouse gas sources and sinks comprehensively. This approach could employ an "index" relating net emissions of various greenhouse gases by further development of the index formulated by Working Group I.

Each of the approaches outlined above, however, poses potentially significant challenges in terms of implementation and acceptability. There is an incomplete understanding of the economic and social consequences of these various approaches. It is evident that further work is required in all countries, and in ongoing IPCC work, to fully evaluate the practicality of such measures and costs and benefits associated with different mechanisms, especially with their use internationally. It has, however, been pointed out that an international system of tradeable permits, or, alternatively, an international system of emissions charges, could offer the potential of serving as a cost-efficient main instrument for achieving a defined target for the reduction of greenhouse gas emissions.

Finally, it was stressed that in order to share equitably the economic burdens, implementation of any of the international economic instruments discussed above should take into account the circumstances that most emissions affecting the atmosphere at present originated in the industrialized countries where the scope for change is the greatest, and that, under present conditions, emissions from developing countries are growing and may need to grow in order to meet their development requirements and thus, over time, are likely to represent an increasingly significant percentage of global emissions. It is appreciated that each instrument assessed has a role in meeting greenhouse gas emission objectives, but the suitability of particular instruments is dependent on the particular circumstances and at this stage no measure can be considered universally superior to any other available mechanisms.

7.4 Financial Mechanisms

Industrialized and developing countries consider it important that assurances of financial mechanisms are needed for undertaking adequate measures to limit and/or adapt to climate change.

Guiding Principles

The following principles should guide the financial approach:

a) Industrialized countries and developing countries have a common responsibility in dealing with problems arising from climate change, and effective responses require a global effort.

b) Industrialized countries should take the lead and have specific responsibilities on two levels:
   (i) major part of emissions affecting the atmosphere at present originates in industrialized countries where the scope for change is greatest. Industrialized countries should adopt domestic measures to limit climate change by adapting their own economies in line with future agreements to limit emissions;
   (ii) to cooperate with developing countries in international action, without standing in the way of the latter's development, by contributing additional financial resources, by appropriate transfer of technology, by engaging in close cooperation

concerning scientific observation, by analysis and research, and finally by means of technical cooperation geared to forestalling and managing environmental problems.

c) Emissions from developing countries are growing and may need to grow in order to meet their development requirements and thus, over time, are likely to represent in increasingly significant percentage of global emissions. Developing countries should, within the limits feasible, take measures to suitably adapt their economies. Financial resources channeled to developing countries would be most effective if focused on those activities that contribute both to limiting greenhouse gas emissions and promoting economic development. Areas for cooperation and assistance could include:
   - efficient use of energy resources and the increased use of fossil fuels with lower greenhouse gas emission rates or non-fossil sources;
   - rational forest management practices and agricultural techniques that reduce greenhouse gas emissions;
   - facilitating technology transfer and technology development;
   - measures that enhance the capacity of developing countries to develop programmes to address climate change, including research and development activities and public awareness and education;
   - participation by developing countries in international forums on global climate change, such as the IPCC.

It was also recognized that cooperation and assistance for adaptive measures would be required, noting that for some regions and countries, adaptation rather than limitation activities are potentially most important.

A number of possible sources for generating financial resources were considered. These include general taxation, specific taxation on greenhouse gas emissions, and emissions trading. For the significant complexities and implications of such taxes, reference is made to the economic measures paper (section 7.3). Creative suggestions include using undisbursed official resources, which might result from savings on government energy bills and lower levels of military expenditures, a fixed percentage tax on travel tickets, and levies on countries that have been unable to meet their obligations. The question has also been raised of whether such financial cooperation and assistance should be given only to those countries that abstain from activities producing greenhouse gases. A positive international economic environment, including further reduction of trade barriers and implementation of more equitable trade practices, would help to generate resources that can be applied toward pressing needs.

With respect to institutional mechanisms for providing financial cooperation and assistance to developing countries, a two-track approach was considered.

i) One track built on work under way or planned in existing institutions. In this regard, the World Bank, a number of regional banks, other multilateral organizations, and bilateral agencies have initiated efforts to incorporate global climate change issues into their programmes. Bilateral donors could further integrate and reinforce the environmental components of their assistance programmes and develop co-financing arrangements with multilateral institutions while ensuring that this does not impose inappropriate environmental conditions.

ii) Parallel to this track the possibility of new mechanisms and facilities was considered. Some developing and industrialized countries suggested that new mechanisms directly related to a future climate convention and protocols, such as a new international fund, were required. It was added that such new instruments could be located within the World Bank (with new rules) or elsewhere. It was also noted that the Global Environmental Facility proposed by the World Bank in collaboration with UNEP and UNDP was welcomed by industrialized and developing countries at the World Bank Development Committee meeting in May 1990.

It was noted that the issue of generating financial resources was distinct from that of allocating those resources.

Areas identified for future work include studies, with donor assistance, for developing countries on their current and projected net emissions levels and assistance and cooperation needs for limiting such emissions. Further consideration is also needed of the important role which the private sector might play, through technology transfer, foreign direct investment, and other means to assist and cooperate with developing countries to respond to climate change.

7.5 Legal and Institutional Mechanisms

A number of institutions and international legal mechanisms exist that have a bearing on the climate change issue, in particular those dealing with the environment, science and technology, energy, natural resources, and financial assistance. One of these existing international legal mechanisms, the Vienna Convention on the Protection of the Ozone Layer and its associated Montreal Protocol on Substances that Deplete the Ozone Layer, deals specifically with reducing emissions of important greenhouse gases that also deplete the ozone layer. However, there is a general view that, while existing legal instruments and institutions related to climate change should be fully utilized and further strengthened, they are insufficient alone to meet the challenge.

A consensus emerged at the 44th session of the UN General Assembly on the need to prepare as a matter of urgency a framework convention on climate change, laying down, as a minimum, general principles and obligations. It should, in the view of RSWG, be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced range of countries while permitting timely action to be taken. It may contain provisions for separate annexes/protocol(s) to deal with specific obligations. As part of the commitment of the parties to action on greenhouse gas emissions and adverse effects of climate change, the convention should also address the particular financial and other needs of the developing countries (notably those most vulnerable to climate change agriculturally or otherwise), the question of access to and transfer of technology, the need for research and monitoring, and institutional requirements.

Decisions will have to be taken on a number of key issues. These include:

- the political imperative of striking the correct balances (a) between the arguments for a far-reaching, action-oriented convention and the need for urgent adoption of a convention so as to begin tackling the problem of climate change; and (b) among the risks of inaction, the costs of action, and current levels of scientific uncertainty;
- the extent to which specific obligations, particularly on the control of emissions of greenhouse gases, should be included in the convention itself, possibly as annexes, or be the subject of a separate protocol(s);
- the timing of negotiation of protocol(s) in relation to the negotiations on the convention;
- the introduction, as appropriate, of sound scientific bases for establishing emission targets (such as total emission levels, per capita emissions, emissions per GNP, emissions per energy use, climatic conditions, past performance, geographic characteristics, fossil fuel resource base, carbon intensity per unit of energy, energy intensity per GNP, socio-economic costs and benefits, or other equitable considerations);
- the extent to which specific goals with respect to global levels of emissions or atmospheric concentrations of greenhouse gases should be addressed;
- whether obligations should be equitably differentiated according to countries' respective responsibilities for causing and combating climate change and their level of development;
- the need for additional resources for developing countries and the manner in which this should be addressed, particularly in terms of the nature, size, and conditions of the funding, even if detailed arrangements form the subject of a separate protocol;
- the basis on which the promotion of the development and transfer of technology and provision of technical assistance and cooperation to developing countries should take place, taking into account considerations such as terms of transfer (preferential or non-preferential, commercial or non-commercial), assured access, intellectual property rights, the environmental

soundness of such technology, and the financial implications;

- the nature of any new institutions to be created by the convention (such as Conference of the Parties, an Executive Organ, as well as other bodies), together with their functions, composition and decision-making powers, e.g., whether or not they should exercise supervision and control over the obligations undertaken.

The international negotiation on a framework convention should start as quickly as possible after the completion of the IPCC interim report. The full and effective participation of developing countries in this process is essential. Many, essentially developing, countries stressed that the negotiation must be conducted in the forum, manner, and with the timing to be decided by the UN General Assembly. This understanding also applies to any associated protocols. In the view of many countries and international and non-governmental organizations, the process should be conducted with a view of concluding it not later than the 1992 UN Conference on Environment and Development.

The foregoing does not necessarily constitute an exclusive list of issues that will arise in the negotiations. However, a readiness to address these fundamental problems will be a prerequisite for ensuring the success of the negotiations and the support of a sufficiently wide and representative spread of nations. The legal measures topic paper developed by the Working Group is given in Annex I.

ANNEX I

LEGAL AND INSTITUTIONAL MECHANISMS

EXECUTIVE SUMMARY

1) The coordinators' report has as its primary objective the compilation of elements that might be included in a future framework Convention on Climate Change, and a discussion of the issues that are likely to arise in the context of developing those elements.

2) There is a general view that while existing legal instruments and institutions with a bearing on climate should be fully utilized and further strengthened, they are insufficient alone to meet the challenge. A very broad international consensus has therefore emerged in the IPCC, confirmed notably at the 44th United Nations General Assembly, on the need for a framework Convention on Climate Change. Such a Convention should generally follow the format of the Vienna Convention for the Protection of the Ozone Layer, in laying down, as a minimum, general principles and obligations. It should further be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced spread of countries while permitting timely action to be taken; it should contain provision for separate annexes/protocols to deal with specific obligations. As part of the commitment of the parties to action on greenhouse gas emissions and the adverse effects of global warming, the Convention would also address the particular financial needs of the developing countries, the question of the access to and transfer of technology, and institutional requirements.

3) The paper points out a number of issues to be decided in the negotiation of a Convention. In general these are:

- the political imperative of striking the correct balances: on the one hand, between the arguments for a far-reaching, action-oriented Convention and the need for urgent adoption of such a Convention so as to begin tackling the problem of climate change; and, on the other hand, between the cost of inaction and the lack of scientific certainty;
- the extent to which specific obligations, particularly on the control of emissions of carbon dioxide and other greenhouse gases, should be included in the Convention itself or be the subject of separate protocol(s):
- the timing of negotiations of such protocol(s) in relation to the negotiations on the Convention.

4) In particular, within the Convention the following specific issues will need to be addressed:

(a) *Financial needs of developing countries.* The need for additional resources for developing countries and the manner in

which this should be addressed, particularly in terms of the nature, size, and conditions of the funding, even if detailed arrangements form the subject of a separate protocol, will have to be considered by the negotiating parties.

(b) *Development and transfer of technology.* The basis on which the promotion of the development and transfer of technology and provision of technical assistance to developing countries should take place will need to be elaborated, taking into account considerations such as terms of transfer, assured access, intellectual property rights, and the environmental soundness of such technology.

(c) *Institutions.* Views differ substantially on the role and powers of the institutions to be created by the Convention, particularly in exercising supervision and control over the obligations undertaken.

5) The inclusion of any particular element in the paper does not imply consensus with respect to that element, or the agreement of any particular government to include that element in a Convention.

6) The coordinators have not sought to make a value judgment in listing and summarizing in the attached paper the elements proposed for inclusion in a framework Convention: their text seeks merely to assist the future negotiators in their task. They note, however, that a readiness to address the foregoing fundamental problems in a realistic manner will be a prerequisite for ensuring the success of the negotiations and the support of a sufficiently wide and representative spread of nations.

Possible Elements for Inclusion in a Framework Convention on Climate Change

PREAMBLE

In keeping with common treaty practice including the format of the Vienna Convention, the Climate Change Convention would contain a preamble which might seek to address some or all of the following items:

- a description of the problem and reasons for action (need for timely and effective response without awaiting absolute scientific certainty);
- reference to relevant international legal instruments (such as the Vienna Convention and Montreal Protocol) and declarations (such as UNGA Resolution 43/53 and Principle 21 of the Stockholm Declaration);
- recognition that climate change is a common concern of mankind, affects humanity as a whole, and should be approached within a global framework, without prejudice to the sovereignty of states over the airspace superadjacent to their territory as recognized under international law;
- recognition of the need for an environment of a quality that permits a life of dignity and well-being for present and future generations;
- reference to the balance between the sovereign right of states to exploit natural resources and the concomitant duty to protect and conserve climate for the benefit of mankind, in a manner not to diminish either;
- endorsement and elaboration of the concept of sustainable development;
- recognition of the need to improve scientific knowledge (e.g., through systematic observation) and to study the social and economic impacts of climate change, respecting national sovereignty;
- recognition of the importance of the development and transfer of technology and of the circumstances and needs, particularly financial, of developing countries; need for regulatory, supportive, and adjustment measures to take into account different levels of development and thus differing needs of countries;
- recognition of the responsibility of all countries to make efforts at the national, regional, and global levels to limit or reduce greenhouse gas emissions and prevent activities that could adversely affect climate, while bearing in mind that:
  - –most emissions affecting the atmosphere at present originate in industrialized countries where the scope for change is greatest;
  - –implementation may take place in different time frames for different categories of countries and may be qualified by the means at the disposal of individual countries and their scientific and technical capabilities;
  - –emissions from developing countries are growing and may need to grow in order to meet their development requirements and thus, over time, are likely to represent an in-

creasingly significant percentage of global emissions;

- recognition of the need to develop strategies to absorb greenhouse gases, i.e., protect and increase greenhouse gas sinks; to limit or reduce anthropogenic greenhouse gas emissions; and to adapt human activities to the impacts of climate change.

Other key issues that will have to be addressed during the development of the preambular language include:

- should mankind's interest in a viable environment be characterized as a fundamental right?
- is there an entitlement not to be subjected, directly or indirectly, to the adverse effects of climate change?
- should there be a reference to the precautionary principle?
- in view of the interrelationship among all greenhouse gases, their sources and sinks, should they be treated collectively?
- should countries be permitted to meet their aggregate global climate objectives through joint arrangements?
- should reference be made to weather modification agreements such as the ENMOD treaty as relevant legal instruments?
- is there a common interest of mankind in the development and application of technologies to protect and preserve climate?
- does the concept of sustainable development exclude or include the imposition of new conditionality in the provision of financial assistance to developing countries, and does it imply a link between the protection and preservation of the environment, including climate change, and economic development, so that both are to be secured in a coherent and consistent manner?
- should the preamble address the particular problems of countries with an agricultural system vulnerable to climate change and with limited access to capital and technologies, recognizing the link with sustainable development?
- is there a minimum standard of living that is a prerequisite to adopting response strategies to address climate change?

DEFINITIONS

As is the practice, definitions will need to be elaborated in a specific article on definitions. The terms that will need to be defined will depend on the purpose of the Convention and thus the language used by the negotiating parties.

GENERAL OBLIGATIONS

Following the format of such treaties as the Vienna Convention, an article would set out the general obligations agreed to by the parties to the Convention. Such obligations may relate to, for example:

- the adoption of appropriate measures to protect against the adverse effects of climate change, to limit, reduce, adapt to, and, as far as possible, prevent climate change in accordance with the means at the disposal of individual countries and their scientific and technical capabilities; and to avoid creating other environmental problems in taking such measures;
- the protection, stabilization, and improvement of the composition of the atmosphere in order to conserve climate for the benefit of present and future generations;
- taking steps having the effect of limiting climate change but which are already justified on other grounds;
- the use of climate for peaceful purposes only, in a spirit of good neighborliness;
- cooperation by means of research, systematic observation, and information exchange in order to understand better and assess the effects of human activities on the climate and the potential adverse environmental and socio-economic impacts that could result from climate change, respecting national sovereignty;
- the encouragement of the development and transfer of relevant technologies, as well as the provision of technical and financial assistance, taking into account the particular needs of developing countries to enable them to fulfill their obligations;

- cooperation in the formulation and harmonization of policies and strategies directed at limiting, reducing, adapting to, and, as far as possible, preventing climate change;
- cooperation in the adoption of appropriate legal or administrative measures to address climate change;
- provision for bilateral, multilateral, and regional agreements or arrangements not incompatible with the Convention and any annex/protocol, including opportunities for groups of countries to fulfill the requirements on a regional or subregional basis;
- cooperation with competent international organizations effectively to meet the objectives of the Convention;
- the encouragement of and cooperation in the promotion of public education and awareness of the environmental and socio-economic impacts of greenhouse gas emissions and of climate change;
- the strengthening or modification if necessary of existing legal and institutional instruments and arrangements relating to climate change;
- a provision on funding mechanisms.

Other key issues will have to be addressed in the process of elaborating this article, such as the questions below:

- should there be a provision setting any specific goals with respect to levels of emissions (global or national) or atmospheric concentrations of greenhouse gases while ensuring stable development of the world economy, particularly stabilization by industrialized countries, as a first step, and later reduction of CO_2 emissions and emissions of other greenhouse gases not controlled by the Montreal Protocol? Such a provision would not exclude the application of more stringent national or regional emission goals than those that may be provided for in the Convention and/or any annex/protocol.
- in light of the preambular language, should there be a provision recognizing that implementation of obligations may take place in different time frames for different categories of country and/or may be qualified by the means at the disposal of individual countries and their scientific and technical capabilities?
- should there be a commitment to formulate appropriate measures such as annexes, protocols, or other legal instruments and, if so, should such formulation be on a sound scientific basis or on the basis of the best available scientific knowledge?
- in addressing the transfer of technology particularly to developing countries, what should be the terms of such transfers (i.e., commercial versus non-commercial, preferential versus non-preferential, the relationship between transfers and the protection of intellectual property rights)?
- should funding mechanisms be limited to making full use of existing mechanisms or also entail new and additional resources and mechanisms?
- should provision be made for environmental impact assessments of planned activities that are likely to cause significant climate change as well as for prior notice of such activities?
- what should be the basis of emission goals—e.g., total emission levels, per capita emissions, emissions per GNP, emissions per energy use, climatic conditions, past performance, geographic characteristics, fossil fuel resource base, carbon intensity per unit of energy, energy intensity per GNP, socio-economic costs and benefits, or other equitable considerations?
- should the particular problem of sea level rise be specifically addressed?
- is there a link between nuclear stockpiles and climate change?

INSTITUTIONS

It has been the general practice under international environmental agreements to establish various institutional mechanisms. The parties to a Climate Change Convention might, therefore, wish to make provision for a Conference of the Parties, an Executive Organ, and a Secretariat. The Conference of the Parties may, among other things: keep under continuous review the implementation of the Convention and take appropriate decisions to this end; review current scientific information; and promote harmonization of policies and strategies directed at

limiting, reducing, adapting to, and, as far as possible, preventing climate change.

Questions that will arise in developing provisions for appropriate institutional mechanisms include:

- should any of the Convention's institutions (e.g., the Conference of the Parties and/or the Executive Organ) have the ability to take decisions, *inter alia*, on response strategies or functions in respect of surveillance, verification, and compliance that would be binding on all the parties and, if so, should such an institution represent all of the parties or be composed of a limited number of parties, e.g., based on equitable geographic representation?
- what should be the role of the Secretariat?
- what should be the decision-making procedures, including voting requirements (e.g., consensus, majority)?
- if a trust fund or other financial mechanism were established under the Convention, how should it be administered?
- should scientific and/or other bodies be established on a permanent or ad hoc basis, to provide advice and make recommendations to the Conference of the Parties concerning research activities and measures to deal with climate change?
- should the composition of the above bodies reflect equitable climatic or geographic representation?
- should there be a provision for working groups, e.g., on scientific matters as well as on socio-economic impacts and response strategies?
- is there a need for innovative approaches to institutional mechanisms in the light of the nature of the climate change issue?
- what should be the role of non-governmental organizations?

RESEARCH, SYSTEMATIC OBSERVATIONS, AND ANALYSIS

It would appear to follow general practice to include provision for cooperation in research and systematic monitoring. In terms of research, each party might be called upon to undertake, initiate, and/or cooperate in, directly or through international bodies, the conduct of research on and analysis of:

- physical and chemical processes that may affect climate;
- substances, practices, processes, and activities that could modify the climate;
- techniques for monitoring and measuring greenhouse gas emission rates and their uptake by sinks;
- improved climate models, particularly for regional climates;
- environmental, social, and economic effects that could result from modifications of climate;
- alternative substances, technologies, and practices;
- environmental, social, and economic effects of response strategies;
- human activities affecting climate;
- coastal areas with particular reference to sea level rise;
- water resources; and
- energy efficiency.

The parties might also be called upon to cooperate in establishing and improving, directly or through competent international bodies, and taking fully into account national legislation and relevant ongoing activities at the national, regional, and international levels, joint or complementary programmes for systematic monitoring and analysis of climate, including a possible worldwide system; and cooperate in ensuring the collection, validation, and transmission of research, observational data, and analysis through appropriate data centers.

Other issues that will arise in developing this provision include:

- should consideration be given to the establishment of panels of experts or of an independent scientific board responsible for the coordination of data collection from the above areas of research and analysis and for periodic assessment of the data?
- should provision be made for on-site inspection?
- should there be provision for open and non-discriminatory access to meteorological data developed by all countries?
- should a specific research fund be established?

INFORMATION EXCHANGE AND REPORTING

Precedents would suggest the inclusion of a provision for the transmission of information through the Secretariat to the Conference of the Parties on measures adopted by them in implementation of the Convention and of protocols to which they are party. In an annex to the Vienna Convention, the types of information exchanged are specified and include scientific, technical, socio-economic, commercial, and legal information.

For the purposes of elaborating this provision, issues having to be addressed by the negotiating parties include the following:

- is there a need for the elaboration of a comprehensive international research programme in order to facilitate cooperation in the exchange of scientific, technological, and other information on climate change?
- should parties be obliged to report on measures they have adopted for the implementation of the Convention, with the possible inclusion of regular reporting on a comparable basis of their emissions of greenhouse gases?
- should each party additionally be called upon to develop a national inventory of emissions, strategies, and available technologies for addressing climate change? If so, the Convention might also call for the exchange of information on such inventories, strategies, and technologies.

DEVELOPMENT AND TRANSFER OF TECHNOLOGY

While the issue of technology has been addressed in the section on General Obligations, it might be considered desirable to include separate provisions on technology transfer and technical cooperation. Such provisions could call upon the parties to promote the development and transfer of technology and technical cooperation, taking into account particularly the needs of developing countries, to enable them to take measures to protect against the adverse effects of climate change, to limit, reduce, and, as far as possible, prevent climate change, or to adapt to it.

Another issue that will arise is: should special terms be attached to climate-related transfers of technology (such as a preferential and/or non-commercial basis and assured access to, and transfer of, environmentally sound technologies on favorable terms to developing countries), taking into consideration the protection of intellectual property rights?

SETTLEMENT OF DISPUTES

It would be usual international practice to include a provision on the settlement of disputes that may arise concerning the interpretation or application of the Convention and/or any annex/protocol. Provisions similar to those in the Vienna Convention for the Protection of the Ozone Layer might be employed, i.e., voluntary resort to arbitration or the International Court of Justice (with a binding award), or, if neither of those options is elected, mandatory resort to conciliation (with a recommendatory award).

OTHER PROVISIONS

It would be the usual international practice to include clauses on the following topics:

- amendment of the Convention;
- status, adoption, and amendment of annexes;
- adoption and entry into force of, and amendments to, protocols;
- signature;
- ratification;
- accession;
- right to vote;
- relationship between the Convention and any protocol(s);

- entry into force;
- reservations;
- withdrawal;
- depositary;
- authentic texts.

ANNEXES AND PROTOCOLS

The negotiating parties may wish the Convention to provide for the possibility of annexes and/or protocols. Annexes might be concluded as integral parts of the Convention, while protocols might be concluded subsequently (as in the case of the Montreal Protocol to the Vienna Convention on Protection of the Ozone Layer). While it is recognized that the Convention is to be all-encompassing, the negotiating parties will have to decide whether greenhouse gases, their sources and sinks, are to be dealt with, individually, in groups, or, comprehensively, in annexes or protocols to the Convention. The following, among others, might also be considered as possible subjects for annexes or protocols to the Convention:

- agricultural practices;
- forest management;
- funding mechanisms;
- research and systematic observations;
- energy conservation and alternative sources of energy;
- liability and compensation;
- international emissions trading;
- international taxation system;
- development and transfer of climate change-related technologies.

Issues that will arise in connection with the development of annexes and protocols include:

- timing, i.e., negotiating parties advocating a more action-oriented Convention may seek to include specific obligations in annexes as opposed to subsequent protocols and/or negotiate one or more protocols in parallel with the Convention negotiations;
- sequence, i.e., if there is to be a series of protocols, in what order should they be taken up?