Overview

Preface to the IPCC Overview

The IPCC First Assessment Report consists of

- this IPCC Overview,
- the Policymaker Summaries of the three IPCC Working Groups (concerned with assessment respectively of the science, impacts and response strategies) and the IPCC Special Committee on the Participation of Developing Countries, and
- the three reports of the Working Groups.

The Overview brings together material from the four Policymaker Summaries. It presents conclusions, proposes lines of possible action (including suggestions as to the factors which might form the basis for negotiations) and outlines further work which is required for a more complete understanding of the problems of climate change resulting from human activities.

Because the Overview cannot reflect all aspects of the problem which are presented in the three full reports of the Working Groups and the four Policymaker Summaries, it should be read in conjunction with them.

The issues, options and strategies presented in the Report are intended to assist policymakers and future negotiators in their respective tasks. Further consideration of the Report should be given by every government as it cuts across different sectors in all countries. It should be noted that the Report reflects the technical assessment of experts rather than government positions, particularly those governments that could not participate in all Working Groups of IPCC.

This Overview reflects the conclusions of the reports of (i) the three IPCC Working Groups on science, impacts, and response strategies, and (ii) the Policymaker Summaries of the IPCC Working Groups and the IPCC Special Committee on the Participation of Developing Countries.

1. Science

This section is structured similarly to the Policymaker Summary of Working Group I.

1.0.1 *We are certain of the following:*

- There is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be.

- Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it.

1.0.2 *We calculate with confidence that:*

- Some gases are potentially more effective than others at changing climate, and their relative effectiveness can be estimated. Carbon dioxide has been responsible for over half of the enhanced greenhouse effect in the past, and is likely to remain so in the future.

- Atmospheric concentrations of the long-lived gases (carbon dioxide, nitrous oxide and the CFCs) adjust only slowly to changes of emissions. Continued emissions of these gases at present rates would commit us to increased concentrations for centuries ahead. The longer emissions continue to increase at present-day rates, the greater reductions would have to be for concentrations to stabilize at a given level.

- For the four scenarios of future emissions which IPCC has developed as assumptions (ranging from one where few or no steps are taken to limit emissions, viz., Scenario A or Business-as-Usual Scenario, through others with increasing levels of controls respectively called Scenarios B, C and D), there will be a doubling of equivalent carbon dioxide concentrations from pre-industrial levels by about 2025, 2040 and 2050 in Scenarios A, B, and C respectively (see the section "Which gases are the most important?" in the Policymaker Summary of Working Group I for a description of the concept of equivalent carbon dioxide). See the Appendix for a description of the IPCC emissions scenarios.

- Stabilization of equivalent carbon dioxide concentrations at about twice the pre-industrial level would occur under Scenario D towards the end of the next century. Immediate reductions of over 60% in the net (sources minus sinks) emissions from human activities of long-lived gases would achieve stabilization of concentration at today's levels; methane concentrations would be stabilized with a 15—20% reduction.

- The human-caused emissions of carbon dioxide are much smaller than the natural exchange rates of carbon dioxide between the atmosphere and the oceans, and between the atmosphere and the terrestrial system. The natural exchange rates were, however, in close balance before human-induced emissions began; the steady anthropogenic emissions into the atmosphere represent a significant disturbance of the natural carbon cycle.

1.0.3 *Based on current model results, we predict:*

- An average 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—0.5°C per decade) assuming the IPCC Scenario A (Business-as-Usual) emissions of greenhouse gases; this is a more rapid increase than seen over the past 10,000 years. This will result in a likely increase in the global mean temperature of about 1°C above the present value by 2025 (about 2°C above that in the pre-industrial period), and 3°C above today's value before the end of the next century (about 4°C above pre-industrial). The rise will not be steady because of other factors.

- Under the other IPCC emissions scenarios which assume progressively increasing levels of controls, rates of increase in global mean temperature of about 0.2°C per decade (Scenario B), just above 0.1°C per decade (Scenario C) and about 0.1°C per decade (Scenario D). The rise will not be steady because of other factors.

- Land surfaces warm more rapidly than the oceans, and higher northern latitudes warm more than the global mean in winter.

- The oceans act as a heat sink and thus delay the full effect of a greenhouse warming. Therefore, we would be committed to a further temperature rise which would progressively become apparent in the ensuing decades and centuries. Models predict that as greenhouse gases increase, the realized temperature rise at any given time is between 50 and 80% of the committed temperature rise.

- Under the IPCC Scenario A (Business-as-Usual) emissions, 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), mainly due to thermal expansion of the oceans and the melting of some land ice. The predicted rise is about 20 cm in global mean sea level by 2030, and 65 cm by the end of the next century. There will be significant regional variations.

1.0.4 *With regard to uncertainties, we note that:*

- There are many uncertainties in our predictions particularly with regard to the timing, magnitude and regional patterns of climate change, especially changes in precipitation.

  - These uncertainties are due to our incomplete understanding of sources and sinks of greenhouse gases and the responses of clouds, oceans and polar ice sheets to a change of the radiative forcing caused by increasing greenhouse gas concentrations.

  - These processes are already partially understood, and we are confident that the uncertainties can be reduced by further research. However, the complexity of the system means that we cannot rule out surprises.

1.0.5 *Our judgement is that:*

- Global mean surface air temperature has increased by 0.3 to 0.6°C over the last 100 years, with the five global-average warmest years being in the 1980's. Over the same period global sea-level increased by 10 to 20 cm. These increases have not been smooth in time, nor uniform over the globe.

- The size of the warming over the last century is broadly consistent with the prediction by climate models, but is also of the same magnitude as natural climate variability. If the sole cause of the observed warming were the human-made greenhouse effect, then the implied climate sensitivity would be near the lower end of the range inferred from models. Thus the observed increase could be largely due to this natural variability; alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.

- Measurements from ice cores going back 160,000 years show that the Earth's temperature closely paralleled the amount of carbon dioxide and methane in the atmosphere. Although we do not know the details of cause and effect, calculations indicate that changes in these greenhouse gases were part, but not all, of the reasons for the large (5—7°C) global temperature swings between ice ages and interglacial periods.

- Natural sources and sinks of greenhouse gases are sensitive to a change in climate. Although many of the response (feedback) processes are poorly understood, it appears that, as climate warms, these feedbacks will lead to an overall increase, rather than a decrease, in natural greenhouse gas abundances. For this reason, climate change is likely to be greater than the estimates given above.

2. Impacts

2.0.1 The report on impacts of Working Group II is based on the work of a number of subgroups, using independent studies which have used different methodologies. Based on the existing literature, the studies have used several scenarios to assess the potential impacts of climate change. These have the features of:

i) an effective doubling of CO_2 in the atmosphere between now and 2025 to 2050;

ii) a consequent increase of global mean temperature in the range of 1.5°C to 4.5°C;

iii) an unequal global distribution of this temperature increase, namely a smaller increase of half the global mean in the tropical regions and a larger increase of twice the global mean in the polar regions;

iv) a sea-level rise of about 0.3—0.5 m by 2050 and about 1 m by 2100, together with a rise in the temperature of the surface ocean layer of between 0.2° and 2.5°C.

2.0.2 These scenarios pre-date, but are in line with, the assessment of Working Group I which, for Scenario A (Business-as-Usual) has estimated the magnitude of sea-level rise at about 20 cm by 2030 and about 65 cm by the end of the next century. Working Group I has also predicted the increase in global mean temperatures to be about 1°C above the present value by 2025 and 3°C before the end of the next century.

2.0.3 Any predicted effects of climate change must be viewed in the context of our present dynamic and changing world. Large-scale natural events such as El Niño can cause significant impacts on agriculture and human settlement. The predicted population explosion will produce severe impacts on land use and on the demands for energy, fresh water, food and housing, which will vary from region to region according to national incomes and rates of development. In many cases, the impacts will be felt most severely in regions already under stress, mainly the developing countries. Human-induced climate change due to continued uncontrolled emissions will accentuate these impacts. For instance, climate change, pollution and ultraviolet-B radiation from ozone depletion can interact, reinforcing their damaging effects on materials and organisms. Increases in atmospheric concentrations of greenhouse gases may lead to irreversible change in the climate which could be detectable by the end of this century.

2.0.4 Comprehensive estimates of the physical and biological effects of climate change at the regional level are difficult. Confidence in regional estimates of critical climatic factors is low. This is particularly true of precipitation and soil moisture, where there is considerable disagreement between various general circulation model and palaeo-analogue results. Moreover, there are several scientific uncertainties regarding the relationship between climate change and biological effects and between these effects and socioeconomic consequences.

2.0.5 This impact study part of the Overview does not attempt to anticipate any adaptation, technological innovation or any other measures to diminish the adverse effects of climate change that will take place in the same time frame. This is especially important for heavily managed sectors, eg, agriculture, forestry and public health.

2.0.6 Finally, the issue of timing and rates of change need to be considered; there will be lags between:

i) emissions of greenhouse gases and doubling of concentrations;

ii) doubling of greenhouse gas concentrations and change in climate;

iii) changes in climate and resultant physical and biological effects; and

iv) changes in physical and ecological effects and resultant socioeconomic (including ecological) consequences. The shorter the lags, the less the ability to cope and the greater the socioeconomic impacts.

2.0.7 There is uncertainty related to these time lags. The changes will not be steady and surprises cannot be ruled out. The severity of the impacts will depend to a large degree on the rate of climate change.

2.0.8 Despite these uncertainties, Working Group II has been able to reach some major conclusions. These are presented below.

2.1 Agriculture and forestry

2.1.1 Sufficient evidence is now available from a variety of different studies to indicate that changes of climate would have an important effect on agriculture and livestock. Studies have not yet conclusively determined whether, on average, global agricultural potential will increase or decrease. Negative impacts could be felt at the regional level as a result of changes in weather and pests associated with climate change, and changes in ground-level ozone associated with pollutants, necessitating innovations in technology and agricultural management practices. There may be severe effects in some regions, particularly decline in production in regions of high present-day vulnerability that are least able to adjust. These include Brazil, Peru, the Sahel Region of Africa, Southeast Asia, and the Asian region of the USSR and China. There is a possibility that potential productivity of high and mid latitudes may increase because of a prolonged growing season, but it is not likely to open up large new areas for production and it will be mainly confined to the Northern Hemisphere.

2.1.2 Patterns of agricultural trade could be altered by decreased cereal production in some of the currently high-production areas, such as western Europe, southern USA, parts of South America and western Australia. Horticultural production in mid-latitude regions may be reduced. On the other hand, cereal production could increase in northern Europe. Policy responses directed to breeding new plant cultivars, and agricultural management designed to cope with changed climate conditions, could lessen the severity of regional impacts. On the balance, the evidence suggests that in the face of estimated changes of climate, food production at the global level can be maintained at essentially the same level as would have occurred without climate change; however, the cost of achieving this is unclear. Nonetheless, climate change may intensify difficulties in coping with rapid population growth. An increase or change in UV-B radiation at ground level resulting from the depletion of stratospheric ozone will have a negative impact on crops and livestock.

2.1.3 The rotation period of forests is long and current forests will mature and decline during a climate in which they are increasingly more poorly adapted. Actual impacts depend on the physiological adaptability of trees and the host-parasite relationship. Large losses from both factors in the form of forest declines can occur. Losses from wildfire will be increasingly extensive. The climate zones which control species distribution will move poleward and to higher elevations. Managed forests require large inputs in terms of choice of seedlot and spacing, thinning and protection. They provide a variety of products from fuel to food.

2.1.4 The degree of dependency on products varies among countries, as does the ability to cope with and to withstand loss. The most sensitive areas will be where species are close to their biological limits in terms of temperature and moisture. This is likely to be, for example, in semi-arid areas. Social stresses can be expected to increase and consequent anthropogenic damage to forests may occur. These increased and non-sustainable uses will place more pressure on forest investments, forest conservation and sound forest management.

2.2 Natural terrestrial ecosystems

2.2.1 Natural terrestrial ecosystems could face significant consequences as a result of the global increases in the atmospheric concentrations of greenhouse gases and the associated climatic changes. Projected changes in temperature and precipitation suggest that climatic zones could shift several hundred kilometres towards the poles over the next fifty years. Flora and fauna would lag behind these climatic shifts, surviving in their present location and, therefore, could find themselves in a different climatic regime. These regimes may be more or less hospitable and, therefore, could increase productivity for some species and decrease that of others. Ecosystems are not expected to move as a single unit, but would have a new structure as a consequence of alterations in distribution and abundance of species.

2.2.2 The rate of projected climate changes is the major factor determining the type and degree of climatic impacts on natural terrestrial ecosystems. These rates are likely to be faster than the ability of some species to respond and responses may be sudden or gradual.

2.2.3 Some species could be lost owing to increased stress leading to a reduction of global biological diversity. Increased incidence of disturbances such as pest outbreaks and fire are likely to occur in some areas and these could enhance projected ecosystem changes.

2.2.4 Consequences of CO_2 enrichment and climate change for natural terrestrial ecosystems could be modified by other environmental factors, both natural and man-induced (e.g. by air pollution).

2.2.5 Most at risk are those communities in which the options for adaptability are limited (e.g. montane, alpine, polar, island and coastal communities, remnant vegetation, and heritage sites and reserves) and those communities where climatic changes add to existing stresses. The socioeconomic consequences of these impacts will be significant, especially for those regions of the globe where societies and related economies are dependent on natural terrestrial ecosystems for their welfare. Changes in the availability of food, fuel, medicine, construction material and income are possible as these ecosystems are changed. Important fibre products could also be affected in some regions.

2.3 Hydrology and water resources

2.3.1 Relatively small climate changes can cause large water resource problems in many areas, especially arid and semi-arid regions and those humid areas where demand or pollution has led to water scarcity. Little is known about regional details of greenhouse-gas-induced hydro-meteorological change. It appears that many areas will have increased precipitation, soil moisture and water storage, thus altering patterns of agricultural, ecosystem and other water use. Water availability will decrease in other areas, a most important factor for already marginal situations, such as the Sahelian zone in Africa. This has significant implications for agriculture, for water storage and distribution, and for generation of hydroelectric power. In some limited areas, for example, under an assumed scenario of a 1°C to 2°C temperature increase, coupled with a 10% reduction in precipitation, a 40—70% reduction in annual runoff could occur. Regions such as southern Asia, that are dependent on unregulated river systems, are particularly vulnerable to hydrometeorological change. On the other hand, regions such as the western USSR and western United States that have large regulated water resource systems are less sensitive to the range of hydrometeorological changes in the assumed scenario. In addition to changes in water supply, water demand may also change through human efforts to conserve, and through improved growth efficiency of plants in a higher CO_2 environment. Net socioeconomic consequences must consider both supply and demand for water. Future design in water resource engineering will need to take possible impacts into account when considering structures with a life span to the end of the next century. Where precipitation increases, water management practices, such as urban storm drainage systems, may require upgrading in capacity. Change in drought risk represents potentially the most serious impact of climate change on agriculture at both regional and global levels.

2.4 Human settlements, energy, transport, and industrial sectors, human health and air quality

2.4.1 The most vulnerable human settlements are those especially exposed to natural hazards, e g coastal or river flooding, severe drought, landslides, severe wind storms and tropical cyclones. The most vulnerable populations are in developing countries, in the lower-income groups: residents of coastal lowlands and islands, populations in semi-arid grasslands, and the urban poor in squatter settlements, slums and shanty towns, especially in megacities. In coastal lowlands such as in Bangladesh, China and Egypt, as well as in small island nations, inundation due to sea-level rise and storm surges could lead to significant movements of people. Major health impacts are possible, especially in large urban areas, owing to changes in availability of water and food and increased health problems due to heat stress spreading of infections. Changes in precipitation and temperature could radically alter the patterns of vector-borne and viral diseases by shifting them to higher latitudes, thus putting large populations at risk. As similar events have in the past, these changes could initiate large migrations of people, leading over a number of years to severe disruptions of settlement patterns and social instability in some areas.

2.4.2 Global warming can be expected to affect the availability of water resources and biomass, both major sources of energy in many developing countries. These effects are likely to differ between and within regions with some areas losing and others gaining water and biomass. Such changes in areas which lose water may jeopardize energy supply and materials essential for human habitation and energy. Moreover, climate change itself is also likely to have different effects between regions on the availability of other forms of renewable energy such as wind and solar power. In developed countries some of the greatest impacts on the energy, transport and industrial sectors may be determined by policy responses to climate change such as fuel regulations, emission fees or policies promoting greater use of mass transit. In developing countries, climate-related changes in the availability and price of production resources such as energy, water, food and fibre may affect the competitive position of many industries.

2.4.3 Global warming and increased ultraviolet radiation resulting from depletion of stratospheric ozone may produce adverse impacts on air quality such as increases in ground-level ozone in some polluted urban areas. An increase of ultraviolet-B radiation intensity at the Earth's surface would increase the risk of damage to the eye and skin and may disrupt the marine food chain.

2.5 Oceans and coastal zones

2.5.1 Global warming will accelerate sea-level rise, modify ocean circulation and change marine ecosystems, with considerable socioeconomic consequences. These effects will be added to present trends of rising sea-level, and other effects that have already stressed coastal resources, such as pollution and over-harvesting. A 30—50 cm sea-level rise (projected by 2050) will threaten low islands and coastal zones. A 1 m rise by 2100 would render some island countries uninhabitable, displace tens of millions of people, seriously threaten low-lying urban areas, flood productive land, contaminate fresh water supplies and change coastlines. All of these impacts would be exacerbated if droughts and storms become more severe. Coastal protection would involve very significant costs. Rapid sea-level rise would change coastal ecology and threaten many important fisheries. Reductions in sea ice will benefit shipping, but seriously impact on ice-dependent marine mammals and birds.

2.5.2 Impacts on the global oceans will include changes in the heat balance, shifts in ocean circulation which will affect the capacity of the ocean to absorb heat and CO_2 and changes in upwelling zones associated with fisheries. Effects will vary by geographic zones, with changes in habitats, a decrease in biological diversity and shifts in marine organisms and productive zones, including commercially important species. Such regional shifts in fisheries will have major socioeconomic impacts.

2.6 Seasonal snow cover, ice and permafrost

2.6.1 The global areal extent and volume of elements of the terrestrial cryosphere (seasonal snow cover, near-surface layers of permafrost and some masses of ice) will be substantially reduced. These reductions, when reflected regionally could have significant impacts on related ecosystems and social and economic activities. Compounding these impacts in some regions is that, as a result of the associated climatic warming positive feedbacks, the reductions could be sudden rather than gradual.

2.6.2 The areal coverage of seasonal snow and its duration are projected to decrease in most regions, particularly at mid latitudes, with some regions at high latitudes possibly experiencing increases in seasonal snow cover. Changes in the volume of snow cover, or the length of the snow cover season, will have both positive and negative impacts on regional water resources (as a result of changes in the volume and the timing of runoff from snowmelt), on regional transportation (road, marine, air and rail), and on recreation sectors.

2.6.3 Globally, the ice contained in glaciers and ice sheets is projected to decrease, with regional responses complicated by the effect of increased snowfall in some areas which could lead to accumulation of ice. Glacial recession will have significant implications for local and regional water resources, and thus impact on water availability and on hydroelectric power potential. Glacial recession and loss of ice from ice sheets will also contribute to sea-level rise. Permafrost, which currently underlies 20—25% of the land mass of the Northern Hemisphere, could experience significant degradation within the next 40—50 years. Projected increases in the thickness of the freeze-thaw (active) layer above the permafrost and a recession of permafrost to higher latitudes and altitudes could lead to increases in terrain instability, erosion and landslides in those areas which currently contain permafrost. As a result, overlying ecosystems could be significantly altered and the integrity of man-made structures and facilities reduced, thereby influencing existing human settlements and development opportunities.

3. Response strategies

3.0.1 The consideration of climate change response strategies presents formidable difficulties for policymakers. The information available to make sound policy analyses is inadequate because of:

(a) uncertainty with respect to how effective specific response options or groups of options would be in actually averting potential climate change;

(b) uncertainty with respect to the costs, effects on economic growth, and other economic and social implications of specific response options or groups of options.

3.0.2 The IPCC recommends a programme for the development and implementation of global, comprehensive and phased action for the resolution of the global warming problem under a flexible and progressive approach.

- A major dilemma of the issue of climate change due to increasing emission of greenhouse gases in the atmosphere is that actions may be required well before many of the specific issues that are and will be raised can be analyzed more thoroughly by further research.

- The CFCs are being phased out to protect the stratospheric ozone layer. This action will also effectively slow down the rate of increase of radiative forcing of greenhouse gases in the atmosphere. Every effort should be made to find replacements that have little or no greenhouse warming potential or ozone depletion potential rather than the HCFCs and HFCs that are now being considered.

- The single largest anthropogenic source of radiative forcing is energy production and use. The energy sector accounts for an estimated 46% (with an uncertainty range of 38—54%) of the enhanced radiative forcing resulting from human activities.

- It is noted that emissions due to fossil fuel combustion amount to about 70—90% of the total anthropogenic emissions of CO_2 into the atmosphere, whereas the remaining 10—30% is due to human use of terrestrial ecosystems. A major decrease of the rate of deforestation as well as an increase in afforestation would contribute significantly to slowing the rate of CO_2 concentrations increase in the atmosphere; but it would be well below that required to stop it. This underlines that when forestry measures have been introduced, other measures to limit or reduce greenhouse emissions should not be neglected.

3.1 Roles of industrialized and developing countries

- Industrialized and developing countries have a common but varied responsibility in dealing with the problem of climate change and its adverse effects. The former should take the lead in two ways:

  i) 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.

  ii) To co-operate 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 co-operation in scientific observation, analysis and research, and finally by means of technical co-operation geared to forestalling and managing environmental problems.

- Sustainable development[1] in industrialized as well as developing countries requires proper concern for environmental protection as the basis for continued economic growth. Environmental considerations must be systematically integrated into all plans for development. The right balance must be struck between economic growth and environmental objectives.

- Emissions from developing countries are growing in order to meet their development requirements and thus, over time, are likely to represent an increasingly significant percentage of global emissions. As the greenhouse gas emissions in developing countries are increasing with their population and economic growth, rapid transfer, on a preferential basis, to developing countries, of technologies which help to monitor, limit or adapt to climate change, without hindering their economic development, is an urgent requirement. Developing countries should, within the limits feasible, take measures to suitably adapt their economies. Recognizing the poverty that prevails among the populations of developing countries, it is natural that achieving economic growth is given priority by them. Narrowing the gap between the industrialized and developing world would provide a basis for a full partnership of all nations in the world and would assist developing countries in dealing with the climate change issue.

3.2 Options

- The climate scenario studies of Working Groups I and III outline control policies on emissions that would slow global warming from the presently predicted value of about 0.3°C per decade to about 0.1°C per decade (see Appendix).

- The potentially serious consequences of climate change give sufficient reasons to begin adopting response strategies that can be justified immediately even in the face of significant uncertainties. The response strategies include:

  – phasing out of CFC emissions and careful assessment of the greenhouse gas potential of proposed substitutes;

  – efficiency improvements and conservation in energy supply, conversion and end use, in particular through improving diffusion of energy-efficient technologies, improving the efficiency of mass-produced goods, reviewing energy-related price and tariff systems to better reflect environmental costs;

  – sustainable forest management and afforestation;

  – use of cleaner, more efficient energy sources with lower or no emissions of greenhouse gases;

  – review of agriculture practices.

[1] Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs and does not imply in any way encroachment upon national sovereignty. (Annex II to decision 15/2 of the 15th session of the UNEP Governing Council, Nairobi, May 1989

- There is no single quick-fix technological option for limiting greenhouse gas emissions. Phased and flexible response strategies should be designed to enhance relevant technological research, development and deployment, including improvement and reassessment of existing technologies. Such strategies should involve opportunities for international co-operation. A comprehensive strategy addressing all aspects of the problem and reflecting environmental, economic and social costs and benefits is necessary.

- 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 take into account the need to deal with the issue of the rate of growth of the world population.

- Subject to their particular circumstances, individual nations, or groups of 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.

- A large number of options were preliminarily assessed by IPCC Working Group III. 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 Working Group 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;

  – 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.

3.2.1 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.

- In the long-term perspective, work should begin on defining criteria for selection of appropriate options which would reflect the impacts of climate change and its costs and benefits on the one hand, and social and economic costs and benefits of the options on the other.

- Consideration of measures for reducing the impacts of global climate change should begin as soon as possible, particularly with regard to disaster preparedness policies, coastal zone management and control measures for desertification, many of these being justified in their own right. Measures to limit or adapt to climate change should be as cost-effective as possible while taking into account important social implications. Limitation and adaptation should be considered as an integrated package.

- 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 should begin as soon as possible.

- Environmental objectives can be pursued through regulations and/or through market-based economic instruments. The latter, through their encouragement of flexible selection of abatement measures, tend to encourage innovation and the development of improved technologies and practices for reducing emissions and therefore frequently offer the possibility of achieving environmental improvements at lower costs than through regulatory mechanisms. It is not likely, 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:

i) information problems, which can often cause markets to produce less effective or unfavourable environmental outcomes;

ii) existing measures and institutions, which can encourage individuals to behave in environmentally damaging ways; and

iii) balancing competing objectives (social, environmental and economic).

3.2.2 An initial response strategy may therefore be to address information problems directly and to review existing measures which 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.

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

  i) one track built on work underway or planned in existing institutions. Bilateral donors could further integrate and reinforce the environmental components of their assistance programmes and develop cofinancing 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 that might be agreed upon, such as a new international fund, were required.

- Governments should undertake now:

  – accelerated and co-ordinated research programmes to reduce scientific and socioeconomic uncertainties with a view towards improving the basis for response strategies and measures;

  – review of planning in the fields of energy, industry, transportation, urban areas, coastal zones and resource use and management;

  – encouragement of beneficial behavioral and structural (e.g. transportation and housing infrastructure) changes;

  – expansion of the global ocean observing and monitoring systems.

3.2.3 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.

4. Participation of developing countries

4.0.1 It is obvious that the impact on and the participation by the developing countries in the further development of a future strategy is essential. The IPCC has attempted to address this specific issue by establishing a Special Committee on the Participation of Developing Countries and requested it to identify factors inhibiting the full participation of the developing countries in IPCC and recommend remedial measures where possible. The Committee stressed that full participation includes not only the physical presence at meetings but also the development of national competence to address all issues of concern such as the appreciation of the scientific basis of climate change, the potential impacts on society of such change and evaluations of practical response strategies for national/regional applications.

4.0.2 The factors that kept developing countries from fully participating were identified by the Special Committee as:

- insufficient information;
- insufficient communication;
- limited human resources;
- institutional difficulties;
- limited financial resources.

4.0.3 On some of these factors, the IPCC Working Groups have developed policy options which are to be found in their respective reports.

- Developing countries will, in some cases, need additional financial resources for supporting their efforts to promote activities which contribute both to limiting greenhouse gas emissions and/or adapting to the adverse effects of climate change, while at the same time promote economic development. Areas of co-operation could include, inter alia:

  – efficient use of energy resources, the use of fossil fuels with lower greenhouse gas emission rates or non-fossil sources, the development of clean and renewable energy sources, such as: biomass, wind-power, wave-power, hydroelectric and solar, wherever applicable;

  – increased rational utilization of forest products, sound forest management practices and agricultural techniques which reduce the negative effects on climate;

  – facilitating the development and transfer of clean and safe technologies in areas which could include:

+ the building and manufacturing industries;

+ public transport systems;

+ industry;

– measures which enhance the capacity of developing countries to develop programmes to address climate change, including research and development activities and public awareness and education programmes, such as:

+ the development of the human resources necessary to tackle the problem of climate change and its adverse effects;

+ the provision of study and training programmes in subjects and techniques related to climate change;

+ the provision of skilled personnel and the material necessary to organize education programmes to develop locally the skills necessary to assess climate change and combat its adverse effects;

+ the development of climate-related research programmes organized on a regional basis;

– facilitating the participation of developing countries in fora and organizations such as: the International Geosphere-Biosphere Programme, the Land-Ocean Interactions in the Coastal Zone, the Biosphere Aspects of the Hydrological Cycle, the Global Change Impact on Agriculture and Society, the World Climate Programme, the Man and the Biosphere Programme;

– facilitating participation by developing countries in international fora on global climate change such as the IPCC;

– strengthening existing education and research institutions and the development of new ones at national and regional levels.

- Further, co-operation and assistance for adaptive measures would be required, noting that for some regions and countries, adaptation rather than limitation activities are potentially most important.

- The IPCC concludes that the recommendations of the Special Committee need not and should not await the outcome of future negotiations on a climate convention. It appeals to the multilateral and bilateral funding organizations to implement its recommendations. It further appeals to governments for continuing and increased contributions to the IPCC Trust Fund on an urgent basis.

5. International co-operation and future work

- The measures noted above require a high degree of international co-operation with due respect for national sovereignty of states. The international negotiations on a framework convention should start as quickly as possible after presentation of this Report in line with Resolution SS II/3 Climate.C. (August 1990) of the UNEP Governing Council and Resolution 8 (EC-XLII, June 1990) of the WMO Executive Council. Many, essentially developing, countries stressed that the negotiations must be conducted in the forum, manner and with the timing to be decided by the UN General Assembly.

5.0.1 This convention, and any additional protocols that might be agreed upon, would provide a firm basis for effective co-operation to act on greenhouse gas emissions and adapt to any adverse effects of climate change. The convention should recognize climate change as a common concern of mankind and, 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.

5.0.2 Key issues for negotiations 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 including research and monitoring that may be required, and in particular, the requests of the developing countries for additional financial resources and for the transfer of technology on a preferential basis. The possible elements of a framework convention on climate change were identified and discussed by Working Group III in its legal measures topic paper, appended to its Policymaker Summary.

- The IPCC recommends that research regarding the science of climate change in general, technological development and the international economic implications, be intensified.

- 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 the implementation of such response options as deemed necessary and appropriate. Further efforts to achieve such global understanding are urgently needed.

APPENDIX

Emissions scenarios developed by IPCC

The IPCC used two methods to develop scenarios of future emissions:

- One method used global models to develop four scenarios which were subsequently used by Working Group I to develop scenarios of future warming. All of these four scenarios assumed the same global economic growth rates taken from the World Bank projections and the same population growth estimates taken from the United Nations studies. The anthropogenic emissions of carbon dioxide and methane from these scenarios are shown in Figures 1 and 2 below.

- The second method used studies of the energy and agriculture sectors submitted by over 21 countries and international organizations to estimate CO_2 emissions.

Both scenario approaches indicate that CO_2 emissions will grow from about 7 BtC (billion or 1000 million tonnes carbon) per year now to 12-15 BtC per year by the year 2025. Scenario A (Business-as-Usual) includes a partial phase-out of CFCs under the Montreal Protocol and lower CO_2 and CH_4 emissions than the Reference Scenario. The Reference Scenario developed through country and international studies of the energy and agriculture groups, includes higher CO_2 emissions and assumed a total CFC phase-out. The results indicate that the CO_2 equivalent concentrations and their effects on global climate are similar.

Method 1[2]

Scenario A (Business-as-Usual) 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.

Scenario B (Low Emissions Scenario) assumes that the energy supply mix of fossil fuels shifts towards natural gas, large efficiency increases are achieved, deforestation is reversed and emissions of CFCs are reduced by 50% from their 1986 levels. This results in an equivalent doubling of pre-industrial carbon dioxide by about 2040.

Scenario C (Control Policies Scenario) assumes that a shift towards renewable energies and safe nuclear energy takes place in the latter part of the next century, CFC gases are phased out and agricultural emissions (methane and nitrous oxide) are limited; an equivalent doubling of pre-industrial carbon dioxide will occur in about 2050.

Scenario D (Accelerated Policies Scenario) assumes that a rapid shift to renewable energies and safe nuclear energy takes place early in the next century, stringent emission controls in industrial countries and moderate growth of emissions in developing countries. This scenario, which assumes carbon dioxide emissions are reduced to 50% of 1985 levels, stabilizes equivalent carbon dioxide concentrations at about twice the pre-industrial levels towards the end of the next century.

Figure 1 Projected man-made CO_2 emmissions (Billion or 1000 million tonnes carbon per year)

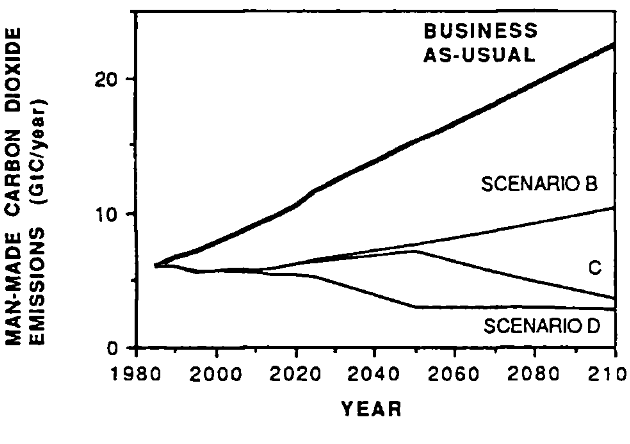
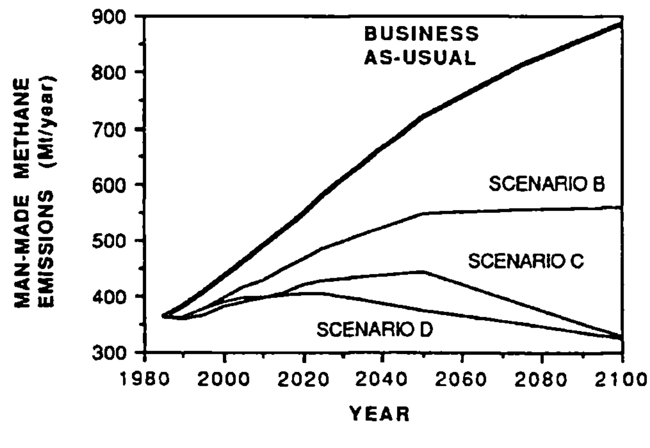


Figure 2 Projected man-made Methane emmissions (Million tonnes per year)



[2] All of the scenarios assumed some level of compliance with the Montreal Protocol but not with all of the (June 1990) amendments agreed to in London. The London amendments to the Montreal Protocol, when fully implemented, would result in a virtually complete elimination of production of fully halogenated CFCs, halons, carbon tetrachloride and methyl chloroform early in the 21st century. The Parties of the Protocol also call for later elimination of HCFCs. Thus, the assumptions of Scenarios A and B overestimate the radiative forcing potential of CFCs and halons. Additionally, the UN has provided recent population projections that estimate higher population than used in the global model scenarios (Scenarios A through D); use of these newer projections would increase future CO_2 emissions. Additionally, the Reference Scenario CO_2 emissions are higher than Scenario A (Business-as-Usual), suggesting Scenario A (Business-as-Usual) may be an underestimate.

Method 2 (see footnote 2 on previous page)

Using the second method, the so-called Reference Scenario was developed by the Energy and Industry Subgroup and Agriculture and Forestry Subgroup of Working Group III. Under the Reference Scenario, global CO_2 emissions from all sectors grow from approximately 7.0 BtC (per year) in 1985 to over 15 BtC (per year) in 2025. The energy contribution grows from about 5 BtC (per year) to over 12 BtC (per year). Primary energy demand more than doubles between 1985 and 2025 with an average growth rate of 2.1%. The per capita energy emissions in the industrialized countries increase from 3.1 tonnes carbon (TC) in 1985 to 4.7 TC in 2025; for the developing countries, they rise from 0.4 TC in 1985 to 0.8 TC in 2025.

Summary

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. No full assessment was made of the total economic costs and benefits, technological feasibility, or market potential of the underlying policy assumptions. Because of the inherent limitations in our ability to estimate future rates of population and economic growth, individual behaviour, technological innovation, and other factors which are crucial for determining emission rates over the course of the next century, there is some uncertainty in the projections of greenhouse gas emissions. Reflecting these inherent difficulties, the IPCC's work on emissions scenarios are the best estimates at this time covering emissions over the next century, but continued work to develop improved assumptions and methods for scenario estimates will be useful to guide the development of response strategies.