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WMO/UNEP INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

REPORT OF THE FOURTH SESSION OF THE WMO/UNEP INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

Sundsvall, Sweden, 27–30 August 1990

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1. OPENING OF THE SESSION

The fourth plenary session of the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC) was opened at 1000hrs on Monday, 27 August 1990 by Professor Bert Bolin, Chairman of the Panel, at the Tonhallen Conference Centre, Sundsvall, Sweden.

The list of participants is given in Appendix A.

1.1 Statement by the Prime Minister of Sweden, Mr. Ingvar Carlsson

Mr. Ingvar Carlsson welcomed the participants to Sweden. He said:

"Mr Executive Director, Mr. Secretary General, Mr. Chairman, Delegates, Ladies and Gentlemen,

It is a privilege for me to address the fourth session of the Intergovernmental Panel on Climate Change.

Upon the initiative of the United Nations Environment Programme and the World Meteorological Organization, the world's most eminent specialists and experts on environment and climate have been asked by their respective governments to address a uniquely complex problem: does man by his activities change the composition of the atmosphere and the biosphere to the extent that even the climate itself will change? This is no small question to answer. Your report is an excellent one. I want to thank all contributors. We laymen have every reason to be impressed with the skill with which you have condensed inherent and unavoidable complexities into conclusions accessible to us all. We are also impressed with the work of the experts on possible strategies for the years ahead.

I would like to share with you my understanding of the issues you have presented to us.

First, the estimates. Your best estimates are that the rate of climate change is now some 0.3 °C per decade. The earth's ecosystem has never before been exposed to such a high rate of change.

Second, the equally clearly presented uncertainties. Decades could in fact pass before scientists can claim to fully understand whether a change due to human activities actually occurred or not.

Third, the inertia of the climate. Once knowledge is at hand, further change is already unavoidable.

Fourth, the uncertain, perhaps even unpredictable but extremely worrisome consequences of a possible climate change - in particular for developing countries.

These four impressions alone are sufficient to state the unique challenge you have presented to us. No generation of political leaders has ever been presented with a similar task.

You have also estimated that greenhouse gas emissions from, in particular, fossil fuels will have to be cut substantially. According

to these estimates, reductions of some 60 per cent is necessary in order to reduce the rate of climate change to rates that the biosphere could conceivably cope with.

Poor use less fossil fuels than rich. This holds for rich and poor people as well as rich and poor nations. But poor in the third world have a right to a decent living.

Yet, there is cause for some optimism. True, there have been setbacks. True, there is still poverty. True, absolute numbers have not even fallen. But it is equally true that literacy is increasing and health is improving in most parts of the world. The battle against poverty is being won in many areas of the world. We know that population, environment, natural resources and development are closely inter-related. Preventative and precautionary action is the only longer term remedy for the problems of development and environment. There can be no common action against climate change without common action against poverty, destitution and, indeed, oppression and injustice. Policies must recognize global interdependence and joint responsibilities. This was also the central conclusion of the Brundtland report. In my view, this underlines the necessity to additional assistance from the rich world. The 0.7% goal should just be a first step. The funding needs must be based on a fair burden sharing.

Let me return to the developed world.

The material you have presented demonstrates the crucial role of the industrialized countries. These countries are responsible for some 75% of the total emission of carbon dioxide. You also demonstrate that the technological potential for reductions is large.

As expected, the differences in the per capita emissions of carbon dioxide are large between industrialized and non-industrialized nations. But this is not the whole picture. Differences are even larger within the group of industrialized countries. The difference between the per capita emissions of, say, Japan and China is less than half the difference between the per capita emissions of the US and Japan.

Some countries in the OECD have more than twice the per capita emissions than other OECD countries - with no corresponding difference in living standard. Some countries in eastern Europe have much higher per capita emissions than many West European countries - with a much lower standard of living.

This illustrates the responsibilities of the industrialized world. Its emissions must be cut, and, judging from the differences within the group of industrialized countries, there seems to be ample room for improvement.

Every nation can take some action now. Let me give only one Swedish example on energy consumption: we have recently introduced a carbon tax, as part of a major restructuring of our taxation system. The gasoline price has increased more than thirty per cent. This has turned an annual four per cent increase of gasoline use into a projected reduction for this year. But this, and other taxation measures, only affects consumption in Sweden. We cannot take unilateral action that would hurt those sectors of our economy that are exposed to competition from abroad.

Thus, concerted international action in necessary. I would like to highlight four points for the next few years:

- First, a global convention on climate change should be completed at the 1992 UN Conference on Environment and Development. A clear commitment to first stabilize and then reduce greenhouse gas emission is necessary. The London agreement on the reduction of CFCs was one important step forward. The next steps will be taken during autumn, when the negotiating body will start its work.

- Second, developing countries must be allowed an increasing share of energy use. There is also the need for additional aid to the poor countries. The industrialized nations must bear the brunt of the burden, as a joint responsibility.

- Third, there is a need for massive expansion of research and development in new energy sources as well as energy efficiency. More efficient resource management of the energy and transport sector should be promoted.

- Fourth, there is the need for international programs for the future reduction of greenhouse gases. The OECD countries have to take the lead in this work. I look forward to joint programs within the OECD group, within the ECE group and within the European group of countries. There is for example the need for reducing the European coal use, particularly in Central Europe, in order to reduce pollution of acid substances and heavy metals, but also greenhouse gases. Corresponding programs for other parts of the OECD area are necessary.

These four points should be seen as initial precautionary steps for a more far reaching commitment. Further steps have to be taken as knowledge and experience builds up.

The Intergovernmental Panel on Climate Change should continue to assess the scientific advancement of our understanding of the climate and the impacts of climate change.

You have raised the awareness of the risks for climate change. What scientists have suspected for many years has now reached the policymakers in governments and business in order for action to occur. What we now have to do is to take precautionary action. There is no way of turning back into ignorance.

I wish you luck with the coming four days!

Thank you."

1.2 Opening Remarks by Prof. G.O.P. Obasi, the Secretary General of the World Meteorological Organization (WMO)

"It gives me great pleasure to address you on this auspicious occasion - the fourth Plenary Meeting of the Intergovernmental Panel on Climate Change. Auspicious because at this session the Panel will approve its report which will be submitted to the United Nations General Assembly. Prior to this, the report will be seen by the Second World Climate Conference which, I have no doubt, will reflect the conclusions of the Panel in the Ministerial Declaration to be drawn up at that Conference. I might add, also, that the importance of this meeting has been greatly enhanced by the reputation which the IPCC has built up in the short two years of its existence, not only in scientific circles, but also in the political arena.

Let me first therefore take this opportunity, through you, Mr.

Prime Minister, to thank the Government of Sweden for hosting this historic meeting and for providing these excellent facilities for our sessions. Sweden is, of course, one of the foremost proponents of environmental protection. Its constant support to the work of the IPCC is therefore not perhaps surprising but I would like to convey, on behalf of the World Meteorological Organization, our grateful thanks to the Government of Sweden for its pioneering efforts to preserve our planet.

May I also thank you personally, Mr. Prime Minister, for the penetrating and encouraging remarks you have just addressed to us and for honouring us with your presence on this occasion.

It was in June 1988 that the World Meteorological Organization's Executive Council first agreed to establish an Intergovernmental Panel on Climate Change. This was confirmed shortly thereafter by the UNEP Governing Council. The first meeting of the Panel was held in Geneva, in November of 1988. These developments were subsequently endorsed by the UN General Assembly in its resolution on "Protection of Global Climate for Present and Future Generations of Mankind" passed in December of that same year.

It is useful to recall how short is the history of the IPCC. I think it is fair to say that few of us involved at the beginning believed that so much could be accomplished in such a short time, or that the work of IPCC would assume such enormous importance to governments, their leaders and the people of the world.

The very difficult task set at the first meeting of IPCC, just 21 months ago, is nearly accomplished. Reports on scientific assessment of climate change, on potential impacts of climate change, on formulation of response strategies and on the participation of developing countries have been completed. They form a solid foundation for finalizing the overview and conclusions of the Panel as a whole this week. I am sure that the overview and conclusions emerging from this meeting, here in beautiful Sundsvall, will be sound and very influential.

This would not have happened without outstanding leadership. We have all been fortunate to have Prof. Bolin, Dr. Al-Gain and Dr. Adejokun as leaders of the panel as a whole, and Dr. Houghton, Prof. Izrael, Dr. Bernthal and Mr. Ripert as chairmen of the three working groups and the Special Committee. Dr. Sundararaman and Mr. Tewungwa of the IPCC Secretariat have also worked very hard towards this week. This leadership has been inspiring and effective. More than 1,000 specialists from 70 countries have participated in this great task in one way or another. I would like to congratulate each one of you, and thank you all on behalf of the UN system and of people everywhere. You have participated in the most comprehensive international intergovernmental assessment ever undertaken of a serious environmental and scientific problem and you have completed your work well, and on schedule.

I would add, also, that much of the progress made and the many achievements of the Panel would not have been possible without the strong support and advice of our respected and able Executive Director of UNEP, Dr. Tolba. I very much enjoy working with him and I have personally benefitted greatly from his wide experience. I look forward to continuing working and collaborating with him on several aspects of the important issue of climate change.

Despite the achievements that have been made, I do have one regret. The pace of the activity for completing the IPCC First Assessment Report made it difficult for experts from all interested nations to participate in all the meetings. As it turned out, the WMO/UNEP joint IPCC Secretariat, with guidance from the Special Committee, did their best, within the funding available to them, to foster the active participation of developing countries. But I do realize that furthering such participation has to be one of the main goals and has to be achieved as we move into the future, when steps towards international action to address the issue of greenhouse gases and climate change will be taken.

I believe that the nations of the world will not want to lose such an effective body as the IPCC, even as more formal negotiations of a Climate Convention are underway or completed. At the WMO Executive Council in June, and the recent Special Session of the UNEP Governing Council in August, of this year, it was agreed that a continuing IPCC would be of great value in conducting studies on policy options and risk assessments, and in, from time to time, undertaking assessments of advances in the science and impacts of climate change.

Not only has your achievement in producing this first assessment been a magnificent one in the limited time available, but the process has served to catalyze a worldwide understanding of probably the most profound issue facing humanity. I do not say this lightly. The issue is profound in two fundamental ways.

First, the environmental dimension is truly global in scale and inter-generational in time. It is clear from the IPCC working group reports that economic activities in all countries are contributing to major changes in the chemistry of the whole atmosphere of our small planet. These changes will in turn alter the climate and sea level in ways which will affect all countries, mostly adversely, for many generations to come. Never before has human intervention in natural systems on such a world-wide scale been achieved, documented and projected. We are now face to face with deep moral dilemmas concerning our responsibility for protection of our Earthly home, and our responsibility to future generations.

The second important consideration of this issue is that its solution will require fundamental changes in the world's economic order. OECD officers have already stated that "the present patterns of economic development are not sustainable". The over-exploitation of resources, especially fossil fuel and forest resources, has brought us to our present crossroads. Recent economic patterns have also been characterized by huge financial transfers, the wrong way, from the poor to the rich, as the poor countries struggle to carry their crushing debt loads. To solve the problem of greenhouse gas increases requires the industrialized countries to change their over-consuming ways. It also requires that development in the less industrialized world goes forward in a sustainable manner - and this will require a large flow of assistance both financial and technological, from North to South.

Are the countries of the world ready to meet these challenges implicit in your report? We will soon see. After you have completed your work this week, the report will go to the Second World Climate Conference in Geneva from 29 October to 7 November. The Ministerial part of this Conference will provide the first opportunity for countries to formally respond to your report, especially

the policy options. The scientific sessions will permit careful review of the science aspects of the IPCC report as well as the 10-year global scientific effort of the World Climate Programme.

As the executive head of a scientific and technical agency, I am particularly interested in the recommendations of IPCC on the future needs in research and monitoring and in the outcome of the discussions in the Second World Climate Conference on the World Climate Programme. Further, improvements in model predictions and determination of climate trends, among others, are of paramount importance to my Organization.

Immediately following the Second World Climate Conference, there will be consideration of your report and the Second World Climate Conference outcome at the 45th Session of the United Nations General Assembly. This will give all countries, including those who could not actively participate in the IPCC work, an opportunity to express their views on how we should collectively address the subject.

Finally, in February 1991, national delegates will be invited to gather for the opening of negotiations on a Framework Convention on Climate Change in Washington, D.C. It is very much to be hoped that such a Convention will be ready for signature by the June 1992 UN Conference on Environment and Development in Brazil. WMO and UNEP are already, at the request of the UN General Assembly, making preparations for these formal negotiations.

In this context, I would propose that this IPCC plenary session decide on a mechanism for responding quickly to the needs of the negotiators when they begin their task on a convention and the associated protocols.

In this year, 1990, we could be on the threshold of a new era marked by respect for the environment of planet Earth, and by environmental and economic equity between nations. I hope that we may all continue to work together to make it so.

Thank you all."

1.3 Opening Remarks by Dr. M.K. Tolba, the Executive Director of the United Nations Environment Programme (UNEP)

"Mr Prime Minister, Prof. Obasi, Secretary General of WMO, Mr Chairman, Your Excellencies, Distinguished Delegates, Ladies and Gentlemen.

It is an honour to join this distinguished assembly, and to express the deep appreciation of the United Nations Environment Programme to you Mr Prime Minister, and through you to the Government and people of Sweden for hosting this critical meeting of the Intergovernmental Panel on Climate Change. We meet to conclude the first phase of the Panel's work, and to adopt its eagerly awaited report. UNEP comes too much to you in Sweden, Mr. Prime Minister, in fact UNEP was born in Stockholm. Since then you never faltered in extending the required nurturing and support.

Let me also express my profound gratitude to my colleague and friend Professor Obasi and his colleagues at the World Meteorological Organisation for the exemplary co-operation we are having together. A special word of thanks goes to my friend Professor Bert Bolin and members of his Bureau and to the Chairmen of the three Working Groups: Dr John Houghton, Prof. Yuri Izrael and Dr. Fred Benthal - for their truly outstanding work in preparing this First Assessment Report. Let me also

thank my friend and colleague Jean Ripert, Chairman of the Special Committee on the Participation of Developing Countries. A number of countries from the global South have participated in the IPCC. True, that number could and should be higher. But your efforts have facilitated the participation of a number of developing countries during this first phase of the IPCC process.

Ladies and Gentlemen,

Efforts of the IPCC in the past eighteen months have been amongst the most daunting and intensive in the history of science.

Over one thousand leading scientists pulled together from developing and developed countries, united in a single cause: to sharpen our understanding of climate change and global warming, and chart effective, equitable global responses. In spite of uncertainties and lack of knowledge in a number of areas the verdict of your deliberations is clear: our planet is already committed to global warming. It is now (and I quote from Working Group I) "certain that emissions resulting from human activities are substantially increasing the concentrations of greenhouse gases and these increases will enhance the greenhouse effect resulting on average in an additional warming of the Earth's surface".

Scientific evidence indicates we face warming trends faster than at any time in 10,000 years. If human activity continues this unsustainable strain on our living biosphere, average temperatures may rise by about 0.3 degrees Celsius each decade, and by about 3° C before the end of the twenty-first century.

The current findings confirm a sea-level rise of about 20 cm could happen over four decades; and a 65 cm rise by the end of the next century. Should that occur, coral islands and low-lying coastal areas - unless defended at great cost - face catastrophe. If only one percent of the world's expected population of six billion by the end of this decade are adversely affected by sea level rise induced by global warming, there will be 60 million more environmental victims, environmental refugees.

Your reports are sobering analyses of other impacts, including the possibility of sudden, abrupt changes in climatic patterns. Weather, pest and agricultural disease patterns may change. Forests face the likelihood of increased mortality. Biological diversity could be further impoverished. Securing global food supplies for skyrocketing populations in poor and marginal lands, subject to unpredictable climatic regimes could involve challenges unknown to humanity. In many cases, and I quote from the report of Working Group II, "the impacts will be felt most severely in regions already under stress, mainly the developing countries".

Mr Chairman,

The findings of this Panel are the most authoritative to date, a real advance in scientific knowledge since the time when experts - convened by the WMO, UNEP and the International Council of Scientific Unions - met in Villach several years ago. In the past decade, the WMO World Climate Programme has steadily built the case for climate change. Now, your report leaves little doubt: the longer uncontrolled greenhouse gas emissions continue, the more difficult and costly inevitable control and adaptation measures will be. Stabilization of atmospheric greenhouse gas concentrations at present levels demand - in most cases - a minimum immediate reduction of 60 % in global

greenhouse gas emissions. That is not the conclusion of ecological prophets of doom. These are the findings of distinguished scientists from all over the globe.

The facts before us are horrifying, demanding we act now. While the Montreal Protocol - amended in London two months back - has bought us time by ensuring the virtual elimination of some of the most powerful and longlived greenhouse gases - the chlorofluorocarbons - we must ensure their replacements have little or no greenhouse potential and we must go very much further in limiting other greenhouse gases and adapting to potential impacts of climate change.

Ladies and Gentlemen,

No one expected the First Report of your Panel to answer all questions and close all knowledge gaps. Significant unknowns persist. We need feedbacks for climate modelling. We need to elaborate regional climatic patterns. We need further elaboration and costing of necessary actions.

The work of your Panel should remain the world's most reliable knowledge base - scientific, economic, social, public policy - feeding into and responding to the needs of the international negotiations for a Global Convention on Climate Change. The General Assembly and governing bodies of the World Meteorological Organisation and UNEP want such negotiations to commence <u>now</u>, immediately following the adoption of your First Report. And your Working Group III points the direction in this respect where it says "the potentially serious consequences of climate change on the global environment give sufficient reasons to begin by adopting response strategies that can be justified immediately even in the face of significant uncertainties".

Negotiations on the Global Convention need to hammer out coordinated global actions designed around specific schedules and targets to limit greenhouse gas emissions in key sectors, such as energy, industry, transportation, agriculture and forestry. We are talking about changing the world's key economic engines driven by fossil fuels, and changes in key sources of public income. Difficult as that will be, control strategies to save the planet are beneficial in <u>their own right</u>. Increased energy conservation and efficiency would tackle <u>known</u>, persistent environmental problems, including acid rain and chronic air pollution. But for action to occur the on-going, expert input of the IPCC is crucial. That is why I recommend - and the Governing Council of UNEP endorsed - the continuation of the work of the Panel as a joint Panel with WMO.

Mr Prime Minister, Mr Chairman, Ladies and Gentlemen,

No individual country can protect its patch of sky, or lower the level of greenhouse gases overhead. We need a truly global partnership, in which the global South is appropriately compensated, financially assisted by resources additional to the current flows, and ensured access to efficient technologies, to become real partners in the required major global effort. Over and above, East and Central European countries must also be assisted to join fully the global effort.

The London meeting of the Parties to the Montreal Protocol has set the tone on how to proceed, what difficulties are expected, what compromises are needed.

I am fully aware it will be much more difficult to negotiate a meaningful climate convention, a convention with clout, not a paper tiger. I am also fully aware people everywhere will agree a planetary hothouse can not be left to our children.

Let us therefore leave Sundsvall committed to begin in this decade - the last in this millennium - the difficult but unavoidable task of saving our planet. Let us leave Sundsvall committed to revising our attitudes and our actions, to opening our eyes to the damage we are causing to this fragile planet we don't own: the planet which actually belongs to the beautiful children we have just heard singing songs for life. Our planet is theirs and their children's. Let us thus leave Sundsvall committed to moving intergenerational responsibility from a slogan to a belief, to action. Let us leave Sundsvall committed to pulling together to ensure the judgement of history on everyone/on each of us/is not a condemnation, but a recognition of a victory in the push towards global partnership.

Thank you."

1.4 Opening Remarks by Prof. B. Bolin, Chairman of the Intergovernmental Panel on Climate Change (IPCC)

"Mr Prime Minister, Professor Obasi, Secretary-General of WMO, Dr Tolba, Executive Director of UNEP, Delegates, Ladies and Gentlemen,

The IPCC, has been working for about one and a half year to produce a first assessment of a possible future man-induced climate change. Extensive reports from the four working groups that were formed by IPCC are available as well as the Overview and Conclusions and an Executive Summary that will be the subject for discussions at this fourth plenary meeting of the Panel. I wish to express my sincere thanks to all those that have worked so hard to achieve this. Time has been short and in spite of some shortcomings I expect that the report can serve as a knowledge base for some years.

The purpose of this brief intervention is to focus on a few aspects of the problem that I consider important.

First of all it is likely that the discussions about this subject might lead into analyses of a large number of details, which in themselves are important, but that also may conceal the broad and most likely serious long-term problem that may be confronting humankind. Let us keep in mind, during these next few days that we indeed must view this issue in a 50 year perspective.

Also there is a need to develop further a solidarity between nations. As a matter of fact I think such a broad attitude to the problem is necessary in order for us to ultimately reach agreements on actions that may well have to be far-reaching and in the long run are going to be costly.

We are, however, confronted with a dilemma which is not easily resolved. The uncertainty of the predictions about future changes of climate and associated impacts are considerable and it does not seem likely that much more accurate predictions will be available for quite some time. The question then being asked by some is: Is it really justified to prepare for actions already now with the aim to slow down the build

up of greenhouse gases in the atmosphere - why not wait until our knowledge is more accurate?

My answer is: We need to reach agreements on some action programmes soon. The reasons are found in the report. I wish on this occasion to spell out the reasons that I consider most essential. The task of IPCC is, however not to draw up an action programme. This will be a subject for negotiations. But the work by the IPCC has convinced me that it is urgent to begin.

* We know for sure that the greenhouse gases are increasing and, if specific preventive actions are not taken, that their collective effect within about 40 years might be equivalent to about a doubling of carbon dioxide in the atmosphere (over its preindustrial concentration).

* There will be a change of climate, even though we do not know its magnitude very well, nor how rapidly it will come about. Also, the uncertainty range given implies that it is about as likely that future changes could be larger than the most probable change that has been predicted as smaller.

* The inertia of the climate system delays and conceals the climate changes that well may be on the way, but does not prevent them from occurring. At any one time the observed change is significantly less than what the increase of greenhouse gases already emitted ultimately will bring about.

* Increased concentrations of greenhouse gases that may occur in the future will return to preindustrial levels only slowly, i.e. on the time scale of a century or more, even if effective limitations of the emissions were quickly agreed upon at that time. Changes of climate that may take place would be with us for a long time.

* Admittedly, we do not know well how serious the impacts of climatic changes could be for the nations of the world, since we cannot yet and will probably not for quite some time be able to predict their regional distribution. It should be recognized, however, that spatial variability of regional changes of climate will be significantly larger than the spatial variability of the predicted global changes.

* If no preventive measures are taken beyond phasing out CFC-gases in accordance with the revised protocol for protection of the ozone-layer, burning of fossil fuels will be contributing to the increase of the greenhouse effect by more than 60% of the total in the beginning of the next century.

* In the past it has taken of the order of half a century to develop a primary energy resource, e.g. oil, to become a major component of the global energy supply system. There are no reasons to believe that the development of a supply system for other energy sources, e.g. renewable

sources, could be achieved more quickly.

* Measures to reduce the emissions of greenhouse gases that would be beneficial for society in other regards also are available and could be employed. We could in this way buy time for further research and for international negotiations with the aim to reach agreements on more far-reaching preventive measures to the extent necessary.

* It seems important to explore what can be achieved with such an initially modest approach, also in view of the need to understand better the economic implications of a major programme for combatting global climate change.

Is it likely that such a more limited action programme will be adequate in the long term? I doubt that. But economists also point out that a more far-reaching and drastic programme could not be successfully implemented quickly and might have major negative impacts on world economy.

The crucial question becomes: How much of a climate change is going to be acceptable, whatever we may mean by the word acceptable?

Well, we do not know and it will take time until we know better.

It may well take another ten years, even if a significant change of climate is actually already on the way. The stakes are high and some insurance against the development towards an ever more rapid exploitation of our natural resources would be most desirable and would represent a prudent strategy. The later we get going the more difficult and costly will it be to take more stringent counter-measures at a later time, if necessary.

Obvious measures to be agreed upon and implemented in the near future would be as follows:

* The agreement on phasing out the use of key CFC-gases should be implemented as soon as possible. It is important to make sure that substitutes do not have significant greenhouse effects.

* Increase the efficiency both in energy production and energy use; this should be pursued with urgency and could to a considerable degree be paid for by the energy savings that would be achieved in this way.

* Improved forest management could contribute significantly in preventing further increase of carbon dioxide in the atmosphere.

However, a climate change cannot be stopped without substantial reductions of the use of fossil fuels.

In view of the very long lead times for the development of new energy supply systems, it is urgent to find ways and means to establish some long term policy for a sustainable supply of energy for the world as a whole. Reliance on coal, oil and gas, might not only double but in the long term perhaps even triple the atmospheric carbon dioxide concentrations. Breeder reactors probably would have to replace the traditional reactors, if nuclear

energy should be a long term solution. We do not today know much about their security nor the cost for such an energy supply system. A sustainable solution must, however, ultimately to a substantial degree be based on the use of solar energy in one way or the other. Major financial resources are required now for research and development to provide the long term solutions that a decade or two from now might well be of crucial importance. It is remarkable that such research and development efforts at present merely have about 10% of the resources that are set aside for developing nuclear energy.

Last but not least, most of the increasing greenhouse gas concentrations in the atmosphere are still due to the industrialized countries of the world although this situation is changing. It is not surprising that developing countries now wish to get access to reasonably cheap energy for their development.

Is it not obvious that the technologically advanced countries do have responsibility to aid in the transfer of advanced and efficient techniques to the developing countries in their striving for better living conditions? It is even in their own interests, since it could become an effective measure for reducing the rate of increase of greenhouse gases in the atmosphere to the benefit of all nations.

I wish finally to emphasize, that the IPCC has been given the task to assess our knowledge of the likeliness and the characteristics of a climatic change as well as its impacts and to provide information on means to combat or mitigate such changes. The IPCC should, however, not be a forum for political negotiations. It is important that a scientific-technical basis be provided for negotiations towards international agreements on preventive actions. Such a basis should be established in close international cooperation, since the process itself will help in resolving differences among nations. I am convinced that we will serve our purpose best by giving as clear a description as possible of the issue.

It is of course, not possible to avoid completely political considerations having an imprint on a report of the present kind. Simply the choice of matters to be considered in the analysis will partly be based on value judgements which may well differ from one country to another. It has been my aim to minimize the influences of such considerations as much as possible in conducting the work of IPCC. I will welcome suggestions that would further improve the report in this regard. It is also important that facts are provided as clearly as possible not the least on issues that may be controversial. In this way I hope that the report can serve as a basis for negotiations.

I am looking forward to working with you during the coming four days. The report that will come out of this meeting should hopefully be a milestone in dealing with the issue of global climate change.

Thank you."

1.5 Agenda and programme of work of the session

1.5.1 The Panel agreed (i) to discuss and adopt the IPCC First Assessment Report and (ii) as part of such discussion, to consider the report of the session of the Special Committee on the Participation of Developing

Countries, convened as an open-ended group (Sundsvall, 24-25 August 1990).

1.5.2 The Panel also agreed that the parts of the report of its third plenary session (Washington, D.C., 5-7 February 1990) annexed as Appendices C and D be moved to the body of the report.

1.5.3 The Panel further agreed that, since the policymakers summaries of the Working Groups and the Special Committee had been approved by their respective plenaries, they would not be subject to amendment at the session. Nonetheless, their content could be discussed in the course of the consideration of the First Assessment Report.

1.5.4 The Panel also agreed to arrive at its decisions by consensus.

2. REPORT OF THE PRE-PLENARY ORIENTATION SESSION OF THE SPECIAL COMMITTEE, CONVENED AS AN OPEN-ENDED GROUP (SUNDSVALL, 24-25 AUGUST 1990)

2.1 The Chairman of the Special Committee emphasized the following points in his remarks to the panel:

i. It may be recalled that the Special Committee did not formally adopt its report during its third session (Geneva, 31 May - 1 June 1990); also the summary was drafted subsequent to the third session by its Chairman. After discussion and adoption of some amendments, the Committee formally adopted its report and summary. In the course of this action, it decided to request the Panel (a) to consider its report to be its policymakers summary and (b) to consider its previously-called policymakers summary as its executive summary to form part of its policymakers summary. The Special Committee recognized that its newly-named policymakers summary could not be considered in isolation; it should be read together with the rest of the IPCC First Assessment Report (see section 3 below).

ii. In the event of the continuation of the work of IPCC, the Committee agreed that a body similar to itself could serve the following needs:

(a) to act as a focal point for discussions on the science of, impacts of, and possible response options to climate change;

(b) to review the progress of the implementation of the recommendations of the Committee.

Under (a) the Committee pointed out the need to estimate the economic costs and benefits associated with the different response options in relation to the needs for economic development. This is critically needed particularly in the case of small island states. Country-specific studies, following the pattern of those done under the Montreal Protocol would be valuable; developing countries should make every effort to undertake such studies jointly or otherwise.

Under (b) regional and sub-regional co-operation should be promoted to increase the capacity of the developing countries in, inter alia,

- atmospheric research and monitoring in general
- detection of climate change
- climate modeling
- setting up climatological data banks
- observations of greenhouse gases
- oceanic monitoring and research.

Specific projects for this purpose and for enhancing public awareness, information exchange and training, especially in advanced fields of research, should be developed and implemented.

iii. The Committee pointed out that the plethora of meetings and their concurrent schedulings, while necessitated by the time pressure placed on IPCC in the past few months, made it very difficult to enable effective participation. More care should be devoted to better planning of the meetings in the future.

iv. While the attendance of the developing countries at IPCC meetings has shown a commendable increase, there are still not enough of them participating. It would be truly beneficial to encourage fuller participation by the developing countries as this would improve the relevance of IPCC findings and reports. Full participation includes the development of national capacity to address the issues of concern such as the appreciation of the scientific basis for climate change, the potential impacts of such change and evaluations of practical response strategies for national applications.

v. In this context, the Committee requested its Chairman to convey to the Panel:

a) its conclusion that the implementation of its recommended actions need not and should not await the outcome of future negotiations on a climate convention;

b) the need to mobilize the assistance of multilateral, bilateral and other funding organizations to implement its recommended actions;

c) the need to appeal to governments and other potential donors for continuing and increased contributions to the IPCC Trust Fund on an urgent basis to further encourage the participation of the developing countries in IPCC activities.

3. IPCC FIRST ASSESSMENT REPORT

3.1. The Panel adopted the Overview to the IPCC First Assessment Report. The Overview, as adopted, is given in the following pages.

3.2 The Panel defined its First Assessment Report as follows:

* the Overview,
* the Policymakers Summaries of its three Working Groups and its Special Committee on the Participation of Developing Countries, and
* the full reports of its three Working Groups.

3.3 The Panel recommended that its Overview be read not in isolation but in conjunction with the rest of its First Assessment Report.

4. DATE AND VENUE OF THE NEXT SESSION OF THE PANEL

The Panel decided to meet in its next session after the 45th session of the UN General Assembly and the first negotiating session on the framework convention on climate change. The decision on the date and venue was left to the Chairman of the Panel.

5. CLOSING OF THE SESSION

The fourth plenary session of the Intergovernmental Panel on Climate Change closed at 0305hrs on Friday, 31 August 1990.

WMO

UNEP

INTERGOVERNMENTAL PANEL ON
CLIMATE CHANGE

IPCC FIRST ASSESSMENT REPORT

OVERVIEW

31 AUGUST 1990

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PREFACE

TO THE IPCC OVERVIEW

The IPCC First Assessment Report consists of

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

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

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

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

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

1. SCIENCE

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

We are certain of the following:

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

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

We calculate with confidence that:

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

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

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

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

* The human-caused emissions of carbon dioxide are much smaller than the natural exchange rates of carbon dioxide between the atmosphere and the oceans, and between the atmosphere and the

terrestrial system. The natural exchange rates were, however, in close balance before human-induced emissions began; the steady anthropogenic emissions into the atmosphere represent a significant disturbance of the natural carbon cycle.

Based on current model results, we predict:

* An average rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2 - 0.5°C per decade) assuming the IPCC Scenario A (Business as Usual) emissions of greenhouse gases; this is a more rapid increase than seen over the past 10,000 years. This will result in a likely increase in the global mean temperature of about 1°C above the present value by 2025 (about 2°C above that in the pre-industrial period), and 3°C above today's value before the end of the next century (about 4°C above pre-industrial). The rise will not be steady because of other factors.

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

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

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

* Under the IPCC Scenario A (Business as Usual) emissions, an average rate of global mean sea-level rise of about 6 cm per decade over the next century (with an uncertainty range of 3 - 10 cm per decade), mainly due to thermal expansion of the oceans and the melting of some land ice. The predicted rise is about 20 cm in global mean sea level by 2030, and 65 cm by the end of the next century. There will be significant regional variations.

With regard to uncertainties, we note that:

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

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

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

Our judgement is that:

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

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

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

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

2. IMPACTS

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

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

ii) a consequent increase of global mean temperature in the range of 1.5°C to 4° - 5°C;

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

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

These scenarios pre-date, but are in line with, the assessment of Working Group I which, for Scenario

A (Business as Usual) has estimated the magnitude of sea-level rise at about 20 cm by 2030 and about 65 cm by the end of the next century. Working Group I has also predicted the increase in global mean temperatures to be about 1°C above the present value by 2025 and 3°C before the end of the next century.

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

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

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

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

i) emissions of greenhouse gases and doubling of concentrations;

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

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

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

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

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

2.1 Agriculture and forestry

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

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

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

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

2.2 Natural terrestrial ecosystems

Natural terrestrial ecosystems could face significant consequences

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

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

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

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

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

2.3 Hydrology and water resources

Relatively small climate changes can cause large water resource problems in many areas, especially arid and semi-arid regions and those humid areas where demand or pollution has led to water scarcity. Little is known about regional details of greenhouse-gas-induced hydrometeorological change. It appears that many areas will have increased precipitation, soil moisture and water storage, thus altering patterns of agricultural, ecosystem and other water use. Water availability will decrease in other areas, a most important factor for already marginal situations, such as the Sahelian zone in Africa. This has significant implications for agriculture, for water storage and distribution, and for generation of hydroelectric power. In some limited areas, for example, under an assumed scenario of a 1°C to 2°C temperature increase, coupled with a 10% reduction in precipitation, a 40-70% reduction in annual runoff could occur. Regions such as southern Asia, that are dependent on unregulated river systems, are particularly vulnerable to hydrometeorological change. On the other hand, regions such as the western USSR and western United States that have large regulated water resource systems are less sensitive to the range of hydrometeorological changes in the assumed scenario. In addition

to changes in water supply, water demand may also change through human efforts to conserve, and through improved growth efficiency of plants in a higher CO_2 environment. Net socioeconomic consequences must consider both supply and demand for water. Future design in water resource engineering will need to take possible impacts into account when considering structures with a life span to the end of the next century. Where precipitation increases, water management practices, such as urban storm drainage systems, may require upgrading in capacity. Change in drought risk represents potentially the most serious impact of climate change on agriculture at both regional and global levels.

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

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

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

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

2.5 Oceans and coastal zones

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

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

2.6 Seasonal snow cover, ice and permafrost

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

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

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

permafrost. As a result, overlying ecosystems could be significantly altered and the integrity of man-made structures and facilities reduced, thereby influencing existing human settlements and development opportunities.

3. RESPONSE STRATEGIES

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

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

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

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

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

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

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

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

3.1 Roles of industrialized and developing countries

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

  i) A major part of emissions affecting the atmosphere at present originates in industrialized countries where the scope for change is greatest. Industrialized countries should adopt domestic measures to

limit climate change by adapting their own economies in line with future agreements to limit emissions.

ii) To co-operate with developing countries in international action, without standing in the way of the latter's development by contributing additional financial resources, by appropriate transfer of technology, by engaging in close co-operation in scientific observation, analysis and research, and finally by means of technical co-operation geared to forestalling and managing environmental problems.

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

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

3.2 Options

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

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

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

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

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

- o sustainable forest management and afforestation;

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

- o review of agriculture practices.

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

* Because a large, projected increase in world population will be a major factor in causing the projected increase in global greenhouse gases, it is essential that global climate change strategies take into account the need to deal with the issue of the rate of growth of the world population.

* Subject to their particular circumstances, individual nations, or groups of nations, may wish to consider taking steps now to attempt to limit, stabilize or reduce the emission of greenhouse gases resulting from human activities and prevent the destruction and improve the effectiveness of sinks. One option that governments may wish to consider is the setting of targets for CO_2 and other greenhouse gases.

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

  - o beneficial for reasons other than climate change and justifiable in their own right, for example increased energy efficiency and lower greenhouse gas emission technologies, better management of forests, and other natural resources, and reductions in emissions of CFCs and other ozone depleting substances that are also radiatively important gases;

  - o economically efficient and cost effective, in particular those that use market-based mechanisms;

  - o able to serve multiple social, economic and environmental purposes;

- o flexible and phased, so that they can be easily modified to respond to increased understanding of scientific, technological and economic aspects of climate change;
- o compatible with economic growth and the concept of sustainable development;
- o administratively practical and effective in terms of application, monitoring and enforcement;
- o reflecting obligations of both industrialized and developing countries in addressing this issue, while recognizing the special needs of developing countries, in particular in the areas of financing and technology.

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

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

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

* Assessing areas at risk from sea-level rise and developing comprehensive management plans to reduce future vulnerability of populations and coastal developments and ecosystems as part of coastal zone management plans should begin as soon as possible.

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

* Three factors are considered as potential barriers to the operation of markets and/or the achievement of environmental objectives through

market mechanisms. These are:

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

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

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

An initial response strategy may therefore be to address information problems directly and to review existing measures which may be barriers. For example, prior to possible adoption of a system of emission charges, countries should examine existing subsidies and tax incentives on energy and other relevant greenhouse gas producing sectors.

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

  i) one track built on work underway or planned in existing institutions. Bilateral donors could further integrate and reinforce the environmental components of their assistance programmes and develop cofinancing arrangements with multilateral institutions while ensuring that this does not impose inappropriate environmental conditions.

  ii) parallel to this track the possibility of new mechanisms and facilities was considered. Some developing and industrialized countries suggested that new mechanisms directly related to a future climate convention and protocols that might be agreed upon, such as a new international fund, were required.

* Governments should undertake now:

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

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

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

  o expansion of the global ocean observing and monitoring systems.

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

4. PARTICIPATION OF DEVELOPING COUNTRIES

It is obvious that the impact on and the participation by the developing countries in the further

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

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

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

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

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

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

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

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

  - the building and manufacturing industries;
  - public transport systems;
  - industry;

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

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

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

  - the provision of skilled personnel and the material necessary to organize education programmes to develop

locally the skills necessary to assess climate change and combat its adverse effects;

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

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

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

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

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

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

5. INTERNATIONAL CO-OPERATION AND FUTURE WORK

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

This convention, and any additional protocols that might be agreed upon, would provide a firm basis for effective co-operation to act on greenhouse gas emissions and adapt to any adverse effects of climate change. The convention should recognize climate change as a common concern of mankind and, at a minimum, contain general principles and obligations. It should be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced range of countries while permitting timely action to be taken.

Key issues for negotiations will include the criteria, timing, legal form and incidence of any obligations to control the net emissions of greenhouse

gases, how to address equitably the consequences for all, any institutional mechanisms including research and monitoring that may be required, and in particular, the requests of the developing countries for additional financial resources and for the transfer of technology on a preferential basis. The possible elements of a framework convention on climate change were identified and discussed by Working Group III in its legal measures topic paper, appended to its Policymakers Summary.

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

* Because climate change would affect, either directly or indirectly, almost every sector of society, broad global understanding of the issue will facilitate the adoption and the implementation of such response options as deemed necessary and appropriate. Further efforts to achieve such global understanding are urgently needed.

APPENDIX

Emissions scenarios developed by IPCC

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

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

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

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

Figure 1. Projected Man-Made CO_2 Emissions
(Billion or 1000 million tonnes carbon per year)

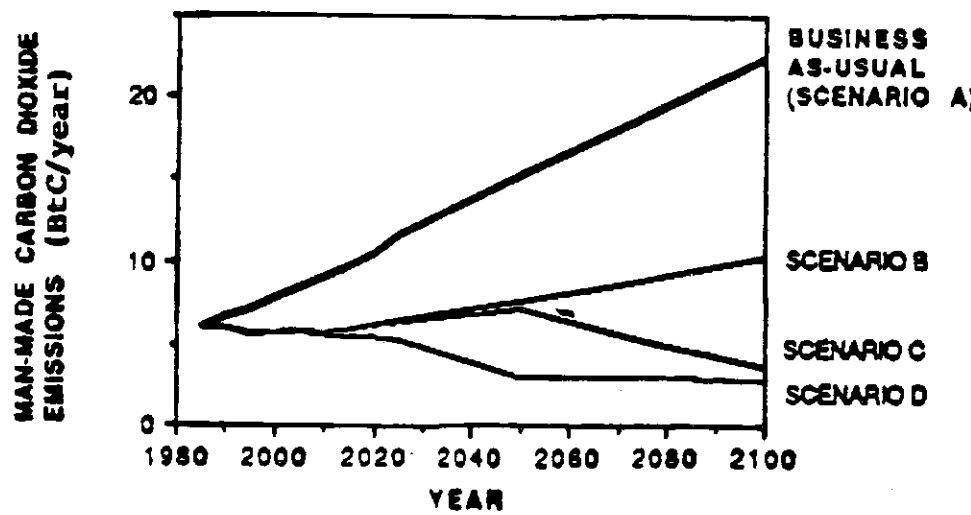
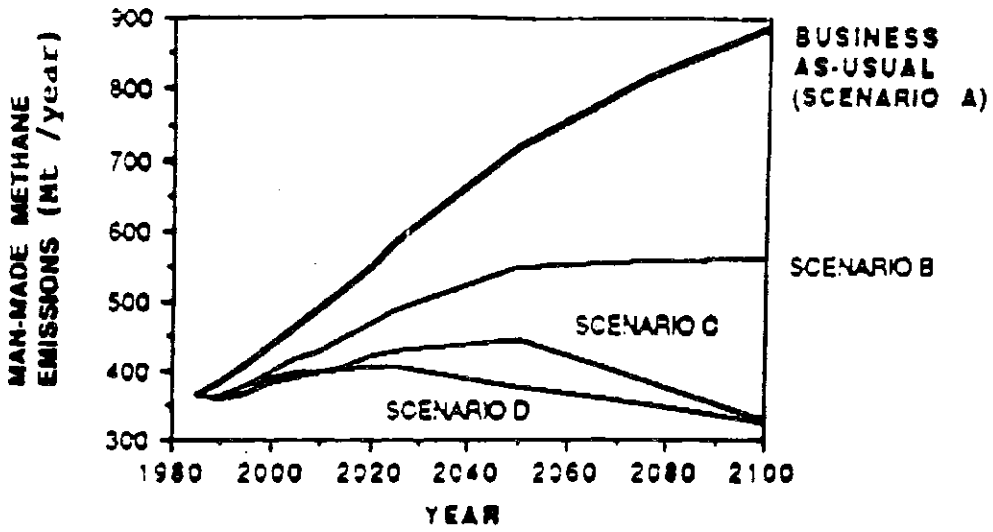


Figure 2. Projected Man-Made Methane Emissions (Million tonnes per year)



Method 1[2]

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

Scenario B (Low Emissions Scenario) assumes that the energy supply mix of fossil fuels shifts towards natural gas, large efficiency increases

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

are achieved, deforestation is reversed and emissions of CFCs are reduced by 50% from their 1986 levels. This results in an equivalent doubling of pre-industrial carbon dioxide by about 2040.

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

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

Method 2 (see footnote 2 on previous page)

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

Summary

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