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FOR A FRAMEWORK CONVENTION ON CLIMATE CHANGE
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MATTERS RELATING TO COMMITMENTS

REVIEW OF THE ADEQUACY OF COMMITMENTS IN ARTICLE 4, PARAGRAPH 2 (A) AND (B)

Annotated compilation of international, peer-reviewed literature

Note by the interim secretariat

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I. INTRODUCTION

1. The Committee at its ninth and tenth sessions discussed the review of the adequacy of commitments in Article 4.2(a) and (b) and reached a number of conclusions (A/AC.237/55, paras. 50-59 and A/AC.237/76, paras. 38-54). At its ninth session, the Committee concluded, inter alia, that the review of the adequacy of commitments would be based in part on a compilation and synthesis of information on the global situation, including relevant scientific, social and economic information. The Intergovernmental Panel on Climate Change (IPCC) First Assessment Report (1990), the Supplement thereto (1992) and the Special Report (November 1994) would be key inputs to the review. At its tenth session the Committee agreed, inter alia, that at its eleventh session Working Group I would carry out, on an interim basis, the most pressing tasks of the subsidiary bodies including the tasks listed in Article 4.2(d), and make the necessary recommendations thereon to COP 1 (see A/AC.237/76, para. 22 (b)). The Committee requested the interim secretariat to prepare an annotated compilation of information on the global situation, based on available peer-reviewed scientific, technical, social and economic information contained in approved reports from the IPCC and other relevant intergovernmental bodies.

2. In selecting relevant material, the interim secretariat has taken the following approach:

(a) The compilation does not include information on the Special Report, since the Summaries for policy makers of that report will be made available by the IPCC secretariat to delegations at the eleventh session of the Committee;

(b) New material from the IPCC other than that included in the Special Report and intended for the Second Assessment Report has not been considered since it would not fulfil the criteria set by the Committee;

(c) Other IPCC reports, and in particular, those mentioned in the First Assessment Report (1990) and its Supplement (1992) have been included;

(d) In identifying "relevant intergovernmental bodies", the interim secretariat has built upon the earlier work of the Committee (see A/AC.237/41, paras. 107-113). Those United Nations entities and other international organizations listed in document A/AC.237/39 and Add.1 that, according to the information in that document, could be expected to provide relevant information, were requested to make this available. In its request, the interim secretariat specifically asked for information that had not been taken into account in the preparation of any of the above-mentioned IPCC documents; it suggested that detailed findings of a narrow scope would be less suitable for consideration by the Committee than more broadly-based assessments.

II. SCOPE OF THE NOTE AND ACTION BY THE COMMITTEE

3. The annex to this document contains, in accordance with the request from the Committee, a compilation of peer-reviewed scientific, technical, social and economic information from reports approved by the IPCC or other relevant intergovernmental bodies. The annotations consist of descriptions of the contents of compiled documents: they are not intended to summarize the information provided in the document but to give an indication of the issues addressed. Some documents that have been made available are not annotated but are only listed. In some cases, this was for technical reasons; in others, it was because the scope of the document was too limited (for example, because it provided a progress report on a programme rather than an assessment of results).

4. The compilation should not be seen as an exhaustive listing of relevant documents but as an attempt to assist the Committee in identifying some of the relevant scientific, social and economic information on the global situation beyond the recent IPCC Special Report. Intergovernmental organizations other than those indicated in paragraph 2 (d) above, as well as non-governmental organizations, may also have generated relevant information. Such organizations are requested to provide the interim secretariat with such information so that it can be included in its reference library.

5. The Committee is invited to make use of this compilation at the eleventh session. The note is intended to provide background in support of the review of the adequacy of commitments in Article 4.2(a) and (b); no discussion on the document is foreseen.

Annex

COMPILATION OF RELEVANT LITERATURE

A.I. REPORTS BY THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC),* jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)

Climate change 1992: the supplementary report to the IPCC scientific assessment, J.T. Houghton, B.A. Callander and S.K. Varney, eds., Cambridge University Press, Cambridge and New York. 198 p.

1. This report constitutes the second major contribution of IPCC Working Group I. It presents an update to the First Scientific Assessment (published in 1990), paying special attention to the key conclusions of that report and to the new issues which were brought to prominence in the international scientific debate during the eighteen months following the publication of the First Assessment. Of six tasks identified by the IPCC at its fifth session (Geneva, March 1991), this report focuses on two, namely, tasks 1 and 6.

2. Task 1 involved an assessment of current net emissions of greenhouse gases. The work involved a detailed analysis of the sources and sinks of all of the most important greenhouse gases and an estimation of the global warming potential of each gas. Task 6 initiated the development of a new set of IPCC scenarios that describe a range of possible trajectories for future greenhouse gas emissions.

3. The findings of scientific research since the publication of the First Scientific Assessment Report reinforce and strengthen the main conclusions of the 1990 Scientific Assessment Report. In addition, there were several important new scientific findings. The original main conclusions include the following:

* Emissions resulting from human activities are substantially increasing atmospheric concentrations of greenhouse gases.
* If the radiative forcing on the atmosphere that results from the aggregate effects of the buildup of all anthropogenic greenhouse gases increases to a level that is approximately equivalent to the forcing that would result from doubling the pre-industrial concentration of carbon dioxide alone, the planet will be committed to an increase in average surface temperature that is likely to be in the range of 1.5 - 4.5°C.

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* Annotations to the 1990 reports follow those to the 1992 Supplement.
See also *Climate change: the IPCC 1990 and 1992 Assessments - IPCC First Assessment Report Overview and Policymakers Summaries and 1992 IPCC Supplement.* (Available from the IPCC secretariat in Chinese, English, French and Spanish; photocopies are available in Arabic and Russian).

* Many uncertainties exist in scientific predictions of future climate change, in particular with regard to the timing, magnitude and regional patterns of future climate change.
* Global mean surface temperature increased by 0.3-0.6ºC in the last 100 years; this warming is broadly consistent with the predictions of climate models but still within the range of natural variability.
* Unequivocal detection of the enhanced greenhouse effect will take 10 years or more.

In addition, the new findings and conclusions summarized for this supplement include the following:

* Depletion of ozone in the lower stratosphere has a cooling effect which is believed to be comparable to the warming effects of chlorofluorocarbons (CFCs) over the last decade or so.
* The cooling effects of sulfate aerosols in the Northern Hemisphere may have offset a significant portion of the warming due to greenhouse gas buildup in the last several decades.
* The global warming potential remains a useful concept but its practical utility depends for many gases on better understanding of their indirect as well direct effects.
* While the rate of growth in concentration of many greenhouse gases has remained steady or increased, the growth in concentration of methane and some halogens has slowed down.
* Climate models have continued to improve in terms of their physical realism and their ability to simulate present climate on large scales.
* Transient simulations using coupled ocean/atmosphere models suggest a rate of global warming that is consistent, given the uncertainties, with the rate of 0.3ºC per decade that was projected in scenario A of the First Scientific Assessment Report.

Climate change 1992: the supplementary report to the IPCC impacts assessment, W.J.McG. Tegart and G.W. Sheldon, eds., Australian Government Publishing Service, Canberra.

4. This report represents the contribution of Working Group II to the 1992 Supplement of the IPCC. Working Group II examined aspects of four tasks for this report. These were tasks 2, 3, 4, and 5:

* prediction of the regional distributions of climate change and associated impacts studies, including model validation studies;
* energy and related industry issues;
* agriculture and forestry-related issues;
* vulnerability to sealevel rise.

5. The working group used the results of a questionnaire circulated in 1991 to define areas of concern to many countries regarding regional climate impacts. The impact areas highlighted in the responses to the questionnaire included the impacts of climate change on regional hydrology and water resources, agriculture and forestry, desertification, oceans and coastal zones, cyclones, droughts and other extreme events. National responses also showed concerns about the extent to which global climate change may increase the risks associated with climate variability, especially in those parts of the world where climate variability is known to have significant economic and social impacts. Many countries also expressed concerns about the effects of increases in UV-B radiation caused by changes in atmospheric composition and behaviour.

6. The findings of the subgroups and task forces of Working Group II reported under the four tasks reinforce the conclusions of the 1990 Scientific Assessment Report. Task 2 required a further delineation of the projections of regional distributions of climate change and the associated impacts. In terms of projections of regional climate change, the working group concludes that the prediction of regional climate change is still subject to great uncertainty, in particular changes in precipitation. The working group emphasizes that progress in the development of global circulation models is urgently needed, particularly in terms of the ability of these models to simulate the effects of global warming at the regional level. Additional work is needed regarding the changes that may result from global warming in arid and semi-arid regions.

7. To assist this process, Working Group II prepared guidelines for assessing the socio-economic and environmental impacts of potential climate change. These new guidelines outline a framework for the study of climate-environment-society interactions and the estimation of the impacts of climate change across various geographical regions and economic sectors.

8. The working group emphasizes the need to increase the available information and data to support impact studies, particularly in developing countries. This need can be addressed by enhancing and, where appropriate, establishing integrated monitoring programmes as well as constructing concurrent social and economic assessments at the national, regional, and global levels. Data quality needs to be assured and data analyses need to be carried out carefully, using common protocols including Geographical Information Systems. Monitoring of sensitive terrestrial and marine ecosystems should be given priority, along with monitoring of those species and ecosystems which have significant social and/or economic values.

9. In terms of human settlements, recent studies for the Maldives and for certain Pacific Island states have reconfirmed that small low-lying island states and large populations living in low-lying coastal areas will be increasingly vulnerable to sealevel rise, storm surges and coastal flooding, particularly if adaptive measures are inadequate.

10. With respect to task 3, the high dependency on biomass and hydro-electric energy in many developing countries indicates to the working group that these countries will remain very sensitive to the impacts of climate change. Biomass production, which many developing countries depend on for much of their energy needs, could be altered by climate change. The working group notes that there has been little new work on the socio-economic impacts of climate change in the areas of energy, human settlement, transport and industrial sectors, human health and air quality.

11. Knowledge of the effects of climate change on human health has extended and confirmed the previously reported results related to shifts in the habitats of disease vectors. Diseases such as malaria, lymphatic filariasis, schistosomiasis, leishmaniasis, onchocerciasis, dengue fever, and Australian and Japanese encephalitis could increase or be reintroduced in many countries as a result of global warming. Recent studies have linked UV-B radiation to additional effects on human health, including negative effects on the human immunosuppression system and vision.

12. New studies reinforce the working group's earlier conclusions with respect to task 4 concerning the effects of climate change on agriculture and forestry. Recent studies confirm that drought is the impact of climate change that poses the greatest risk for agriculture, and consequently arid and semi-arid regions are likely to most vulnerable to climate change. Other studies indicate that climate change may be beneficial for insect growth and abundance, with negative effects expected for crops, livestock, and forest production as a result of increased exposure to these pests.

13. The direct and indirect consequences of elevated temperatures and carbon dioxide (CO_2) concentration on agricultural production remain uncertain. Some scientists emphasize the results of studies in controlled settings which suggest the likelihood of enhanced photosynthesis and more efficient water use, while others are sceptical that these benefits will arise in farmers fields under changing climate conditions. Adaptation to climate change by the existing agricultural system should be possible in principle, and the existing systems of agricultural research should be able to provide new crop cultivars that can maintain high yields and nutritional quality. However, efforts will be needed to make such advances available to small farmers in developing countries in a timely way.

14. Further studies have confirmed the earlier conclusions of this working group that the impacts of climate change may have significant socio-economic consequences. This is especially true for those regions where economic and social welfare and economic development are highly dependent on the forest sector. Key uncertainties include:

* the extent of managed and natural forests;
* the genetics and physiology of tree species and the relationships among species;
* the distribution of regional impacts; and
* the linkages among regional impacts and socio-economic structures.

15. Recent analyses reinforce the conclusion drawn by this working group in 1990 that natural terrestrial ecosystems could face significant environmental impacts as a result of future global warming and associated climate change. These studies continue to suggest that the rate of these changes will be the principal factor in determining the type and degree of impacts, with a variety of responses expected in different regions and for different communities within ecosystems. Current projections continue to suggest that the rate of future change may be faster than some component species are able to adapt or migrate. The responses of some species and ecosystems may be sudden, potentially leading to ecosystem destabilization and degradation.

16. The working group concludes that water availability is likely to be a key factor in determining the impacts of climate change on natural ecosystems. Projected climate changes are expected to result in an accelerated reduction of tropical forest on the African continent and an encroachment of the Sahel syndrome into the savannas. Given the range of projected climate changes, profound and potentially negative impacts are expected for some important fisheries.

17. The working group observes that uncertainties and gaps continue to exist in our understanding of the environmental impacts and the socio-economic consequences of climate changes. These uncertainties are caused in part by lack of information and data on:

* fundamental ecological processes;
* the links between climate and atmospheric chemistry on the one hand and ecosystem responses on the other;
* the links between natural terrestrial ecosystem changes and social and economic welfare under a changing climate; and
* the sensitivity of ecosystems and their component species to climate change.

18. The working group notes that although a number of studies have been completed since 1990 on the impacts of climate change on hydrology, there is not yet adequate information on regions affected by aridity and desertification. The principal conclusions of these recent studies were:

* Large gaps exist in the knowledge base regarding the implications of climate change for less developed nations;
* Differences in the outputs of the global circulation models coupled with large differences in hydrologic sensitivity make it difficult to offer region-specific impact assessments;

* Temporal streamflow characteristics exhibited greater variability and amplification of extremes in nearly all regions;
* Unregulated hydrologic systems are more vulnerable to potential hydrologic alterations due to climate change.

19. With respect to task 5, recent studies confirm the earlier conclusion of this working group that rising sealevel is of more concern to low-lying coastal ecosystems than rising water temperatures. However, sealevel rise combined with temperature increases and higher levels of exposure to UV-B radiation are likely to have strong impacts on marine ecosystems, including redistributions and changes in biotic production. With respect to temperature rise, marine organisms in the tropics live closer to their maximum thermal tolerance than those in temperate climates. Most migratory organisms are expected to tolerate the increased water temperatures but temperature rise may trigger bleaching events in some corals.

20. New findings indicate that UV-B radiation reaching oceanic and coastal zone environments will increase faster than expected when the first IPCC Impacts Assessment was written. Since so many marine resources spend all or substantial parts of their lives near the water surface, there is a significant threat to some fisheries. There is also a potential risk of leaching bacteria and viral agents into the coastal waters due to the inundation of coastal septic sewerage systems.

21. The working group highlighted several issues for further consideration. The authors stress the continuing need for research on the regional impacts of climate change, especially the impacts on cyclones, storm surges, and other extreme events. The working group emphasizes the importance of country studies and the need to develop coherent guidelines for these studies. In addition, the working group stresses the importance of wide dissemination of the information developed by the IPCC and the need for increased funding of climate research activities.

Climate change 1992: the supplementary report of Working Group III, WMO and UNEP, Geneva.

22. This work summarizes the efforts of Working Group III to address tasks 3, 4, and 5 of the work programme identified by the IPCC for their 1992 Supplement to the First Scientific Assessment Report. Task 3, concerning energy and industry-related issues, was given to the Energy and Industry Subgroup (EIS) of Working Group III. This work undertaken by the EIS was further divided into ten sub-tasks.

23. The first sub-task involved conducting a comprehensive evaluation of technological options for mitigating global warming. The tentative findings include:

* a recognition that energy conservation and improved efficiency in energy supply, distribution and end-use can be one of the most effective options for mitigating greenhouse gas emissions;

* a conclusion that technologies for carbon capture and sequestration deserve further study;
* the observation that nuclear power has the technological potential to be one of the major energy sources of the next century;
* the conclusion that various existing and promising non-fossil and renewable energy technologies can contribute to energy supply without rapidly increasing the emissions of greenhouse gases; and
* the observation that the physical potential of biomass for energy use is high but in some regions limited by competition with other potential uses for arable land.

24. Sub-task 2 of the EIS developed the IPCC Technology Characterization Inventory. This inventory provides a source of consistent, documented data on a wide range of energy-related technologies. Special interest is given to technologies with relevance to the energy needs of developing countries. Data is offered in five categories:

* primary energy production technologies;
* secondary energy conservation and processing technologies;
* energy transfer technologies;
* energy end-use technologies; and
* greenhouse gas control technologies.

25. Under sub-task 3, the EIS surveyed technological options for reducing methane emissions. In many cases, the identified options provide a range of secondary benefits including reduced air pollution, better protection of surface and groundwater, enhanced productivity, reduced risk of explosion, and improved availability and use of energy resources.

26. The study developed under sub-task 4 addresses the topic of increasing electricity end-use efficiency by providing a review of the following topics:

* the status of available technologies for increasing electric end-use efficiency;
* factors that limit the deployment and use of these technologies; and
* policies to increase the efficiency of electricity use.

27. Sub-task 5 assessed the prospects for increased use of natural gas as an energy resource. This study provides a comprehensive analysis of demand and supply for natural gas out to 2005, including the institutional framework surrounding the production, transmission and use of natural gas. The primary focus is on demand for gas in the Organisation for Economic Co-operation and Development (OECD) but sources and uses outside the OECD are also addressed.

28. A thematic analysis of the road transport sector (sub-task 6) was not completed in time for the 1992 IPCC Supplement.

29. Sub-task 7 included a review of the use of biomass as a source of energy. The report concludes that bioenergy offers important opportunities to reduce greenhouse gas emissions through the displacement of fossil fuels. The report notes that some biomass combustion technologies also reduce emissions of other air pollutants.

30. Under sub-task 8, the EIS reviewed various studies of the economic impacts of greenhouse gas response measures that might be taken by industrialized countries. The studies indicated that carbon tax measures could reduce gross domestic product growth in some countries. The impacts, in principle, could be reduced if flexible, phased, comprehensive, and concerted response strategies were adopted to control greenhouse gas emissions.

31. The analysis conducted under sub-task 9 concerns the factors affecting regional and sectoral differences in energy consumption and related CO_2 emissions. The assessment indicates that such factors as economic development, population growth, energy conservation, changes in industrial structure, fuel switching, and technological advance all influence the regional and sectoral patterns of historical energy consumption and CO_2 emissions.

32. The final sub-task of the EIS assessment produced a survey of country studies and other official national studies, including greenhouse gas emissions inventories, impact studies, and emissions mitigation analyses. This survey was conducted in conjunction with UNEP. More than 50 country studies and other reports were reviewed for this survey.

33. The Agriculture and Forestry Subgroup (AFOS) of Working Group III undertook to address task 4. There were two elements in this task:

* an assessment of greenhouse gas emissions from the agriculture and forestry sectors; and
* an assessment of the technologies and management systems available in the agriculture and forestry sectors to mitigate future emissions or to adapt to future changes in climate.

34. As far as the net carbon dioxide release from agriculture is concerned, forest clearing in the tropical and subtropical regions of the world continues to be the major source. Additionally, the cultivation of virgin land in all regions leads to gradual carbon losses. Global warming may also speed up decomposition of soil organic matter, thereby releasing additional CO_2 to the atmosphere.

35. In the absence of mitigation measures, this assessment reinforced the earlier conclusions of the working group and found that methane emissions are likely to continue to increase over time. Total global emissions and emissions rates from individual sources are estimated to be essentially at the same levels as projected in the First Scientific Assessment Report.

36. The AFOS report noted that, in order to reduce the net carbon dioxide release from agriculture, improving the productivity of arable land should be given priority over the cultivation of virgin soils. In addition, in less populated areas, marginal farmland could be set aside for either rangeland or forest use. Reduced soil tillage practices, improved utilization of organic wastes as soil amendments, and adjusting crop rotations to include forage crops will all reduce carbon emissions from agriculture. The principal approaches to reducing methane emissions remain as reported in the 1990 Assessment Report.

37. The AFOS noted that forests provide human societies with a range of economically important products but those forests are increasingly being threatened by human activities in many regions. The group concluded that concerted action is needed to protect the world's forests. Four principal options were identified:

* slow current deforestation and degradation;
* increase forest biomass through improved management;
* improve the use of wood; and
* promote afforestation.

38. The Coastal Zone Management Subgroup (CZMS) undertook to address task 5, assessing the vulnerability of human societies to sealevel rise. The CZMS attempted to:

* develop a common methodology to assess vulnerability to the potential impacts of accelerated sealevel rise and consider response strategies;
* conduct a number of country studies using the identified methodology; and
* identify the needs in developing countries for strengthening the capability to develop coastal zone management programs.

39. The CZMS made 10 recommendations, including the following:

* Coastal countries which have not completed vulnerability assessments should do so now and start the planning process for appropriate response strategies.
* All countries should support research and observations on accelerated sealevel rise.
* Industrial countries and international organizations should assist developing countries in developing their national capacities to participate in international research and observations of sealevel rise.
* International organizations should support research on cost-effective response measures to assist coastal nations to adapt to the adverse impacts of sealevel rise.
* All countries should promote public education and initiatives which increase awareness of accelerated sealevel rise and other impacts of global climate change on coastal resources.

* National governments and international organizations should strengthen national, regional and international programmes and institutions with a view to coordinating the assessment of the vulnerability of coastal areas to sealevel rise and meeting the needs of vulnerable developing countries in this regard.
* All countries should recognize the effectiveness of worldwide cooperation between coastal nations and international organizations as has been developed under the IPCC framework, and give further support to the work of the CZMS.

Climate change: the IPCC scientific assessment, J.T. Houghton, G.J Jenkins and J.J. Ephraums, eds., Cambridge University Press, Cambridge and New York, 1990. 339 p.
(Also available in Chinese, French, Russian and Spanish.)

40. This report represents the contribution of IPCC Working Group I to the First Scientific Assessment Report of the IPCC. This report provides an overview of the international consensus on the science of the greenhouse problem. The report:

* summarizes what is known about the basic physics of the climate system;
* identifies the principal sources, sinks, and characteristics of the most important greenhouse gases;
* explores, on the basis of climate modelling studies, the range of climate changes that may be expected to occur if the buildup of greenhouse gases in the atmosphere reaches a level equivalent to doubling the pre-industrial concentration of carbon dioxide alone; and
* assesses the most important consequences that might arise if the future unfolds along the lines of any of four possible scenarios developed by the Subgroup on Emissions scenarios of IPCC Working Group III.

41. The authors summarize the findings in terms of five areas. These findings include:

(a) What is known with certainty today about the climate system and the future range of possible climate changes;
(b) What can be calculated with confidence today based on the best available data and analytic tools available to climate scientists;
(c) What can reasonably be predicted about likely future climate changes based on current models of the climate system;
(d) What judgments have been reached about future climate change by the mainstream elements of the international scientific community, given the persistent uncertainties that have been recognized as cascading through this problem; and
(e) What additional research needs to be done in the coming decades in order to improve our understanding of the climate system and our ability to predict the behaviour of that system in the face of uncertain future human interventions.

42. The authors conclude with certainty that there is and has been a natural greenhouse effect that raises the average temperature of the earth's surface beyond what it would have been in the absence of the greenhouse effect. They further conclude that emissions of certain radiatively active gases that result from human activities are substantially increasing the atmospheric concentrations of these gases and that these increases will cause an additional warming of the earth's surface.

43. The authors calculate with confidence that some gases are potentially more effective than others in changing climate and that the relative effectiveness of the key gases can be estimated. Because of the physics and chemistry of the atmosphere, atmospheric concentrations of some of the more long-lived of these gases adjust only slowly to changes in emissions rates. Thus, continued emissions at present rates would commit the planet to increases in atmospheric concentrations of these gases for centuries to come and the longer emissions continue to increase, the greater reductions that would be required to stabilize concentrations in the future at any given level. In particular, the authors note that to stabilize the concentrations of the long-lived gases at today's level would require reductions in emissions rates of more than 60 per cent from their 1990 levels.

44. Using the best currently available models, the working group predicts that under the IPCC 1990 business-as-usual scenario (scenario A), the global mean surface temperature would increase by about 0.3° C per decade (with an uncertainty range of 0.2°C to 0.5°C per decade). This is greater than any global temperature increase seen over the last 10,000 years. This change will not occur in the form of a simple, steady increase (due to the influence of other factors) but will likely increase global average temperature by 1°C above the present value by 2025 and by 3°C before the year 2100. Using the same models, the working group predicts that the other IPCC scenarios will cause rates of increases in global temperature varying from 0.1°C per decade to 0.2°C per decade, depending on the levels of emissions controls which are implemented.

45. The working group estimates some of the impacts of these increases in concentration. The working group predicts that land surfaces will warm more rapidly than oceans and that high northern latitudes will warm more than the global mean in winter. The regional distribution of climate changes cannot now be predicted with certainty but the regional impacts will be different from the global mean.

46. One impact whose principal mechanism is relatively well understood is the effect of global warming on sealevel rise. The working group predicts that, under the IPCC business-as-usual scenario, average global sealevel will rise by about 6 centimetres per decade during the next century (with an uncertainty range of 3-10 centimetres per decade). The predicted rise is about 20 centimetres by 2030 and 65 centimetres by 2100. The observed rise is certain to vary significantly in different regions.

47. The working group emphasizes the many sources of uncertainty which complicate our ability to predict future global climate change. They highlight, in particular, uncertainties concerning:

* future sources and sinks of greenhouse gases;
* the role and behaviour of clouds in a warming world;
* the behaviour of the oceans, especially with respect to heat transfer; and
* the processes controlling the accretion or reduction of polar ice sheets.

48. In the judgment of the working group, recent observations indicate that global mean surface temperature has increased by 0.3ºC to 0.6ºC over the last hundred years, with the five warmest years occurring during the decade of the 1980s. Over the same hundred-year period, global sealevel has been observed to increase by 10-20 centimetres. These increases have not been smooth over time or evenly distributed geographically. The extent of the observed warming is broadly consistent with the predictions from the climate models, but is also of approximately the same magnitude as natural climate variability. There is no conclusive evidence that climate has become more variable during the last several decades.

49. The behaviour of ecosystems affect climate and climate change affects the composition of ecosystems. The working group concludes that some species will benefit while others will be unable to migrate or adapt fast enough and may, as a result, become extinct.

50. The working group concludes that we need:

* To understand better the various climate-related processes, particularly those associated with clouds, oceans, and the carbon cycle;
* To improve the systematic observation of climate-related variables on a global basis;
* To develop improved models of the earth's climate system;
* To increase support for national and international climate research activities, especially in developing countries; and
* To facilitate the exchange of climate data.

*Climate change: the IPCC impacts assessmen*t, WMO and UNEP, Geneva, 1990. (Also available in Chinese, French, Russian and Spanish.)

51. This report is the contribution of Working Group II to the First Scientific Assessment Report of the IPCC. Following the summary for policy makers, the report presents the reports of its five principal subgroups (that is, agriculture and forestry, natural terrestrial ecosystems, hydrology and water resources, human settlements, and oceans and coastal zones). All of the subgroups based on their analysis on the existing scientific literature and used several common scenarios with the following features:

* for a business-as-usual scenario, an effective doubling of carbon dioxide in the atmosphere between 1990 and 2025-2050;
* a consequent increase of global mean temperature in the range between 1.5°C and 4.5°C;
* an unequal distribution of the global temperature increase, with a higher than average increase in the high latitude regions and a less than average increase in the tropical regions; and
* a sealevel rise of about 0.3-0.5 metres by 2050 and about 1 metre by 2100, together with a rise in the surface ocean layer of about 0.2°C to 2.25°C.

52. The working group notes that these common scenarios predate and are slightly different from the scenarios developed for the work of Working Group I. But the two sets of scenarios suggest qualitatively similar types and levels of impacts. The working group further notes that any predicted effects of climate change must be viewed in the context of the dynamic nature of our existing climate, especially the effects of such large-scale natural events as El Niño and the human impacts of population growth and economic activity.

53. The working group concludes that comprehensive estimates of the physical and biological effects of climate change at the regional level are difficult and scientific confidence in such estimates remains low. Continuing and persistent uncertainties affect the relationships between biological systems and physical climate variables and, as a result, the current ability to predict such important parameters as precipitation and soil moisture at the regional level remains weak. The report of the working group does not attempt to anticipate or include consideration of any adaptation, technological innovation, or other measures implemented to diminish the adverse effects of climate change. This responsibility is left in the hands of IPCC Working Group III.

54. The working group report emphasizes the importance of uncertainties in the response of the climate system to increases in emissions of greenhouse gases. In particular, the authors highlighted the uncertainties concerning lags between:

* the emissions of greenhouse gases and the doubling of concentrations;
* the doubling of concentrations and the changes in climate;
* changes in climate and the resultant physical and biological effects; and
* changes in physical and ecological effects and resultant socio-economic (including ecological) consequences.

55. Despite these uncertainties, the working group and its subgroups were able to reach some major conclusions.

56. With respect to agriculture and forestry, the working group concludes that changes in climate would have an important effect on agriculture and livestock. The available evidence does not allow the working group to determine conclusively whether, on average, global agricultural potential will increase or decrease. There may be severe negative effects in some

regions that have little ability to adjust to changes in climate, especially in developing countries. There is some evidence to suggest that potential productivity may increase in some mid- and high-latitude regions. Patterns of trade in agricultural commodities could be altered by decreased cereal production in some currently high-production areas, including western Europe, southern United States, parts of South America and western Australia. The development of new plant cultivars or landraces could lessen some of these effects.

57. Forests have long rotation periods and current forests will mature and decline in a period in which they will be increasingly poorly adapted. Actual impacts will depend on the physiological adaptability and host-parasite relationships. The subgroup concludes that large losses could occur due to both factors. The most sensitive areas will be in regions where species are close to their biological limits in terms of temperature and moisture, for example, in cold or semi-arid areas.

58. The working group concludes that natural terrestrial ecosystems could face significant consequences as a result of future global warming. Projected changes in temperature and precipitation suggest that climatic zones could shift several hundred kilometers toward the poles over the next fifty years. The new regimes could increase productivity for some species and decrease that of others. Ecosystems are not expected to move as a single unit, but would have structure as a consequence of alterations in distribution and abundance of species.

59. The rate of future climate change is the major factor determining the type and degree of climatic impacts on ecosystems. The working group concludes that the expected rates are likely to be faster than the ability of some species to respond and responses may be sudden or gradual. Some species could be lost owing to increased stress; increased incidence of pest outbreaks and fires are likely to occur in some areas and these could enhance projected ecosystem changes. The communities which are most at risk are those in which the options for adaptability are limited (for example, mountain, alpine, island and coastal communities, and heritage sites and reserves) and those where climatic changes add to existing stresses. The working group concludes that the socio-economic consequences of these impacts will be significant, especially for those regions where societies and related ecosystems are dependent on natural ecosystems for their welfare.

60. Relatively small changes can cause large water resource problems in many areas, especially in arid and semi-arid regions and in those humid areas where demand or pollution has led to water scarcity. Little is known with certainty about the regional details of greenhouse gas induced hydrological change. Many areas will have increased precipitation; water availability will decrease in other areas, adding to existing stresses on such marginal lands as the Sahelian zone in Africa. In some areas, a 40 to 70 per cent reduction in precipitation could occur. In addition to changes in water supply, changes in human behaviour may change future patterns of water demand. Future design in water systems engineering will need to take the possible future impacts of climate change into account when considering investments in structures that may have a useful life span of decades to a century.

61. The working group concludes that the most vulnerable human settlements are those especially exposed to natural hazards, for example, coastal or river flooding, severe drought, landslides, severe wind storms, and tropical cyclones. The most vulnerable populations are in developing countries, in lower income groups, residents of coastal lowlands or islands, populations in semi-arid grasslands, and the urban poor. Major health impacts are possible, especially in large urban areas. Changes in precipitation and temperature could radically alter the patterns of vector-borne and viral diseases, thus putting large populations at risk. As similar events have in the past, these changes could initiate large migrations of people, leading to severe disruptions of settlement patterns and social instability in some areas.

62. Global warming will accelerate sealevel rise, modify ocean circulation, and change marine ecosystems, with considerable economic consequences. The working group concludes that a 30 to 50 centimetres sealevel rise will threaten low islands and coastal zones. A 1 metre rise, possible in some scenarios by 2100, would render some island countries uninhabitable, displace tens of millions of people, seriously threaten low-lying urban areas, flood productive agricultural land, contaminate fresh water supplies and change coastlines. The working group notes that all of these impacts would be exacerbated if droughts and storms become more severe. Rapid sealevel rise would change coastal ecology and threaten many important fisheries.

63. The working group concludes that further national and international research is needed on:

* regional effects of climate change on agriculture;
* identification of agricultural management practices and technology appropriate for change climate conditions;
* factors influencing the distribution of species and their sensitivity to climate change;
* intensive assessment of water resources and water quality;
* assessment of vulnerability of countries and their populations to the impacts of climate change;
* identification of populations and agricultural and industrial production at risk in coastal areas and islands;
* integration of climate change impacts into the general planning process, particularly in developing countries; and
* development of methodologies to assess sensitivity of environments and socio-economic systems to climate change.

Climate change: the IPCC response strategies, WMO and UNEP, Geneva, 1990. 270 p. (Also available in Chinese, French, Russian and Spanish.)

64. This report constitutes the contribution of Working Group III to the First Scientific Assessment Report of the IPCC. Following the Summary for Policy makers, the main report is divided into three sections. The first section contains the IPCC emissions scenarios. The second section contains the reports of the subgroups on energy and industry; agriculture, forestry, and other human activities; coastal zone management; and resource use and management. The third section contains detailed discussion of a wide range of implementation measures. This latter discussion is further divided among sections on public education and information, technology development and transfer, economic (market) measures, financial mechanisms, and legal and institutional mechanisms.

65. Working Group III was assigned the task of formulating appropriate strategies of responses to the risks of rapid climate change. This working group took as its starting point the conclusions of Working Groups I and II concerning the extent, timing, and consequences of a continuing buildup of greenhouse gases in the atmosphere. This working group concluded that industrialized and developing countries have a common responsibility in dealing with potential impacts of rapid climate change. Furthermore, they concluded that industrialized countries should adopt domestic measures to limit climate change and should cooperate with developing countries while promoting economic development through appropriate transfers of technology, by cooperating closely on the science, and by means of technical cooperation geared to forestalling and managing environmental problems. Finally, the working group concluded that limitation and adaptation strategies must be considered by each country as part of an integrated package of policies and measures formulated to reduce the risks and damages due to rapid climate change.

66. The working group identified a range of measures that could be implemented to address the problems of rapid climate change. Some of these were appropriate in the shorter term, others in the longer-term. For the shorter term, the working group highlighted the following options and measures to limit future emissions:

* Improve energy efficiency;
* Use cleaner energy sources and technologies;
* Improve forest management and expand forests where possible;
* Phase out the use of CFCs controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer; and
* Improve livestock waste management and alter patterns of fertilizer use.

The working group also highlighted a set of adaptive response measures which are applicable in the shorter term. Those measures included the following:

* Improve emergency and disaster preparedness;
* Develop comprehensive risk management plans; and
* Improve the efficiency of natural resource use.

For the longer term, the working group urged governments to undertake the following actions now:

* Accelerate and coordinate research programmes to reduce scientific uncertainties;
* Develop new technologies in energy, industry, and agriculture;
* Review planning in the fields of energy, industry, transportation, urban areas, coastal zones, and resource use and management;
* Encourage beneficial changes in the structure of national economies; and
* Expand the global ocean observing and monitoring systems.

A.II. REPORTS BY OTHER UNITED NATIONS AGENCIES

A. Food and Agriculture Organization of the United Nations (FAO)

Global climatic change and agricultural production: direct effects of changing hydrological and plant physiological processes, FAO, Rome, 1994.

67. This report summarizes the results of a high-level expert consultation involving 40 outside experts and members of the FAO staff. The participants represented a range of disciplines, regions, and economic situations. The objectives of the discussion were:

* to analyse and assess the effects of higher atmospheric concentrations of CO_2, higher levels of UV-B radiation, higher near-surface ozone concentrations, higher temperatures, and changing precipitation patterns on plant growth and food production;
* to provide an overview of the state of knowledge on individual and combined effects; and
* to identify knowledge gaps and future research needs.

68. The consultative group agreed that population growth, income growth, technological change (including agricultural research), civil strife, and developments in international trade will be the dominant driving forces affecting future agricultural production and the degradation or rehabilitation of natural resources. Nonetheless, human-induced global climate change could have substantial but still uncertain impacts on food production. No clear cut conclusions could be reached by the consultative group on the geographic distribution of the impacts, on the interaction between environmental and socio-economic factors, or on the agricultural sectors that are most likely to be affected by global warming or increases in UV-B radiation.

Bioenergy for development: technical and environmental dimensions, FAO, Rome, 1993.

69. This study examines the present role of biomass in the world's energy supply and calculates the potential for future biomass energy provision in the next century. (Biomass refers in this context to the use of plant matter as an energy source.) Environmental effects of biomass use are examined on the global scale, considering both health effects and sustainable production practices. The report notes that many environmental benefits may accrue from increased use of biomass for energy. These include enhancing soil and watershed protection, raising or maintaining biodiversity, reducing sulfur emissions from the energy sector, promotion of rural development in an environmentally sound manner, and possible reductions in global CO_2 emissions if advanced biomass conversion technologies are used as a substitute for conventional fossil fuel systems. This report estimates that biomass presently supplies about 14 per cent of global primary energy demand and that in the future, could, *theoretically* supply up to three times the current level of world energy use. Many uncertainties exist in these estimates, including the effects of climate change on biomass production, but some scientists argue that biomass production could increase in a world of higher temperatures and elevated CO_2 levels.

B. International Atomic Energy Agency (IAEA)

J.F. van de Vate, *Comparative assessment of full-energy-chain associated emissions of greenhouse gases from different energy sources: a tentative analysis in renewable energy,* vol. 5, part III, Elsevier Science, Pergamon Press, London, 1994. pp. 2359-2361.

70. This study compares the estimates of carbon-equivalent greenhouse gas emissions from a variety of electricity supply technologies. The authors use a full-fuel cycle or full-energy-chain approach. Their review of the literature indicates that conventional fossil fuels have emission factors in the range of 400-1200 g of carbon dioxide/kWh (CO_2/kWh). Renewable energy systems are estimated to have substantially lower emissions factors, that is, 40-200 g of CO_2/kWh. The emissions factors for wind, geothermal, and nuclear technologies are estimated to be approximately 10-50 g of CO_2/kWh.

J.F. van de Vate and L.L. Bennett, "Nuclear power and its role in limiting emissions of carbon dioxide", *IAEA Bulletin*, vol. 4, 1993, pp. 20-26.

71. The authors analyse historical trend data concerning the growth rates of regional per capita emissions and observe that the growth rates over the last two decades have been lowest in the OECD countries. On the basis of this historical trend analysis, the authors conclude that the slow rate of growth in carbon emissions in this region has been due to the high rate of penetration of electricity in these economies and the associated penetration of nuclear fission-based power systems. This study analyses a set of future energy scenarios constructed by the IPCC, the World Energy Council, the International Institute for Applied

Systems Analysis, and the IAEA itself. The three IAEA cases analysed here assume that worldwide equity of per capita CO_2 emissions is reached during the next century. The normative case identified by the IAEA results in CO_2 emissions stabilized at the 1990 global level (that is, approximately 6 gigatons of CO_2 emissions per year). This is achieved through the rapid introduction of fission electric systems on a worldwide basis. The authors conclude that global CO_2 emissions can be substantially reduced only if aggressive policy measures rapidly increase the market share of nuclear energy and energy efficiency technologies first in industrialized and then in developing countries.

J.F. van de Vate, *Comparison of energy sources in terms of full-energy-chain greenhouse gas emissions* (paper prepared for the IFPA Conference, Moscow, November 1994), IAEA, Vienna, 1994.

72. The paper presents the results of an international IAEA workshop on the subject in title, held in Beijing in October 1994. Methods and data bases for full-energy-chain (FENCH) analysis of greenhouse gases (GHG) were discussed and recommended. The results of four major FENCH-GHG studies were compared. Accounting for FENCH-GHG emissions from a number of countries (United States, former USSR, Norway, Brazil and Canada) reveals that these are 9-15 per cent higher than the commonly made estimates of emissions from combustion of fossil fuels. Accounting for extensive methane emissions from natural gas and from hydropower lakes increases national GHG emission rates by 25-50 per cent. Where natural gas and hydropower increased strongly, national FENCH-GHG emission factors increased during the past three decades in contrast with the decreasing CO2-only national emission factors.

Senior expert symposium on electricity and the environment: executive summary and key issues papers (STI/PUB/989), IAEA, Vienna, 1991.

73. These documents summarize the discussions and central themes addressed at a meeting held in Helsinki, Finland, from 13 to 17 May 1991. The meeting was co-sponsored by the Commission of the European Communities, the Council for Mutual Economic Assistance, the International Institute for Applied Systems Analysis, the Nuclear Energy Agency of the OECD, the Economic Commission for Europe, UNEP, World Health Organization (WHO), WMO, the World Bank, and the Ministry of Trade and Industry of the Government of Finland.

74. International groups of experts prepared key issue papers for the meeting on four topics. Although the larger context for these discussions was energy in general, the focus of the meeting was on issues of particular relevance in the electricity sector. The following topics were selected as central themes of the meeting:

* Energy and electricity supply and demand: implications for the environment;
* Energy sources and technologies for electricity generation;

* Comparative environmental and health effects of different energy systems for electricity generation; and
* Incorporation of environmental and health impacts into policy, planning and decision-making for the electricity sector.

C. International Civil Aviation Organization (ICAO)

Boris Balashov and Andrew Smith, "ICAO analyses trends in fuel consumption by world's airlines", *ICAO Journal*, August 1992.

75. This article summarizes recent trends and future projections of fuel consumption by the global civil aviation industry. Trends in aviation fuel consumption are recognized as a key parametre in the assessment of civil aviation's contribution to environmental problems, including the greenhouse effect. Approximately 99 per cent of the fuel consumed by the civil aviation industry is jet fuel. The ICAO projects that annual consumption of jet fuel will increase by more than 50 per cent in the next 20 years, from 132 million tonnes in 1990 to approximately 220 million tonnes in 2010. Fuel consumption and carbon dioxide emissions are expected to increase by about 2.5 per cent per annum over this twenty year period, as the use of air transport steadily increases. Without expected improvements in fuel productivity due to better aircraft design, increases in operational efficiency, and changes in the mix of aircraft in the fleet, jet fuel consumption would have been projected to increase by about 180 per cent from the 1990 level during this period.

D. Intergovernmental Oceanographic Commission (IOC)

Sealevel monitoring in the small island developing States, United Nations Organization for Education, Science and Culture (UNESCO), Paris, 1994.

76. This report was prepared as a follow-up to the United Nations Conference on Environment and Development (Rio de Janeiro, Brazil, June 1992) and as an input to the first Global Conference on the Sustainable Development of Small Island Developing States (Barbados, April 1994). The report gives a brief overview of the current status of sealevel monitoring using tide gauges in countries relevant to the Barbados Conference and relates those efforts to the worldwide monitoring regime. The report begins with a summary of the global monitoring situation vis-à-vis sealevel rise and then highlights the situation in individual island states. The report concludes that:

* Monitoring sealevel change on a global basis is essential to understanding ocean circulation, climate change, and related challenges to coastal engineering projects;
* Island states will play a particularly important role in such monitoring efforts;
* The work is far from complete and should be expanded.

The oceans and climate: a guide to present needs, UNESCO, Paris, 1991.

77. This publication is crafted in two parts. The first section summarizes the results of an experts meeting held 19-21 July 1991. The discussion summarizes what is known, what is not known, what is currently being done, and what needs to be done to improve scientific understanding of the role of the oceans in the climate system and to reduce some of the key uncertainties in predicting future global climate change. The second part of this publication contains a background paper prepared for the experts meeting which assesses the current state of scientific understanding of the ocean's role in climate change and evaluates our ability to detect, monitor and predict future changes.

E. United Nations Conference on Trade and Development (UNCTAD)

Combating global warming: a study on a global system of tradeable emission entitlements, UNCTAD/RDP/DFP/1, UNCTAD, New York, 1992.

78. This report includes a compilation of economic analyses of issues raised by proposals for a system of tradeable emissions permits. The report addresses questions of both equity and efficiency with regard to these approaches. It may be particularly relevant to future discussions of the international regime of joint implementation under the Framework Convention on Climate Change.

F. United Nations Environment Programme (UNEP)

A.T. Ayoub and C.V. Malcolm, *UNEP environmental management guidelines for halophytes for livestock, rehabilitation of degraded land, and carbon sequestration*, UNEP, Nairobi, 1993.

79. The purposes of these guidelines is to aid planners, administrators, and project directors in the successful use of halophytes as a resource for livestock and for the restoration of degraded land. Halophytes are plants which have the ability to grow and complete their life cycle on salt-affected soils. Halophytes are commonly used by peoples in many regions to grow forage for livestock on highly saline soils. Some species of halophytes are also important as drought-tolerant vegetation in arid and semi-arid areas. Many of these plants are also useful as fuel.

80. Halophytic species may be used in the future to provide forage for livestock, to rehabilitate degraded lands, and as a vehicle for sequestering atmospheric carbon. These characteristics may prove particularly important in areas which are affected by drought as a result of global warming.

Eric C.F. Bird, *Submerging coasts: the effects of rising sealevel on coastal environments*, UNEP and Wiley Interscience, West Sussex, 1993.

81. This study seeks to determine what is happening on coasts that are already submerging, and to indicate the changes likely to occur as sealevel rise develops globally. The study examines the changes that would result from a sealevel rise of 1 metre around the world's coastline. Attention is given to geomorphological and associated ecological changes, and then to human responses, as influenced by social, economic and political considerations. The study summarizes the kinds of responses that have taken place on coasts where the sea has been rising due to land subsidence, as a basis for predicting the effects of a global sea level rise. It then explores three possible scenarios: to retreat as the coastline recedes, adapting human activities, where possible, to the changing environment as subsidence proceeds; to try to maintain existing coastlines with defensive structures; or to counter-attack by advancing the coastline seaward by means of land reclamation projects. The final section discusses the many social, economic, and political factors that will complicate the responses that actually occur as sealevel rises around the world's coastline.

P. Hulm, *A climate of crisis: global warming and the island South Pacific*, UNEP and the Association of South Pacific Environmental Institutions, 1989.

82. This study summarizes the current understanding of the science of global climate change and the implications of global warming for the South Pacific Island states. The study reviews the potential impacts of climate change both at the regional and at the global level. In an easy-to-read format, it outlines the steps that can be taken by the island states and the needs for additional research and analysis.

A.R. Magalhaes and M.H. Glantz, *Socio-economic impacts of climate variations and policy responses in Brazil*, UNEP; Secretariat for Planning and Coordination, State of Ceara and Esquel Brasil Foundation, Brasilia, 1992.

83. This study is an attempt to understand the direct and indirect interactions of climate and society in Brazil. A set of 14 climate impact case studies were conducted with sectoral emphasis on the salt industry, agriculture, electric power, health and nutrition, the political aspects of droughts, flood, and freeze damages. The focus of the analysis is on assessing the societal response to recent regional climate-related environmental change. The authors argue that evaluation of such responses can help us to identify strengths and weaknesses, and to better prepare society for an uncertain climatic future. Since societal institutions change rather slowly, lessons can be found in past experiences that can guide us into the future, allowing societies to maintain a higher degree of flexibility in responding to future climate change than might otherwise be the case.

M.L. Parry, A.R. Magalhaes and N.H. Ninh, eds., *The potential socio-economic effects of climate change: a summary of three regional assessments*, Earthwatch, Global Environment Monitoring System, UNEP, Nairobi, 1991.

84. This report summarizes the major conclusions of three regional studies of the potential impacts of climate change. The studies were undertaken by national governments with the support of UNEP. The three studies were in Brazil, Indonesia, Malaysia, Thailand and Vietnam.

85. The Brazilian case study highlights the fact that human actions have frequently led to increased vulnerability of societies to climatic variability. The studies of Indonesia, Malaysia, Thailand, and Vietnam illustrate the compounding effects of some impacts of climate change. For example, a sealevel rise 10 to 30 centimetres (the current best estimate for 2030) could inundate coastal mangrove swamps in all four countries, causing extensive damage to these important fish breeding grounds which are both the cradle of much of the region's biodiversity and the economically important foundation of the fish and prawn industry throughout South-East Asia. One principal conclusion that emerges from this set of studies is that, while scientists cannot yet predict with high precision the nature of likely future changes in regional climate regimes, we can begin to explore the range of potentially useful measures that governments could adopt to mitigate the negative effects of climate change and exploit the positive ones.

M.L. Parry, *Climate change and world agriculture*, Earthscan Publications, London; UNEP, Nairobi; and International Institute for Applied Systems Analysis, Laxenburg, 1990.

86. This volume is an expansion of the IPCC assessment of the potential impacts of climate change on agriculture. It reinforces the conclusion that greenhouse gas-induced changes of climate could have an important effect on agriculture, with the most severe negative impacts probably occurring in regions of high present-day vulnerability that are least able to adjust technologically to such effects. Based on a large number of regional case studies and other analyses, this study concludes that, in many regions, and especially in developing countries, agricultural production is currently limited by climatic conditions. Insufficient rainfall is the most common limiting factor, curtailing the available growing period for many crops. The potential base for rain-fed agriculture is very limited in some regions and any further curtailment of potential due to changes of climate could severely strain the ability of societies in these regions to feed local populations. The most vulnerable regions are mostly located in the cool and cold tropics (for example, the Andean region, the Maghreb of North Africa, the mountain regions of south-west Asia), the Sahel and the Horn of Africa, the Indian subcontinent, and parts of the mainland and insular South-East Asia.

M.L. Parry, T.R. Carter and N.T. Konijn, eds., *The impact of climatic variations on agriculture: assessments in cool temperate and cold regions,* vol. 1, UNEP, Nairobi; International Institute for Applied Systems Analysis, Laxenburg; and Kluwer Academic Publishers, Dordrecht, Boston and London, 1988.

87. This report summarizes the first part of the work of a multi-year, multi-country study on the impacts of climatic variations in the agriculture sector. It is based on case studies that sought to evaluate not just the impacts of climate change on crop yields but also addressed

the higher-order effects and potential societal responses as part of a more integrated approach to impact assessment. This volume, along with its companion volume, represent the work of 76 authors from 50 different scientific institutions in 17 countries. The chapters summarize a series of impact assessments conducted using a common methodology and shared assumptions, to produce compatible and comparable results. (The companion volume reports on results for semi-arid regions.)

88. The report is divided into six sections. Section 1 summarizes the methodology and the results of the case studies. Section 2 analyses the first-order impact models that are used in the case studies. Section 3 explains the derivation of scenarios of CO_2-induced climatic change from general circulation models of the atmosphere. Section 4 examines the recent historical record of changes in surface temperature, sealevel pressure, precipitation, and the inter-annual variability of these climate parameters for the Northern Hemisphere. Section 5 and Section 6, taken together, provide case studies of the advantages and disadvantages of linking biophysical and economic models in attempts to analyse the impacts of climate change.

F.R. Rijsberman and R.J. Swart, *Targets and indicators of climate change*, Stockholm Environment Institute and UNEP, Stockholm, 1990.

89. This study reports on the analysis developed by Working Group II of the Advisory Group on Greenhouse Gases, an international scientific committee organized by the WMO and the UNEP to advise the Executive Directors of these two organizations on issues related to the risks of rapid climate change. The focus of Working Group II was on defining and identifying appropriate indicators and targets of climatic change. Such indicators could provide decisive evidence that the global climate is changing and could provide a yardstick for measuring the progress in reducing the greenhouse effect.

90. The working group considers how targets for climate change might be identified. The working group concludes that measures that are cost-effective now, such as many energy-efficiency improvements, and measures that help to solve other problems, should be implemented even if the threat of climate change did not exist. These measures alone, they note, may not be enough to avoid significant climatic change. The working group also argues that, in the longer term, related issues of economic development and population growth must be addressed. In particular, the working group emphasizes that unpredictable

feedbacks and surprises may lead to unexpected reactions of the global climate system. Hence, they conclude, more stringent measures are required now to reduce emissions and produce longer-term, more significant effects. In addition, the working group highlights the need for regular scientific assessments and possible revisions of initially fixed short-term targets.

91. Several climate policy objectives or goals are identified in this report. The working group formulated the following hierarchy of broad objectives:

* Limit the impacts on human society and natural ecosystems;
* Limit the rate and magnitude of sealevel rise;
* Limit the rate and magnitude of temperature change;
* Stabilize the ambient concentrations of specific greenhouse gases;
* Stabilize and /or reduce emissions of greenhouse gases and enhance sinks to stabilize the atmospheric concentrations of greenhouse gases; and
* Take measures to reduce greenhouse gas emissions in an equitable manner and among different actors.

92. The working group identified three critical indicators of climate change and the associated targets for policy responses. These are the following:

* Indicator: **Sealevel rise**
  Target: A maximum rise in average global sealevel of 0.2 m to 0.5 m above the 1990 level and a maximum rate of rise of 20 to 50 mm per decade.

* Indicator: **Mean global temperature**
  Target: A maximum increase in global average surface temperature of 1-2^{o}C and a maximum rate of change in temperature of 0.1^{o}C per decade.

* Indicator: **CO_2 concentrations**
  Target: Maximum CO_2-equivalent concentrations of 330-400 ppmv for a maximum temperature rise of 1^{o} C and maximum CO_2-equivalent concentrations of 400-560 ppmv for a maximum temperature increase of 2^{o} C (based on a climate sensitivity range of 2-4^{o} C for a doubling of the preindustrial concentration of CO_2).

93. The working group concludes that important scientific uncertainties remain concerning, for example, the precise relationships between greenhouse gas concentrations and temperature, and the relative importance of different greenhouse gases over time. The working group emphasizes that these uncertainties must not be used as an excuse to avoid adopting policies that would help achieve the targets identified in the report. Rather, the uncertainties should be used as a reason to review and adjust the targets at regular intervals.

The impact of climate change, UNEP Environment Library No. 10, Nairobi, 1993.

94. This report summarizes the current state of scientific understanding concerning the global and regional impacts of the buildup of greenhouse gases in the atmosphere. Enhanced greenhouse warming will not affect the planet evenly, and the time taken for the climate to respond in different regions may vary considerably. Based on the IPCC analysis, this report notes that the amount of water available for domestic use, agriculture, industry and generating hydroelectricity can be significantly affected by small changes in global average temperature. Warmer temperatures are likely to increase winter rainfall in some middle and high latitude regions, but other regions may become drier, particularly in the summer. Agriculture in some regions could benefit from warmer temperatures and increased rainfall. But changes in temperature, rainfall, and soil moisture could severely reduce agricultural productivity of marginal lands. Forests, which provide a range of products from food to fuel, will also be affected by changes in temperature and rainfall. The composition of many natural ecosystems will be altered, with unknown consequences.

95. In a warming world, the oceans will heat up and expand and glacial ice will melt, raising the global sealevel. Many of the world's highly populated deltaic regions will be threatened by flooding. Low-lying islands are also vulnerable. Drought, crop failure, and floods may drive millions of people from their homes, creating unprecedented social problems as these environmental refugees seek new places to settle. Changes in rainfall may reduce the availability of water, fuelwood, and animal fodder, indirectly leading to reduced human resistance to disease.

96. Although the timing, severity and distribution of the regional impacts of climate change cannot be predicted today with certainty, this report concludes that governments can take steps now to reduce greenhouse gas emissions, to mitigate the effects of climate change, and to help societies adapt to the negative effects of climate change.

The impacts of climate change on fisheries, UNEP Environment Library No. 13, Nairobi, 1994.

97. Fish populations are under tremendous pressure from year to year. This report summarizes the current state of scientific understanding of the effects of global warming on economically -- and nutritionally -- important fish stocks.

98. This report uses an approach called "forecasting by analogy" to study the ways in which past climate changes have affected living marine resources and to identify the societal responses that have been most successful. This assumes that past responses to crises can be used by decision-makers to identify past strengths and weaknesses in evolving tactical and strategic responses to natural disasters. If this assumption is correct, it could help today's decision-makers in finding approaches to mitigate the negative impacts of climate change on fisheries.

Environmental data report: 1993-1994, Blackwell Publishers, Oxford, 1993.

99. This report, published in cooperation with the World Resources Institute and the United Kingdom Department of the Environment, brings together in a single volume the best available data and information on a wide range of environmental topics. This biennial edition provides updated core data sets on common environmental topics including pollution, health, natural resources, population and human settlements, energy, wastes, and natural disasters.

100. This series of biennial reports is designed as a critical review of currently available environmental data and related information. The authors have selected the data sets in order to provide practical indicators of environmental conditions in ways which can support prudent public policy formulation at all levels of decision-making. The report's authors have attempted to standardize and harmonize the data from different countries and regions so as to facilitate useful comparisons among countries and regions. The authors recognize that some key data, especially for developing countries, are not currently available and emphasize that, to improve the quality of environmental planning and decision-making, international efforts to support the collection and analysis of these data must be increased.

UNEP Greenhouse Gas Abatement Costing Studies, 1992, UNEP Collaborating Centre on Energy and Environment, Riso.

101. This report summarizes a series of national abatement cost studies that applied a common analytic methodology and were funded by UNEP. The report includes a review of modelling approaches and existing abatement costing studies. It also includes the results of the national studies and a set of recommendations for the conduct of additional country studies during Phase 2 of the UNEP Riso project.

Counting the costs, UNEP Collaborating Centre on Energy and Environment, Riso, 1992.

102. This short booklet summarizes Phase 1 of the UNEP Riso Greenhouse Gas Abatement Costing Studies. It discusses the difficulty of calculating the costs of greenhouse gas abatement measures. The study concludes that a common abatement costing methodology is needed and highlights the approach taken in the UNEP Riso study to provide such a methodology.

The full range of responses to anticipated climatic change, UNEP Global Environmental Monitoring System, Beijer Institute for Energy, Resources and the Human Environment, Nairobi, and Stockholm 1989.

103. This report summarizes the state of the science on global climate change and the current understanding of the interactions between the risks of rapid climate change and other environmental problems as of the spring of 1989. It outlines the range of available policy response options and the most important potential barriers to international agreements on cooperative response strategies. It suggests the need for concrete policy targets and physical indicators that can be used to measure the success of international efforts to achieve those targets. The report concludes that comprehensive international scientific assessments should be conducted at regular intervals in order to provide a firm and credible basis for the political and economic policy decisions which must be made by national governments.

C.R. Wilkinson and R.W. Buddemeier, *Global climate change and coral reefs: implications for people and reefs (report of the UNEP-IOC-ASPEI-IUCN Global Task Team on the Implications of Climate Change on Coral Reefs)*, International Union for the Conservation of Nature (IUCN), Gland, 1994.

104. This report is an assessment of the potential and expected effects of global climate change on coral reef ecosystems and the peoples associated with them. The report concludes that coral reefs are being seriously and increasingly stressed by exploitation and anthropogenic environmental changes, including sedimentation, nutrient loading and pollution, physical destruction, and overfishing. These effects are distinct from, and unrelated to, climate change. The authors note that coral reefs have survived massive climate changes in the past and that the changes projected in the IPCC scenarios are less extreme than some of these earlier changes.

105. The major conclusion of the report is that human pressures pose a far greater immediate threat to coral reefs than climate change. The authors note that the essential first step is to preserve reef ecosystems and protect the human communities that depend on them. Rising sealevel will not threaten most coral reef ecosystems and may be advantageous to some, but predicted sealevel rise will devastate the habitability of low lying islands and coastal plains that are protected by coral reefs. Rising temperatures will not endanger reef survival but episodes of high temperature will increase bleaching and mortality, increasing vulnerability to other stresses. The report recommends that prompt and aggressive management efforts be initiated to reduce human stresses on coral reefs and preserve their value for human societies. Training and education are needed to reduce the need for societies and individuals to over-exploit coral reef resources and to build the capacity to understand and manage reefs for long-term sustainability.

A.III. REPORTS BY OTHER INTERGOVERNMENTAL ORGANIZATIONS

A. Organisation for Economic Co-operation and Development (OECD)

C. Complainville and J.O. Martins, *NOx/SOx emissions and carbon abatement*, Economics Department Working Paper No. 149, OECD, Paris, 1994.

106. This paper provides evidence on the reductions of NOx/SOx emissions induced by the adoption of policies to abate emissions of carbon dioxide. It describes the methodology used to compute emissions of these pollutants, and the way that they are treated in the OECD GREEN model. This treatment required a compromise between the "top-down" structure of the model and the very detailed information that, in principle, is required to compute emissions of NOx and SOx. The results of this analysis suggest that, on average, the reductions relative to baseline levels of NOx and SOx emissions may be of the same order of magnitude or higher than the abatement imposed on carbon emissions.

J. Oliveira Martins and D. van der Mensbrugghe, *The OECD GREEN model: an updated overview*, OECD Technical Paper No. 97, OECD, Paris, 1994.

107. This paper presents a brief introduction to the OECD GREEN Model. The GREEN model is a dynamically recursive, multi-sectoral, global computable general equilibrium model. The model places a particular emphasis on the analysis of energy production and consumption. Global economic activity is represented as twelve regional units. Four of the twelve are composed of OECD member countries. The formerly planned economies of eastern and central Europe are divided into two regions, the former Soviet Union and the eastern European economies. Three developing countries (India, China, and Brazil) are represented as separate regions by the model. The dynamic, high-growth economies of Asia and the energy-exporting countries are each represented as separate regions. The twelfth region is called ROW because it contains the rest of the world. The economic activity in each region is divided among eight sectors, five energy-based sectors and three others. The non-energy sectors represent agriculture, energy-intensive industries, and all other goods and services. The model solves for an interregional, single-period equilibrium in 1985, 1990, 1995, 2000, 2005, 2010, 2030 and 2050, using a recursive dynamic algorithm.

108. Several illustrative scenarios are included in this report. These include a baseline or reference scenario, a scenario of emissions stabilization based on region-specific taxes within the OECD subregions, an emissions-stabilization scenario based on a uniform, OECD-wide energy tax, and several scenarios based on assumptions about global agreements to limit future greenhouse gas emissions.

A. Manne and J.O. Martins, *Comparison of model structures and policy scenarios: GREEN and 12RT*, Economics Department Working Paper No. 146, OECD, Paris, 1994.

109. This report presents a comparison of two models participating in the OECD model comparisons project. The OECD GREEN is described above (see Lee and others, 1994) The 12RT model is a detailed process model of physical flows in the global energy industry. The model provides a fully temporal equilibrium based on assumptions of perfect information and foresight. The 12RT model assumes homogeneity among similar goods produced in different regions (and approximates the Heckscher-Olin framework) while the GREEN model assumes that goods from different regions are imperfect substitutes. The analysis carried out for this report compares the costs but not the benefits of greenhouse gas abatement in a baseline case and four policy cases. The policy cases highlight alternative conceptions of emissions stabilization policies and tests of a global carbon tax and a tradeable emissions permit proposal. The study concludes that stabilization of emissions among Annex 1 Parties (only) has a very small impact on future carbon dioxide concentrations in the atmosphere, compared to the baseline scenario. In addition, the future cost (in terms of GNP losses) of stabilizing carbon emissions in Annex 1 countries is quite small, approximately 0.8 per cent of GNP by 2030.

Policy response to the threat of global warming: technical report, issues for discussion, and annexes, Economic Policy Committee, Report No. ECO/CPE/WP1 (94)5 with technical support document and annexes, OECD, Paris, 1994.
(Also available in French.)

110. The purpose of this paper is to assist the process of developing an appropriate policy response to the risk of climate change, given the commitments taken by signing the Framework Convention on Climate Change. The major problem facing policy makers is the challenge of taking far-reaching policy decisions under conditions of significant uncertainty, That is, how to choose sensible policy targets and suitable instruments to achieve them, with limited knowledge of both likely costs and resulting benefits.

111. The paper begins with a brief introduction to, and interpretation of the Framework Convention on Climate Change, followed by a summary of the key uncertainties surrounding the climate change issue, an assessment of the how extending the geographic coverage of efforts to achieve the abatement target implied by the Convention can reduce total cost, and an introduction to the "carbon leakage" problem. This is followed by a review of the main generic classes of response measures available to governments to counter the risks of rapid climate change. The basic problems and possibilities for an efficient overall policy response are then discussed. The fiscal implications of an OECD carbon tax are discussed in detail. The paper concludes with a discussion of the needs for international cooperation and the potential role of joint implementation in achieving the objectives of the Convention as expressed in Article 2.

Global change of planet earth, OECD, Paris, 1994.
(Also available in French.)

112. This volume presents the results of the Megascience Forum sponsored by the OECD to review and evaluate the international scientific effort in global change research. The volume contains the main conclusions reached by this meeting of experts and reviews the principal areas of global change research. It also provides specific information on national research activities and projects as they relate to the international programme, as well as statements on data management policy as these relate to on-going research activities in global systems science.

Climate change: evaluating the socio-economic impacts, OECD, Paris, 1991.
(Also available in French.)

113. This volume contains four short papers which address the socio-economic aspects of climate change. Following a brief introduction of some of the key conceptual issues, chapter two deals with methodological questions. The last two chapters deal with the impacts of climate change on agriculture and with the impacts of sealevel rise. Taken together, these four chapters help the reader to set a balance between the social and economic benefits of actions taken to prevent the buildup of greenhouse gases and the costs incurred due to inaction on this issue.

B. International Energy Agency (IEA)

World energy outlook: 1994 edition, IEA/OECD, Paris, 1994.

114. This report updates the IEA projections of world energy and oil demand out to the year 2010. It also contains four detailed regional studies that focus on economic trends and future energy demand in the OECD Pacific region (including Japan, Australia, and New Zealand), East Asia, China, and the emerging market economies of Central and Eastern Europe.

115. The principal conclusions of the global analysis include the following:

* World demand for primary energy will continue to grow, maintaining an average annual rate of 2.1 per cent which is slightly slower than the expected global average rate of macroeconomic growth. By 2010, the world is projected to consume 70 per cent more commercial energy than it did in 1991.
* OECD energy demand could increase by 28 per cent between 1993 and 2010 with imports constituting 70 per cent of OECD oil consumption in 2010 compared to 58 per cent in 1993.

* Growth in oil and energy demand in the regions outside of the OECD (ROW or rest of the world) is projected to be more rapid than in the OECD. The OECD projects that oil demand in the ROW will grow at an annual rate of approximately 3.8 per cent per annum and that the OECD share of world oil consumption will decline from 56 per cent in 1991 to 47 per cent in 2010.
* Gas consumption is projected to rise at an average annual rate of 2.1 per cent in the OECD and 5.6 per cent in the ROW.
* World coal demand is projected to grow at an average annual rate of 2.1 per cent, with demand outside the OECD projected to increase at an average annual rate of 3.8 per cent per annum. China alone is expected to account for over half of the incremental demand for coal.
* Electricity is the most rapidly growing form of final energy demand. Per capita consumption of electricity is expected to double on average by 2010 in the regions outside the OECD.
* This projection implies a 50 per cent increase in annual global emissions of CO_2 by 2010. Emissions in the OECD continue to increase above the 1990 level while emissions in the ROW more than double.
* The OECD estimates that a carbon tax of approximately US$ 300 per tonne (or about US$34 per barrel of oil) would be required to return OECD emissions in 2010 to their 1990 level.

Climate change policy initiatives: 1994 Update, vol. 1: *OECD countries*, IEA/OECD, Paris, 1994.
(Also available in French.)

116. This study provides an overview of the Framework Convention on Climate Change and the commitments that it contains for developed countries and other Parties to the Convention. It also contains profiles of each of the OECD countries and their climate change response strategies, presented in a standard format. The study presents key comparative energy and CO_2 emissions data, including a review of carbon taxes in effect among the OECD member countries as of 1 January 1994.

Energy policies of IEA countries: 1993 review, IEA/OECD, Paris, 1993.
(Also available in French (1995).)

117. In this volume, IEA observes that one of the key challenges facing policy makers around the world is the need to devise viable strategies to meet the combined objectives of sustainable economic growth, energy security, and environmental protection. This edition of a long-running IEA series was prepared for the twentieth anniversary of the IEA and contains the first round of reviews that have been undertaken on the basis of the IEA's shared goals, a framework programme agreed by IEA ministers in 1993 as a guideline for the formulation of national energy policies and strategies. The report highlights the major energy policy developments and market trends in all IEA member countries and provides an overview of

significant developments that occurred elsewhere in the world during 1992 and 1993. It also presents critical reviews of the energy policies of all IEA member countries as well as in-depth reviews of the energy situations in Austria, Denmark, Germany, Greece, the United Kingdom, and the United States.

Cars and climate change, IEA/OECD, Paris, 1994.
(Also available in French.)

118. In this report, the IEA examines the potential of a wide range of fuels to reduce greenhouse gas emissions from transport. While many alternative fuels can reduce automobile exhaust emissions, most of them result in higher emissions from fuel supply and vehicle manufacturing. In this study, the IEA uses a full fuel-supply cycle approach (sometimes called a life-cycle approach) to take account of emissions during all stages in fuel and vehicle production as well as exhaust emissions during vehicle use.

119. The study concludes that before 2000, a few alternative fuels are likely to be viable, but only in niche or regional markets where their benefits for energy security or for the local environment outweigh their higher overall costs. The study shows that, in some instances, policies aimed as solving other problems associated with car use, including traffic congestion and accidents, have added benefits in the form of reduced greenhouse gas emissions. Indeed, the study finds that an integrated approach to such transport policy issues as local air pollution, energy security, congestion, and accidents may be the most effective way to reduce greenhouse gas emissions from the transport sector.

Biofuels, IEA/OECD, Paris, 1994.
(Also available in French (1995).)

120. Much disagreement remains on whether biofuels are an effective component in solving the problems of air pollution and greenhouse gas emissions. This report examines in detail the assumptions behind many existing studies and offers a new evaluation of the economics of, and energy balances for, biofuel production. Using a full fuel-supply cycle approach, the report shows that biofuels can help reduce the use of petroleum products and the consequent emissions of greenhouse gases, although costs are still high compared to current prices for conventional fossil fuels. The report suggests that there are no overwhelming advantages for any one of the biofuels and concludes that choices among them should reflect local priorities and circumstances.

Energy in developing countries: a sectoral analysis, IEA/OECD, Paris, 1994.
(Also available in French (1995).)

121. As a group, the developing countries represent the largest source of growth in future global energy demand. This study examines recent trends in energy demand in a group of 21 of the most important energy consumers in Asia, Latin America, and Africa, and explores the factors which determine the growth in their future energy demand. In the process, it examines energy demand at the aggregate macro-economic level, as well as in three key energy-using sectors: industry, transport, and households. To explain the historic and projected future patterns of demand growth, the study investigates such factors as:

* structural change at the economy-wide level and within the key target sectors;
* energy intensity trends in specific industries (including iron and steel, cement and chemicals);
* growth in the stocks of road vehicles;
* trends in vehicle fuel economy;
* the changing role of biomass energy in the household sector, and the related effects of increasing urbanization;
* the impacts of household electrification;
* the changing penetration rates for electric appliances; and
* the role of energy prices.

IEA/OECD scoping study: energy and environment technologies to respond to global climate change concerns, IEA/OECD, Paris, 1994.

122. This volume provides a broad-based assessment of a wide range of energy and environmental technology options and development needs. The study highlights the factors that affect the commercial evolution of advanced technologies and reviews current national and international programmes to stimulate further research and development on them. It identifies the technology research and development areas where international cooperation can accelerate the development and deployment of promising energy and environmental technology options and concludes that government and industry efforts to promote longer-term technological breakthroughs should be strengthened.

Greenhouse gases: the energy dimension, IEA/OECD, Paris, 1991.
(Also available in French.)

123. This volume brings together a comprehensive discussion of the relationship between commercial energy use and greenhouse gas emissions in industrialized economies. The book provides a preliminary projection of future world energy demand to 2005, divided among OECD, centrally-planned, and developing country economies. It also offers an analysis of greenhouse gas emissions related to that energy use, arranged by sector and geographic

region. The volume concludes with a review of technologies and policies for limiting future emissions from fossil fuel combustion and provides a foundation for further quantitative analysis of the energy-climate connection.

A.IV. ADDITIONAL REPORTS BY INTERNATIONAL ORGANIZATIONS

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