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IPCC SUPPORTING MATERIAL

Guidance Papers on the Cross Cutting Issues of the Third Assessment Report of the IPCC

July 2000

Edited by R. Pachauri, T. Taniguchi and K. Tanaka

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Preface

The Intergovernmental Panel on Climate Change (IPCC) completed its Second Assessment Report in 1995. The IPCC has three Working Groups that focus on different aspects of climate change, viz. natural science, impacts, and mitigation. However, there are several issues that are common to these working groups, such as the consistent use of terms and conceptual frameworks. For the Third Assessment Report (TAR), the IPCC recognizes the importance of consistency within the output of the three Working Groups in dealing with these 'cross-cutting' issues.

The cross cutting issues selected for the TAR include:

(a) Perspective on development, equity and sustainability (DES)
(b) Costing methods
(c) Frameworks for decision making, including cost-benefit analysis
(d) Uncertainties
(e) Integrated assessment
(f) Scenarios
(g) Biogeochemical/ ecological feedback
(h) Sinks

Guidance papers have been prepared for the first four issues in order to help TAR authors in making more consistent use of terms and concepts in their chapters. Issues (e) to (h) are to be covered mainly by the Special Reports.

This report comprises these four Guidance Papers and a Users Guide for Cross Cutting Issues Guidance Papers. Users Guide consists of Overview, Important Issues, and Check Lists. This report also includes the summaries and conclusions of the following IPCC Expert Meetings, which were held to deepen understanding of the issues among authors as well as to facilitate the completion of guidance papers

- IPCC Expert Meeting on DES (1st), April 27-29, 1999, in Sri Lanka
- IPCC Expert Meeting on Costing methods, June 29-July 1, 1999, in Japan
- IPCC Expert Meeting on DES (2nd), February 26-28, 2000, in Cuba.

As confirmed through telephone calls and the two email conferences on cross cutting issues (conducted between January-March 1999, and in January 2000), the purpose of these Guidance Papers is not to prescribe but to promote mutual understanding among authors. They are intended to provide clear and policy-neutral guidance for authors.

Therefore, this report is essentially for facilitating the work of TAR authors and reviewers in their drafting and review process. At the same time, however, it is expected to be useful for preparation of the future IPCC reports on climate change issues.

IPCC Vice Chairs, R. Pachauri and T. Taniguchi

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USER'S GUIDE FOR CROSS CUTTING ISSUES GUIDANCE PAPERS

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Introduction

The IPCC Third Assessment Report (TAR) is now in the drafting and reviewing process to be completed by the middle of 2001. As part of the TAR process, four guidance papers have been prepared on the following cross-cutting issues: costing methodologies, uncertainty and decision analysis framework (DAF), development, equity, and sustainability (DES).

This user's guide has been prepared to assist authors of the TAR in applying the guidance papers on the cross cutting issues to the various chapters of the TAR. This guide essentially summarizes the main features of the guidance papers, in the expectation that the lead authors would use this summary in seeking the material provided in the guidance papers themselves in particular materials of practical action oriented nature. It is also expected that this summarized guide would be useful for the CLAs and Review Editors of the TAR in assessing the extent to which the individual chapters have considered the four major cross cutting issues in arriving at the contents of each chapter. Hence, the attempt at providing a check list of issues wherever possible in relation to each of the four major cross cutting issues. This guide and its contents are not binding in any way, and its purpose is merely to assist in the consideration of cross cutting issues. This is also expected to be used always in conjunction with the original guidance papers.

Coverage of each paper is offered in a common format:

1. Overview of the Guidance Paper
Introduction and context.
2. Important Issues
Clarification of critical components.
3. Check Lists
Practical lists of questions for authors to foster consistency between chapters.

Objective of the four Guidance Papers

Four papers have been prepared on selected issues that cut across two or more of the Working Group reports of the IPCC. The purpose of the papers is to provide guidance to authors of the IPCC TAR for use in drafting their chapters of the TAR with the goal of achieving consistent use of terms and approaches to the assessment and reporting of information that is relevant to the cross-cutting issues. The guidance is intended to be practical and user-friendly and yet appropriate for application to many disciplines represented in the TAR and the broad range of scientific literature to be assessed. As CLAs and LAs are fully responsible for their scientific assessment in their drafting, the guidance is not intended to restrict the substance of authors' assessment findings. The guidance should be policy neutral and should not be biased in ways that would tend to prejudge findings.

The issues that the guidance papers will address include:

Costing Methodologies

- What approaches have been used in assessing costs associated with impacts, adaptation and mitigation options?
- What common definitions, concepts, assumptions, and methodologies should be used across the chapters and Working Groups?

Uncertainties

- What approaches can be used in the TAR to represent uncertainties concerning the core, the body and the range of informed technical opinions regarding the key issues assessed in the chapters?
- What terms and methods should be used to standardize the assessments of "degree of belief" or "level of confidence" which quantifies and/or qualifies uncertainties in key findings.

Decision Analysis Frameworks (DAF)

- What approaches should be used in the TAR for synthesizing and presenting information for use in possible decision-making frameworks for climate change?
- What information is required from different chapters to successfully use these approaches?

Development, Equity and Sustainability (DES)

- How would climate change and climate policy be related to the issues of development, equity and sustainability?

Policy Relevant Scientific, Technical and Socio-economic Questions (PRSQ)

In view of the importance of PRSQ, which will constitute the main body of the TAR Synthesis Report, and their close linkage with cross cutting issues, a list of the ten PRSQ is attached at the end of this paper together with a table indicating their relevance to each chapter of the three TAR Working Group Reports.

Costing Methodologies: by Drs. Markandya and Halsnæs

1. Overview of the Guidance Paper

The costs of climate change policies are estimated and their implications discussed in many parts of the IPCC's Assessment Report. It is essential therefore that a common understanding of the use of different cost concepts is employed. The guidance paper proposes a set of definitions for these concepts and presents a relation between them. The paper also identifies categories of costs and highlights their relevance in the climate change area. Finally, the paper discusses the relationships of cost concepts with baseline, equity and uncertainties. It recommends that authors clarify what cost assumptions underlie the baselines they apply.

2. Important Issues

- Discussion of cost estimation is predicated on the assumption that all the different activities related to climate change, which involve the use of scarce resources, can indeed be measured in monetary terms.

It is important to note that this 'monetisation' is not always valid. Where resources whose values cannot be monetized are used in sustaining climate change policies, or as a consequence of coping with the impacts of climate change, they should be noted and reported in physical terms. Examples of cases where monetary measurement may not be possible are given in the paper.

- The methodology for cost estimation applies, not only to the costs of mitigating greenhouse gases, but also to the estimation of the impacts of climate change and the cost of adaptation.

In all cases, scarce resources are being employed or transformed -- be they 'concrete' resources such as labour and raw materials in the case of some mitigation measures, or more 'diffuse' resources such as a climate with known properties. The task is to measure these uses in monetary terms as consistently as possible.

- The conceptual foundation of all cost estimation is the value of the scarce resources to individuals.

These values are measured in terms of the willingness to pay (WTP) by individuals to receive the resource or by the willingness of individuals to accept payment (WTA) to part with the resource The costs of WTP and WTA therefore play a critical part in the whole cost methodology. They do not necessarily produce similar valuations.

- Some mitigation measures may generate ancillary benefits or costs, and these are part of a unified framework of cost assessment.

Ancillary benefits and costs are those arising in addition to the direct benefits and costs of policies to reduce GHGs in the atmosphere. Existing studies have identified the health benefits associated with collateral reductions in pollutants as a major source of ancillary benefits.

Concurrently with these benefits, there may be ancillary costs of GHG mitigation. These can range from increased nitrification of soil (a fertilizer effect), to the increase in indoor air pollution.

- Every cost assessment considers all changes in resources demanded and supplied by a given policy in relation to a specific non-policy case – the so-called baseline case.

Figure 1 shows the relationship of various costs that are taken into consideration in this guidance paper. In this figure ancillary benefits should be seen as a component of social cost. They are mainly a form of external cost.

3. Check List

1. If the data reflected financial cost, are all changes in financial flows included? If not, which ones are left out?
   If data reflect social cost:
   (i) To what extent are the costs based on WTP or WTA?
   (ii) What adjustments have been made to the market data in arriving at the private cost component?
   (iii) What assumptions have been used to aggregate the individual costs to arrive at the total costs?
   (iv) What estimation has been made of any changes in external costs?
2. What items of costs, if any, have not been monetised?
3. What discount rates have been chosen? What are the reasons for the choice?
4. What assumptions underlie the forecasts of future costs and how have they been used to generate the forecast values?
5. Are implementation costs estimated?
6. What are the costs of transition from a 'business as usual' policy assumption to the actual policy assumption and what assumptions underlie the generation of the baseline?
7. Are key assumptions on an accepted format used for the costs based on macroeconomic/general equilibrium model?
8. Are the boundaries of uncertainties for the estimates indicated?

Linkages between costing methodologies and related matter for TAR Chapters are summarized in Table 1.

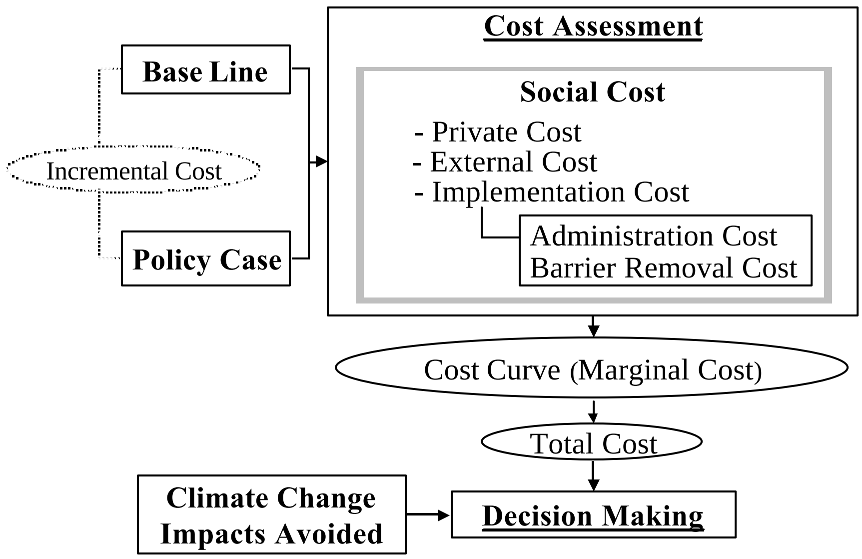

Figure 1 Relation of various costs. (Prepared by K. Tanaka)

Uncertainties: by Drs. Moss and Schneider

1. Overview of the Guidance Paper

The purpose of this paper is to recommend the elements of a common approach for assessing, characterising, and reporting uncertainties in a more consistent—and to the extent possible, quantitative—fashion across the various chapters of the TAR. It is hoped that the guidance will enable authors to be more systematic in characterising the types and sources of uncertainties.

The term "uncertainty" can range in its implication from a lack of absolute sureness to such vagueness that preclude anything more than informed guesses or speculation. Sometimes uncertainty results from a lack of information, and in other cases, it is caused by disagreement about what is known or even knowable. Some categories of uncertainty are amenable to quantification, while other kinds cannot be sensibly expressed in terms of probabilities. Examples of sources of uncertainties, which can be encountered by authors and treated here, are listed below.

Problems with data

Missing, errors, noise, random sampling error and biases.

Problems with models

Structure, parameters, their credibility over time, predictability of the system or effect, and approximation techniques.

Other sources of uncertainty

Concepts/terminology, spatial/temporal units, assumptions, human behavior.

2. Important Issues

- In climate research, the problems of uncertainty are compounded by many fundamental characteristics.

These include a global scale, long time lags between enforcement and response, low frequency variability with characteristic times greater than the length of most instrumental records and the impossibility of before-the-fact experimental controls.

- Climate change and other complex, socio-technical policy issues are not just scientific topics; they are also matters of public debate.

Even good data and careful analysis may be insufficient to dispel some aspects of uncertainty associated with the different standards of evidence and the degrees of risk aversion/acceptance that individuals participating in this debate may hold.

- A "Bayesian" or "subjective" characterisation of probability is most appropriate.

Bayesian approaches are expected to be most often applicable when probabilities are attached to outcomes with an inherent component of subjectivity or to an assessment of the state of the science from which confidence characterisations are offered.

- Authors should explicitly state what sort of approach they are using in a particular case.

3. Check List

Steps recommended for assessing uncertainty in the TAR were summarized below (extracted from Box 1 in the uncertainties guidance paper by Drs. Moss and Schneider).

1. Are the most important factors of uncertainties, and uncertainties that are likely to affect the conclusion identified for each of the major findings, which are expected to be developed in the chapter? Which important factors/variables are treated exogenously or fixed?
2. Are ranges and distributions in the literature, including sources of information on the key causes of uncertainty documented?
3. Given the nature of the uncertainties and the state of science and the purpose of determining the appropriate level of precision:
   (i) Is the state of science such that only qualitative estimates are possible?
   (ii) Is quantification possible, and if so, to how many significant digits?
   (iii) Is the level of uncertainty/precision recalibrated in response to the assessment of new information as the assessment proceeds?

4. Is the distribution of values for a parameter, variable, or outcome characterized quantitatively or qualitatively? Does the writing team identify the end points of the range and/or are any high consequence, low probability outcomes or "outliers" described? What portion of the range is included in the estimate and what is the selection based on? Does the assessment offer the general shape of the distribution (e.g., uniform, bell, bimodal, skewed, symmetric)? How is the assessment of the central tendency of the distribution described?
5. Is the state of scientific information on which the conclusions and/or estimates are based, described and rated using designed terms? Is there consistency in the use of a confidence descriptor? (See Figures 3 and 4 in the guidance paper on "Uncertainties.")
6. Is a "traceable account" prepared to show how the estimates are constructed to describe the writing team's reasons for adopting a particular probability distribution, including important lines of evidence used, the standards of evidence applied, the approaches to combining/reconciling multiple lines of evidence, and the critical uncertainties?
7. What formal probabilistic frameworks have been used in assessing expert judgment (i.e. decision-analytic techniques)?

Linkages between uncertainties and related matter for TAR Chapters are summarized in Table 2.

Decision Analysis Framework (DAF): by Dr. Toth

1. Overview of the Guidance Paper

The purpose of this guidance paper is to provide an overview of the various Decision Analysis Frameworks (DAFs) that have been used or could be used in policy-oriented studies of climate change. DAFs organize climate-relevant information in a suitable framework, apply a decision criterion (both based on some paradigms or theories), and identify options that are better than others under the assumptions characterizing the analytical framework and the application at hand. Possible frameworks range from loose what-if types of studies that allow policymakers to compare outcomes of their alternative courses of action on the basis of their own selection/decision criteria (simulation models or scenario-based free-form participatory exercises are examples) to rigorous arrangements that apply a decision criterion and identify options that are better than others (quantitative, mostly model based inquiries like decision analysis, cost-benefit or cost-effectiveness analyses are most frequently used).

The diversity of decision problems involved in climate change, the multiple level of decision making, and the broad range of decision principles/criteria that can be applied have induced analysts to apply different analytical techniques (or DAFs) and/or to use different versions of the same DAF to the problem at hand. Table 1 in DAF guidance paper provides an overview of the most frequently used DAFs, their compatibility with decision making principles, applicability at different geopolitical levels (global to micro) and in one or more of the main climate policy domains (mitigation, adaptation, and balancing mitigation and adaptation in an integrated procedure).

2. Important Issues

➢ Policy insights from DAFs applied at the same geopolitical level in the same domain can differ for several reasons:

- Different underlying theories/paradigms of the DAF may have been selected and used,
- Different study boundaries may have been chosen (what is included, what is left out),
- Different assumptions about relationships among various components included in the study may have been adopted,
- Different assumptions about external factors may have been indicated.

Presentation of these policy-relevant results is more useful to the policy community if they are supplemented by a pedigree of their sources. This allows the policy audience to understand the conceptual or methodological differences that lead to diverging results and to make use of those results according to their own assessments of the results and validity.

➢ Authors can conduct simple analyses of their own to synthesise information from preceding chapter by adopting one or more different DAFs.

- It is useful to distinguish decision analysis from process analysis parts of the decision-making frameworks.
  Decision analysis parts: providing information for actors involved in decision-making frameworks at various levels.
  Process analysis parts: institutional framework design (how to build policy regimes), procedures of decision making at various levels.
- National climate policy cuts across various kinds of decisions to the extent that emissions constraints will affect future decisions in other areas.
  Examples: energy, agriculture, transport, housing and many other policies at the national level.
- Different principles are shown and defined.
  Decision analysis (DA), Cost-benefit analysis (CBA), Cost-effectiveness analysis (CEA), Tolerable windows approach, Safe landing analysis approach, Game theory, Portfolio theory, Public finance theory, Behavioral decision theory, Ethical and cultural prescriptive rules, Policy exercise approach, Integrated assessment (IA) focus groups, Simulation-Gaming

3. Check List

1. What DAFs were used in exploring decision options on mitigating and adapting to climate change impacts in different sectors and regions?
2. Have the cited studies gone beyond the level of elementary impact assessment and adopted a DAF to inform relevant decision-makers on how, to what extent, and at what cost can possible unfavorable impacts be reduced or countervailed?
3. When DAFs are used in chapters, is the extent to which different DAFs are used and/or can be used in analyzing issues addressed?
4. Is the consistency of the theoretical foundations carefully checked between various DAFs and their particular applications?
5. Are different results from the same DAF spread in response to plausible variations in the boundary conditions available and compared? Are dispersed results drawn from applying different DAFs to the same exogenous assumptions explored?
6. Is the sensitivity of results demonstrated and explained?
7. Do studies employ different DAFs in assessing potentials and barriers concerning specific policies and measures?
8. What are the net costs associated with different climate stabilization levels? How do these costs depend upon different policy instruments, and varying degrees in flexibility?

Linkages between DAFs and related matter for TAR Chapters are summarized in Table 3.

Development, Equity and Sustainability (DES): by Dr. Munasinghe

1. Overview of the Guidance Paper

DES are key cross-cutting issues that pervade the TAR -- especially the chapters of WG2 and WG3. They are also important concepts that are well established worldwide in increasing depth and width in the minds of both decision makers and the general public. Currently, the concept of sustainable development has evolved to encompass three major points of view -- economic, social and environmental – which need to be treated in a holistic balanced manner. Recognising that the climate change issue is a key element of the broader search for sustainable development paths, this paper offers guidance in our examinations of how climate change measures might be incorporated more smoothly into economic, social and environment policies without undermining human welfare and growth potential -- especially in the poorer countries.

2. Important Issues

The following broad and long-term questions related to DES are important for drafting TAR.

- How will expected development patterns and scenarios affect climate change?

- How will climate change impacts, adaptation and mitigation affect sustainable development prospects?
- How could climate change responses be better integrated into sustainable development strategies?

In this context, DES are integral elements of sustainable development. It follows that the need to promote individual prosperity and to develop communities and economies (e.g., through quantitative and/or qualitative improvements) must be met, while sustaining ecological, geophysical and social systems.

The TAR could help to clarify how greater priority might be placed on adjusting the development growth path to reduce GHG emissions while maintaining prospects for improving human welfare (e.g., using win-win and/or no-regrets strategies) or at least not overly impeding such growth.

3. Check List

1. Are climate change impacts and climate strategy evaluated broadly in terms of long term effects on:
   (a) human welfare and equity?
   (b) durability and resilience of ecological, geophysical and socio economic systems?
   (c) stocks of different kinds of capital? (e.g. Manufactured, natural, human and socio-cultural assets)
2. Are there identification and analysis of the literature that attempts to bridge interdisciplinary gaps – economy, ecology and sociology?
3. Is the treatment of economy, society and environment sufficiently balanced in meeting the challenges of sustainable development?
4. Are DES issues systematically addressed, and searched well beyond the mainstream journals – in as many different countries and languages as possible?
5. Are indicators used for the assessment of DES:
   (a) multi-dimensional in nature?
   (b) practical and comprehensive in scope?
   (c) accommodating differences in regions and scale?
6. Is the assessment useful as a practical guide for decision makers to evaluate from the viewpoints of not only governments but also civil society, businesses, NGOs and other stakeholders?

Linkages between sustainable development and related matter for TAR Chapters are summarized in Table 1 in DES guidance paper by Dr. Munasinghe.

Tables: Checklists for IPCC TAR chapters

Table 1:Costing methodologies– Links with TAR Chapters except for WG3 ch.7 "Costing Methodologies".

Issue	Checklist of the issues for IPCC TAR chapters	WG2 Chapters	WG3 Chapters
Costing Methodologies	➢ If data on financial cost, all changes in financial flows included? If not, which ones are left out?	3-19	2-5,8,9
	➢ If data are on social cost: (i) To what extent are the costs based on a WTP/WTA basis? (ii) What adjustments to market data at the private cost component? (iii) What assumptions to aggregate the individual costs to arrive at total costs? (iv) What estimation of any changes in external costs?	3-19	2-5,8,9
	➢ What items of cost monetised?	3-19	3-5,8,9
	➢ What discount rates? Reasons for the choice?	3-19 3-19	2-6,8-10 2-5,8,9
	➢ What assumptions for future costs? How have these been used to generate the forecast values?	3-19	2-6,8-10
	➢ Implementation costs estimated?.	3-19	2-5,8-10
	➢ What attempts to address the equity issues?	3-19	2,5,6,8-10
	➢ What are the costs of transition from a BAU to the actual policy assumption and the assumptions underlying the generation of the baseline, for any baseline adopted?	3-19	2,5,6,8,9
	➢ Key assumptions used for macroeconomic/general equilibrium model based costs?	3-19	2-5,6,8,9
	➢ Uncertainty bounds for the estimates?		

Prepared by K. Tanaka

Table 2: Uncertainties– Links with TAR Chapters.

Issue	Checklist of the issues for IPCC TAR chapters	WG2 Chapters	WG3 Chapters
Uncertainties	➢ Important factors and uncertainties to affect the conclusion identified?	all	all
	➢ Important factors/variables are treated exogenously or fixed?	3-19	2-5,8-10
	➢ Ranges and distributions in the literature, including sources of information on the key causes of uncertainty documented?	2-19	2-10
	➢ For determination of the appropriate level of precision: (a) qualitative estimates are possible? (b) quantification possible? how many significant digits? (c) level of uncertainties/precision recalibrated in response to new information?	2-19	2-5
	➢ Distribution of values characterized quantitatively or qualitatively?	2-19	2-5,8,9
	➢ The end points of the range that the writing team establishes, and/or any high consequence, low probability outcomes or "outliers" identified?	2-19	2-10
	➢ Portion of the range included in the estimate and what the range is based on?	2-19	2-5,8,9
	➢ How is the assessment of the general shape of the distribution?	2-19	2-5,8,9
	➢ How is the assessment of the central tendency of the distribution described?	2-19	2-5,8,9
	➢ Is the state of scientific information described and rated using designed terms?	all	all
	➢ Consistency in the use of confidence descriptor and a clear way to assure this consistency to have a discrete quantitative and/or qualitative term?	all	all
	➢ "Traceable account" prepared to show how the estimates were constructed?	2-19	2-5,8,9
	➢ What are formal probabilistic frameworks used for assessing expert judgment?	all	all

Prepared by K. Tanaka

Table 3: Decision analysis framework – Links with TAR Chapters.

Issue	Checklist of the issues for IPCC TAR chapters	WG2 Chapters	WG3 Chapters
Decision Analysis Framework	➢ Have studies quoted gone beyond the level of elementary impact assessment and adopted a DAF to inform relevant decision-makers on how, to what extent, and at what cost can possible unfavorable impacts be reduced or countervailed?	all all	all all
	➢ When any DAF is used in chapters, is it clear to what extent different DAFs are used and/or could be used in analyzing issues addressed?	2,3,19	2,5,7
	➢ Is the consistency of the theoretical foundations carefully checked between various DAFs and their particular applications?	3-9,18,19 (10-17)	2-5,8,9
	➢ Do studies employ different DAFs in assessing potentials and barriers of technologies for adaptation to the climate change and to reduce emissions or enhance sinks?	3-19	2-6,8,9
	➢ Is the sensitivity of results demonstrated and explained?	3-19	2-6,8,9
	➢ How results from the same DAF spread in response to plausible variations in the boundary conditions, and vice versa, how results disperse if the same exogenous assumptions are implemented in different DAFs?	3-9,18,19	2,6,10
	➢ What are the net costs associated with different climate stabilization levels, each of which is to be attained along different emission paths, and implemented through different policy instruments characterized by varying degrees of flexibility?	4-19	3- 6, 8-10
		4-19	3- 6, 8-10
	Methodologies/Framework:	4-19	3- 6, 8-10
	Decision analysis	19	10
	Cost-benefit analysis	10-19	3- 6, 8-10
	Cost-effectiveness analysis	4-19	3- 6, 8-10
	Tolerable windows/Safe landing	4-19	3- 6, 8-10
	approach	4-19	3- 6
	Game theory		3- 6
	Portfolio theory	10-19	3- 6, 10
	Public finance theory	4-18	3- 6, 8-10
	Behavioral decision theory		3- 6, 10
	Ethical and cultural prescriptive rules		
	Policy exercises		
	Focus groups		
	Simulation- gaming		

Prepared by F. Toth and K. Tanaka

Note: Please refer to Table 1 in DES guidance paper regarding the links with DES issues and relevant matters for TAR.

Policy Relevant Scientific, Technical and Socio-economic Questions (PRSQ)

Q1. What can scientific, technical and socio-economic analyses contribute to the determination of what constitutes dangerous anthropogenic interference with the climate system as referred to in Article 2 of the Framework Convention on Climate Change?

Q2. What is the evidence for, causes of, and consequences of changes in the Earth's climate since the pre-industrial era?

a. Has the Earth's climate changed since the pre-industrial era at the regional and/or global scale? If so, what part, if any, of the observed changes can be attributed to human influence and what part, if any, can be attributed to natural phenomena? What is the basis for that attribution?
b. What is known about the environmental, social and economic consequences of climate changes since the pre-industrial era with an emphasis on the last 50 years?

Q3. What is known about the influence of the increasing atmospheric concentrations of greenhouse gases and aerosols, and the projected human-induced change in climate regionally and globally on:

a. the frequency and magnitude of climate fluctuations, including daily, seasonal, inter-annual, and decadal variability, such as the El Nino-Southern Oscillation cycles and others?
b. the duration, location, frequency and intensity of extreme events such as heat waves, droughts, floods, heavy precipitation, avalanches, storms, tornadoes, and tropical cyclones?
c. the risk of abrupt/non-linear changes in, among others, the sources and sinks of greenhouse gases, ocean circulation and the extent of polar ice and permafrost? If so, can the risk be quantified?
d. the risk of abrupt or non-linear changes in ecological systems

Q4. What is known about the inertia and time-scales associated with the changes in the climate system, ecological systems, and socio-economic sectors and their interactions?

Q5. What is known about the regional and global climatic environmental, and socio-economic consequences in the next 25, 50 and 100 years associated with a range of greenhouse gas emissions arising from scenarios used in the TAR (projections which involve no climate policy intervention),:

To the extent possible, evaluate the:

- projected changes in atmospheric concentrations, climate and sea level;
- impacts and economic costs and benefits of changes in climate and atmospheric composition on human health, diversity and productivity of ecological systems, and socio-economic sectors (particularly agriculture and water);
- the range of options for adaptation, including the costs, benefits and challenges; and
- development, sustainability and equity issues associated with impacts and adaptation at a regional and global level..

Q6. How does the extent and timing of the introduction of a range of emissions reduction actions determine and affect the rate, magnitude and impacts of climate change, and affect the global and regional economy, taking into account the historical and current emissions?

Q7. What is known from sensitivity studies about regional and global climatic, environmental and socio-economic consequences of stabilizing the atmospheric concentrations of greenhouse gases (in carbon dioxide equivalents), at a range of levels from today's to double that level or more , taking into account to the extent possible the effects of aerosols? For each stabilization scenario, including different pathways to stabilization, evaluate the range of costs and benefits, relative to the range of scenarios considered in question 5, in terms of:

- projected changes in atmospheric concentrations, climate and sea level, including changes beyond 100 years;

- impacts and economic costs and benefits of changes in climate and atmospheric composition on human health, diversity and productivity of ecological systems, and socio-economic sectors (particularly agriculture and water);
- the range of options for adaptation, including the costs, benefits and challenges;
- the range of technologies, policies and practices that could be used to achieve each of the stabilization levels, with an evaluation of the national and global costs and benefits, and an assessment of how these costs and benefits would compare, either qualitatively or quantitatively, to the avoided environmental harm that would be achieved by the emissions reductions;
- development, sustainability and equity issues associated with impacts, adaptation and mitigation at a regional and global level.

Q8. What is known about the interactions between projected human-induced changes in climate and other environmental issues, e.g., urban air pollution, regional acid deposition, loss of biological diversity, stratospheric ozone depletion, and desertification and land degradation? What is known about the environmental, social and economic costs and benefits and implications of these interactions for integrating climate change response strategies in an equitable manner into broad sustainable development strategies at the local, regional and global levels?

Q9. What is known about the potential for, and costs and benefits of, and timeframe for reducing greenhouse gas emissions?

a. What would be the economic and social costs and benefits, and equity implications of options for policies and measures, and the mechanisms of the Kyoto Protocol, that might be considered to address climate change regionally and globally?
b. What kind of economic and other policy options might be considered to remove existing and potential barriers and to stimulate private- and public-sector technology transfer and deployment among countries, and what effect might these have on projected emissions?
c. What portfolios of options of research and development, investments, and other policies might be considered that would be most effective to enhance the development and deployment of technologies that address climate change?
d. How does the timing of the options contained in a, b and c affect associated economic costs and benefits, and the atmospheric concentrations of greenhouse gases over the next century and beyond?

Q10. What are the most robust findings and key uncertainties regarding attribution of climate change and regarding model projections of:

- future emissions of greenhouse gases and aerosols;
- future concentrations of greenhouse gases and aerosols;
- future changes in regional and global climate;
- regional and global impacts of climate change; and
- cost and benefits of mitigation and adaptation options?

Socio-economic Questions and their relevance to TAR working group report

WG	Ch	Questions	1	2	3	4	5	6	7	8	9	10
I	1	Overview		x	x		x					x
	2	Observed Climate Variability and Change		x	x		x	x	x	x		x
	3	Carbon Cycle & Atmospheric CO_2		x	x		x	x	x	x		x
	4	Atmospheric Chemistry & GHG		x	x		x	x	x	x		x
	5	Aerosols, their Direct and Indirect Effects		x	x		x	x	x	x		x
	6	Radiative Forcing of CC		x	x		x	x	x	x		x
	7	Physical Climate Processes and Feedbacks		x	x		x	x	x	x		x
	8	Models Evaluation				x	x		x	x		x
	9	Projections of Future CC		x	x	x	x	x	x	x	x	x
	10	Regional Climate Information - Evaluation and Projections	x	x	x	x	x	x	x	x	x	x
	11	Changes in Sea level	x			x	x	x	x	x	x	x
	12	Detection of CC and Attribution of Causes					x	x	x	x	x	x
	13	Climate scenario Development				x	x	x	x	x	x	x
	14	Advancing our Understanding					x	x	x	x		x
II	1	Overview of Impacts Issues					x	x	x	x		x
	2	Methods and Tools								x		x
	3	Development & Application of Scenarios in CC Impact, Adaptation, Vulnerability Assessment	x			x	x	x	x	x		x
	4	Hydrology and Water Resources		x	x	x		x	x	x		x
	5	Ecosystems and Their Services		x	x	x		x	x	x		x
	6	Coastal Zone and Marine Ecosystems		x	x	x	x	x	x	x		x
	7	Human Settlements		x		x	x	x	x	x		x
	8	Financial Services		x		x	x	x	x	x		x
	9	Human Health		x		x	x	x	x	x		x
	10	Africa		x	x		x	x	x	x		x
	11	Asia		x	x		x	x	x	x		x
	12	Australasia		x	x		x	x	x	x		x
	13	Europe		x	x		x	x	x	x		x
	14	Latin America		x	x		x	x	x	x		x
	15	North America		x	x		x	x	x	x		x
	16	Polar Regions (Arctic & Antarctic)		x	x		x	x	x	x		x
	17	Small Island States		x	x		x	x	x	x		x
	18	Adaptation to CC in the Context of Sustainable Development and Equity					x		x			x
	19	Synthesis				x	x	x	x			x
III	1	Scope of the report					x		x	x		x
	2	Greenhouse Gas Emissions Mitigation Scenarios and Implications	x			x		x	x	x	x	x
	3	Technical and Economic Potential of GHG emissions Reduction				x		x	x	x	x	x
	4	Technological and Economic Potential of Options to Enhance, Maintain and Manage Biological Carbon Reservoirs and Geo-Engineering				x		x	x	x	x	x
	5	Barriers, Opportunities and Market Potential of Technologies and Practices				x		x	x	x	x	x
	6	Policies, Measures and Instruments				x		x	x	x	x	x
	7	Costing Methodologies				x		x	x	x	x	x
	8	Global, Regional and National Costs and Ancillary Benefits of Mitigation				x		x	x	x	x	x
	9	Sector Costs and Ancillary Benefits of Mitigation				x		x	x	x	x	x
	10	Decision Making Frameworks				x	x	x	x	x	x	x

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COSTING METHODOLOGIES[1]

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[1] This first draft was prepared after taking into account comments from Q.K. Ahmad, P. Barrie, P. Jiahua, N. Leary, M.Q. Mirza, B. Metz, R. Moss, J.S. Oguntoyinbo, R. Richels, H.J. Schellnhuber, R. Shackelton, R. Swart and J.R. Ybema. This second draft has been prepared following additional comments from Professor Taniguchi and Dr Pachauri as well as those sent to the web site for the cross cutting papers established by TERI, India. Finally a related paper was presented at the IPCC Expert meeting on Costing Issues for Mitigation and Adaptation to Climate Change in Tokyo. Comments from that meeting have also helped improve this revised draft.

1. Introduction

The costs of climate change policies are estimated and their implications discussed in many parts of the IPCC's Assessment Report. The use of consistent cost concepts across the TAR is important, in order to facilitate comparability across different cost assessment approaches. In this guidance paper, we propose a set of definitions for the different concepts and present a relation between them. We suggest that, in every case where costs are referred to, authors make clear which cost concept or concepts they are using. The paper also identifies categories of costs and their relevance in the climate change area. We also suggest that authors use this as a checklist when estimating or referring to the costs of certain measures. Finally, the paper discusses the relationship between cost concepts and baselines. Again, authors are recommended to make clear what cost assumptions underlie the baselines they use. Further details of these concepts can be found in Christensen, Halsnæs and Sathaye, 1998.

Before discussing the methodologies for the assessment of costs three important qualifications are warranted.

First we should remember that the whole discussion of cost estimation is predicated on the assumption that all the different activities related to climate change, which involve the use of scare resources, can indeed be measured in money terms. This applies to mitigation and adaptation activities, as well as to the evaluation of climate change impacts. It is important to note that this assumption is not always valid. The methods described below are relevant to those costs that can be measured in such terms. Where there are uses of resources resulting from climate change-related actions that cannot be put in money terms, they should, nevertheless, be noted and reported in physical terms. Examples of cases where monetary measurement may not be possible are given in the paper.

Second, this methodology for cost estimation presented here applies to the costs of mitigating greenhouse gases and adapting to climate change, as well as to the estimation of the impacts of climate change. In all cases scarce resources are being used up or transformed -- be they 'concrete' resources such as labour and raw materials in the case of some mitigation measures, or more diffuse 'resources' such as a climate with known properties. The task is to measure these uses in monetary terms, as consistently as possible.

Third, and related to that, it is important to allow for the fact that some mitigation measures may generated 'benefits' and these benefits are part of a unified framework of cost assessment. When speaking about costs we normally think of a positive number, reflecting a payment that has to be made in return for some goods or services. In the wider context in which the cost concept is being used here, however, it is necessary, in some cases, to allow for negative costs. It is essential that any cost assessment consider all changes in resources demanded and supplied by a given policy in relation to a specific non-policy case – the so-called baseline case. Some elements of this assessment will be negative, meaning that there are benefits to be gained by undertaking a climate change policy action. In this respect, both the benefits and the costs of a policy action should be included in the estimation. In some cases, the sum of the benefits and costs associated with a climate change policy action will be negative, implying that society benefits from undertaking the mitigation action.

2. Cost Concepts

Welfare Basis of Costs

The conceptual foundation of all cost estimation is the value of the scarce resources to individuals. Thus values are based on individual preferences, and the total value of any resource is the sum of the values of the different individuals involved in the use of the resource. This distinguishes this system of values from one based on 'expert' preferences, or on the preferences of political leaders.

The values which are the foundation of the estimation of costs are measured in terms of the willingness to pay (WTP) by individuals to receive the resource or by the willingness of individuals to accept payment (WTA) to part with the resource. The costs of WTP and WTA therefore play a critical part in the whole cost methodology. A frequent criticism of this basis of costing is that it is inequitable, as they give greater weight to the 'well off'. While acknowledging the validity of this criticism it is important to note that there is no coherent and consistent method of valuation that can replace the existing one in its entirety. Where there is a concern about equity that should be addressed separately from that of cost estimation. The estimated costs are only one piece of information in the decision-making process for climate change.

Social and Financial Costs

A basic distinction in all cost work is between the social cost of any activity or intervention and the financial cost. The key idea behind a social cost of something (call it X) is the full value of the scarce resources that have been used in producing X. That in turn is measured in terms of the value of the next best thing which could have been produced with the same resources, and is called social opportunity cost. This notion of cost may differ greatly from the common notion of cost. For example, take the cost of sequestering carbon by growing trees on a tract of public land. In estimating the costs of such a programme, what do we take as the cost of the land? In some cases a zero 'cost' is attached, because the land is not rented out and no money actually flows from the project implementor to the owner. This, however, is incorrect in social terms. The cost of the land is to be measured in terms of the value of the output that would have been received from that land had it not been used for forestry. Such output may be a market good or service (e.g. agricultural output), and/or a non-market good or service (e.g. recreational use)[2].

It is important to note that the social cost of any activity includes the value of all the resources used in its provision. Some of these are priced and others are not. Non-priced resources are referred to as externalities. It is the sum of the costs of these externalities and the priced resources that makes up the social cost (see below).

Given that opportunity cost is the object of interest, the next question is how does one measure such a cost? The basic principle behind the measurement of opportunity cost is the minimum willingness of the owner of the resource to accept payment for its use, or the maximum willingness of the user of the resource to pay for its use. These two concepts are referred to as willingness to accept (WTA) and willingness to pay (WTP), respectively. To make the example concrete, consider the example of hiring one day of labour by a construction company as part of the programme of building a dyke. The WTA payment for that day of work will be equal to the value s/he attaches to the best alternative use of the time, which is the opportunity cost of that time to the worker. As for as the payment offered by the employer, the WTP will be no greater than the value of the alternative use to which the payment could be put. Hence both the WTA and WTP concepts are related to the concept of opportunity cost[3].

Often a resource is used and there is a financial flow associated with it. This may or may not be equal to the opportunity cost. Working with the land for forestry example, the government may have leased the land to a farmer, who keeps livestock on it. If it is used for forestry the government may demand no payment from the forestry authority. In that situation there would be a loss of income in financial terms to the government although that is an opportunity cost to the government it is incorrect to take it as the social cost. The reason is that the price of the original lease may not be equal to the opportunity cost of that land. Even assuming that the highest value use is livestock, the value of the land is the net income from livestock grazing, after deducting all expenses. Frequently the leases are for much less than that, so the opportunity cost is not equal to the financial flow to the government.

The key points of note with regard to opportunity cost are the following:

a) there exists a social cost for the use of a particular resource, provided this use hinders an alternative use;

[2] In some cases recreation benefits may be marketed. Other examples of non-marketed services include soil erosion control and biodiversity conservation.

[3] In a competitive market the WTA and WTP values are equal for the last worker hired. Where the WTA and WTP values differ, we need to choose between them. This issue is discussed further below.

b) there may be a social cost to the use of a resource even if there are no financial flows associated with that use;
c) If there are any financial flows, the social opportunity cost may or may not be equal to the amount of those flows.
d) Opportunity cost is defined in terms of WTA/WTP, as described above.

In designing mitigation and adaptation programmes decision-makers are interested in both the social and financial costs. Hence writers should report both where possible.

External Cost, Private Cost and Social Cost

The term external cost or externality is used to define the costs arising from any human activity, when the agent responsible for the activity does not take full account of the impacts on others of his or her actions. For example, emissions of particulate pollution from a power station affect the health of people in the vicinity but this is not often considered, or is given inadequate weight in private decision making and there is no market for such impacts. Such a phenomenon is referred to as an externality, and the costs it imposes are referred to as the external costs.
External costs arise when markets fail to provide a link between the person creating the 'externality' and the person being affected by it, or more generally when property rights for the relevant resources are not well defined. If such rights were to be defined, market forces and/or bargaining arrangements would ensure that the benefits and costs of generating the external effect were properly balanced.

These external costs are distinct from the costs that the emitters of the particulates do take into account when determining their outputs, costs such as the prices of fuel, labour, transportation and energy. Categories of costs influencing an individual's decision-making are referred to as private costs. Note that private costs may not always correspond to a financial cost, though generally most of such costs will be financial. For example, a GHG mitigation project may require households to adopt new technologies. The main costs of doing this will be in the form of payments for the equipment etc. But, in addition, they will have to change the way they use energy etc., and these costs may not be reflected in direct financial costs. The latter, which are also called implementation costs (see below) are also part of the private cost, but are not so easy to measure. Another case where private costs and financial costs diverge is when markets are not working efficiently. Thus, if a project involves an investment of $5 million, as estimated by the inputs of land, materials, labour and equipment, that figure is used as the private cost. That may not be the correct cost, however, as far as the estimation of social cost is concerned. If, for example, the labour input is being paid more than its value in alternative employment, the estimated private cost will be higher than the true private cost. Adjustments to private costs based on market prices to bring them into line with social costs are referred to as shadow pricing. A fuller discussion of shadow pricing is to be found in Ray (1984).

To sum up, the total cost to society is made up of both the external cost and the private cost and together they are defined as social cost.

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

The estimation of external costs is done by a number of methods that are discussed in detail elsewhere.

Any authors using or reporting cost data should make clear whether they have adjusted private costs for deviations from social cost and whether they have included external costs.

Average, Marginal and Total Costs

The terms average, marginal and total costs are frequently used. The total cost of a programme is simply all items of cost added together. The average cost is defined as the total cost divided by the number of units of the item whose cost is being assessed. With GHGs, for example, it would be the total cost of a programme, divided by the physical quantity of emissions avoided. By contrast, the marginal cost is the cost of avoiding the last unit of the emission. Marginal cost can also be defined as the rate of change of total cost with respect to the level of control. In all of the above cases, a problem arises when there is more than one objective whose cost is being assessed, or when the cost figures relate to more than one objective. This gives rise to joint costs which are discussed below.

In terms of valuation, all three types of cost are relevant. Programmes with given emission reduction targets are evaluated in terms of minimising total costs, but decisions about the level of mitigation or adaptation to be undertaken will need to consider marginal costs. Average costs are relevant when comparing mitigation programmes with different levels of GHG reduction. Cost efficiency – i.e. minimising the costs of achieving a given target – requires that the marginal costs be equal for all sources of reduction of greenhouse gases. Hence a proper estimation of marginal costs is very important to the development of an efficient climate change strategy.

Incremental Cost

The term incremental cost is used, inter alia, by the Global Environmental Facility, which provides financial support for climate change programmes. Incremental cost is defined as the additional cost a country incurs when undertaking a climate mitigation project, compared with the social cost of the activity the project substitutes[4]. In order to estimate such a cost it is necessary to know the cost the country would incur in the absence of the programme or, in other words, to define the baseline. There may be a difference in incremental cost as estimated by the country and as estimated by an international body such as the GEF due to different perceptions on baseline case and the value of the resources involved. Differences may also arise because of the way that costs are perceived -- the social cost for one group is not necessarily a cost for another.

Incremental cost is a distinct cost concept. As an example, consider a programme, which results in reductions in GHGs through upgrading of gas pipelines. The cost to the country of the programme is $50mn but there are direct benefits, in terms of reduced gas leakage of $25mn. Hence the 'net cost' of the project is $25mn. What is the incremental cost? This depends on what measures the country would have undertaken in the absence of its climate change obligations. It is possible that it would not have undertaken such a project, but implemented a less ambitious project with net costs of $10mn instead. The incremental cost would then be $15mn[5].

From a country's point of view there is, therefore, a distinction between the cost of the project (total or marginal) and the incremental cost. Both concepts are relevant for decision-making purposes. The selection of projects to achieve a certain target reduction should be based on minimising the incremental cost as defined above. The total costs of the project are, however, relevant for determining its financing and may be instrumental in deciding which projects can in fact be implemented. The incremental cost is important for financial reasons, relating to the funding of projects from multinational sources such as the Global Environmental Facility.

Ancillary Costs and Benefits and Joint Costs

A project or intervention for climate change may result in a reduction in the use of resources compared to the situation without the project or intervention. An example is the introduction of energy efficiency measures, which reduce generation of electricity from fossil fuel sources. In such cases the cost savings from reduced resource use should be subtracted from the other costs of the project. If these savings are larger than the costs, the net cost of the whole project is negative. They arise because the present use of resources is inefficient. The reasons for the inefficiency may be that individuals were unaware of the cost saving opportunities, or that there was inertia in their behaviour, or that external costs had not adequately been taken into account in the past.

In estimating the social costs of climate change policies, all changes in cost arising from the policy have to be taken into account. If some of them relate reductions in external costs, they are sometimes

[4] This is the definition adopted by the Framework Convention on Climate Change (FCCC). The FCCC further distinguishes between *agreed full costs* and *agreed full incremental costs*. The term agreed indicates that there is uncertainty about costs and Parties have to agree on underlying assumptions. The difference between agreed full costs and agreed incremental costs is that the former means that all costs associated with an action are going to be covered while the latter implies that only the difference between the cost of the action and a baseline case are to be covered.

[5] In fact the identification of the appropriate 'baseline' –i.e. the situation in the absence of the policy is not straightforward, and is an difficult issue, which needs serious attention. This is discussed further below.

referred to as ancillary benefits. They have also been referred to as secondary or indirect benefits or co-benefits. Hence there are several terms for this category of costs.

Many projects undertaken as part of a climate change programme will have other objectives as well. For example a transport program to develop urban mass transit has the objective of reducing congestion as well as saving in fossil fuel emission and reducing carbon dioxide emissions. In financial and economic analysis, these are referred to as cases of joint cost. They can, however, be dealt with as secondary costs or benefits. If a project is undertaken primarily for the purposes of reducing GHGs, and if it has other impacts, then it is most convenient to treat any costs or benefits relating to those impacts as secondary costs or benefits for the GHG project. For example, if a GHG limitation project consists of measures to increase energy efficiency in transport, some of the costs will be associated with the purchase of more energy efficient vehicles, which in turn will provide benefits for the operators of the vehicles. The cost to the GHG project should then be the total cost of the whole project, plus any secondary costs and less any secondary benefits received by the operators.

In cases where the activity is largely carried out for its own sake, a very small component may be associated with the GHG mitigation. Take a gas pipeline project of $2 billion. Normal design would result in a given level of losses. If, however, the project is designed so that losses are further reduced, the cost may rise to $2.2 billion, after accounting for the value of any reduction in gas losses. In such a case the cost of the GHG project is best treated as the incremental cost of $200 million and appraised accordingly.

The decision of whether or not to treat the associated activities as secondary or treat the GHG project as secondary has to be taken on a judgmental basis. If the project is likely to have taken place regardless, the GHG emission reduction could be regarded as secondary or if it could be justified on the basis of purely non-GHG benefits alone.

Measuring Ancillary Benefits That Are External Benefits

In assessing the costs of GHG emissions reductions ancillary benefits arise primarily because reductions in fossil fuel use generate reductions in local pollutants such as particulate matter. They take the form of reduced damages to agriculture, forestry, materials, health, ecosystems, and amenities. These are also referred to external benefits.

At the same time, there may be ancillary costs of GHG mitigation, such as an increase in indoor air pollution associated with a switch from electricity to household energy sources (such as wood or lignite) or greater reliance on nuclear power with its attendant externalities. In developing countries pollution may rise if electrification slows as a result of policy-induced increases in electricity prices.

The following, taken from Krupnick, Burtraw and Markandya, 2000, offers examples of ancillary benefits (+) and costs (-).

Reduction in particle pollution when fossil fuel use is reduced. (+)
Increased availability of recreational sites when reforestation programs are introduced (+)
Increases in household air pollution relative to a baseline when electrification rates are reduced (-)
Increases in technological efficiency when new technologies are adopted and unit costs fall (+)
Increases in welfare when a shift to carbon taxation and a reduction in reduces un employment (+)
Reductions in road-use related mortality when a shift from private to public transport takes place (+)
Reductions in congestion when a shift from private to public transport takes place (+)
Increases in employment resulting from GHG projects where there is excess supply of labor (+)
Savings in household time in poor rural households when fuel wood use is replaced by renewable energy (+)
Reductions in electricity use resulting from higher electricity prices that cause less use and thereby reduce educational opportunities for children (-).

The external effects described above cannot be valued directly from market data, because there are no 'prices' for the resources associated with the external effects (such as clean air, or clean water). Hence indirect methods have to be adopted. Values have to be inferred from individuals' decisions in related markets, or from directly eliciting the WTP for the environmental good through questionnaires. Values of environmental goods are broadly divided into use values and non-use values. The former are those values resulting from some direct or indirect use to which the environment is put. Non-use values arise when individuals have a WTP for an environmental resource even when they make no use of it, or never will make any use of it. (See Perman et. al. (1999) for a discussion of this distinction).

The following methods have been developed and used in valuing environmental (and other) externalities. Further details can be found in several books (Bateman and Willis, 1999, Markandya et. al, 1999, Hanley et. al, 1997)[6].

Impact Pathway Analyses

In this method, the effects of an action are traced through from the release of pollutants to their dispersion in the ambient environment, to their impacts on natural resources, and on humans. The final stage values the impacts, using market data if such exist. For example, the effects of climate change on agriculture proceeds along such a pathway, with the final valuations based on the prices of agricultural products in the present and future markets for these goods. The same method can be applied to the impacts of climate change on loss of land, changes in energy use and forests (partial valuation only) and to the impacts of sulphur and aerosols on agriculture, materials and forests. Where some of the final impacts cannot be valued through prices that exist in markets one of the methods described below have to be used.

Property Prices or Hedonic Method

Property prices vary according many attributes associated with them. House prices, for example, reflect size, commercial facilities, local infrastructure and other attributes including environmental quality of the house location. Statistically analysing house prices, one can assess the contribution of environmental quality to house price variations which estimates how much people are willing to pay for changes in environmental quality changes. That measure represents a use value for that environmental change from which demand function can be estimated. This method has been used to value external effects such as noise, air quality and visibility.

Travel cost method

By plotting visitation rates to a natural site against travel (and other) costs incurred by visitors, one can estimate a demand curve for the site. The travel costs provide use values. Travel costs will, in this case, also consider travel timing costs. Travel cost methods have been used to value the benefits from recreational sites and from recreational activities that require some travel. In the climate change context they have been applied to value changes in travel patterns for vacations.

Contingent Valuation Method

By asking directly people how much they are willing to pay for a change in a provision of benefits from an environmental resource, one can create a hypothetical market where a demand curve for ecological goods and services can be estimated. This method is the only one by which non-use values can be estimated since hypothetical markets can be created for them. Based on associated preferences, and not on revealed preferences as the other demand approaches, contingent valuation may incur in various biases from strategic answers to lack of information. Such biases are currently well documented and techniques have been developed to avoid them. Contingent valuation methods have been used to value the use and non-use of sites of special significance, health effects, including changes in the risk of death, and damages to ecosystems.

Although the use of such methods of valuation has problems, it provides policy-makers with important information for decision-making purposes. It is suggested that both physical impacts and values should be used in this process. In relation to climate change, the estimation of external effects arises primarily

[6] In the discussions on the paper, commentators have asked for guidance on which techniques of estimation are most suitable for different areas of assessment. Some general advice is given in the descriptions of the different techniques below, but it is only general. Each case has to be considered in the light of the available data. Furthermore it is important to note that not all impacts can be monetised (a point that has been made earlier).

in the assessment of the damages resulting from such change, including agriculture, forests, energy use, recreation and health. In relation to mitigation, the applications are primarily in valuing the impacts of ozone, NO_x, SO_x, particulate matter and secondary particles. In adaptation valuation of external effects will arise with respect to loss of land, changes to recreational facilities and changes to agriculture.

As far as mitigation is concerned, estimation of ancillary benefits has advanced considerably since the SAR. A great deal of work has now been undertaken to value the damages from the major pollutants associated with fossil fuels mentioned above. Studies include ExternE (1997) for the EU, Rowe et al (1995) for the US (New York), Thayer et al (1994) for the US (California), CSERGE (1993) for the UK. The estimates of damages can be reported in terms of ECU/kWh or in terms of ECU/tonne of emissions. Both values are, of course, site dependent; the closer a source is to population, the greater will be the damages. The ExternE work has, however, noted the importance of long distance impacts of most pollutants, so that, for most sources, less than 20% of the total effect is picked up in the impacts over the nearest 50 km (ExternE, 1995). This implies that the total damages will be less site dependent than was originally envisaged.

In addition to the above some estimates have been made, and are being made both of the relationship between pollutant concentrations and impacts and between impacts and damages in developing countries and economies in transition. These include the following:

1. Krupnick et. al (1996) have made estimates for particulate damage for Bulgaria and Hungary.
2. Florig (1993) provided estimates for the Tianjin province of China of health damages from particulate pollution based on US damage values.
3. Work by the World Bank has derived estimates and others, to derive damage estimates for developing countries, by carrying out primary studies in these countries. In Delhi, India, a study by Brandon and Hommann (1995). Lvovsky (1998) found that significant health benefits could be realised if air quality in Delhi were to be improved. These were quantified in money terms. Other epidemiological and valuation studies include: Ostro et al (1996) for Chile; Maddison et al (1997) for 8 cities (Santiago, Sao Paolo, Bombay, Istanbul, Cracow, Shanghai, Bangkok and Manila); Eskeland and Xie (1998) for Mexico City and Santiago; and Ostro (1994) for Jakarta.

Although the methodology in all these studies is not always in accordance with the cost principles discussed above, it is clear that studies of concentrations/impacts relationship and of impacts/damages relationship are now being carried out in developing countries.

Special Issues Arising in the Estimation of Adaptation Costs

Much of the work on climate change has been on the mitigation costs of reducing greenhouse gases. Less has been done on the costs arising from the impacts of climate change, and even less on the costs of adapting to the impacts of climate change. Yet countries are most acutely in need of advice on the last of these, as they prepare for many of the consequences of the change in the climate that will inevitably take place.

The specific issues that arise in adaptation cost assessment are the following: (a) the need to account for uncertain effects and (b) to estimate benefits from reduced impacts that are frequently not reflected in markets. On uncertainty, one of the key issues is the wide variance in the possible impacts. Hence projects such as sea level defences could have a very large benefit (if the increase in sea level is large), or a small or even no benefit (if the increase does not cause inundation). When evaluating projects with such uncertain benefits, account must be taken of the aversion to risk that people have. Individuals have a WTP for a reduction in risk, even if there is no other benefit on average. Hence it may be the case that the expected increase in sea level would cause no impacts and therefore no damage. But individuals would be willing to pay for defences simply on the grounds that it reduced the risk of damage. Measurement of risk premia can be made using methods such as CV, as well as by looking at attitudes to risk in other situations, where a WTP manifests itself in an actual payment (e.g. in financial markets)[7].

[7] These uncertainty issues are dis tinct from the more general ones relating to uncertainty about costs, impacts etc., which are discussed in

The measurement of many of the benefits of adaptation projects will involve reductions in loss of recreational land, a fall in disease rates etc. Estimating these benefits will require the use of the non-market methods of evaluation that have been discussed above. In principle such methods can be widely applied; in practice the range of estimates tends to be quite wide. Nevertheless it is important to try and quantify them, and the range of values obtained can be useful for decision-making purposes even allowing for the substantial uncertainty.

The Time Dimension in Costs[8]

When a project or programme is undertaken, costs will be incurred at various points in time. At the simplest level, investment in a project is incurred in the first few years of the life of the project and thereafter the project incurs some operating costs. In evaluating such programmes we must take account of all such costs, but we cannot treat a dollar of investment cost today and a dollar of operating cost in the future as equivalent. In some cases a project can have costs far into the future. For example, a nuclear power project will have costs of safe disposal of radioactive waste long after the plant has been decommissioned.

There are two issues arising from the time dimension: discounting and the forecasting of future costs.

There are various concepts of total cost that reflect the time dimension. A principal one is the present value cost of a project. This is the sum of all costs over all time periods, with future costs discounted. For a project that has costs C_i in period i the present value cost of the project is:

$$\sum_{i=0}^{i=T} C_i (1+r)^{-i}$$

where the project has costs incurred over T years, and where the annual rate of discount is r. If all costs are in current prices, then the discount rate chosen is called the nominal discount rate. If the costs are in constant prices, the discount rate is called the real discount rate[9].

As the IPCC (1996) report notes, there are two approaches to discounting; a prescriptive approach based on what rates of discount should be applied, and a descriptive approach based on what rates of discount people (savers as well as investors) actually apply in their day-to-day decisions. The former (the social rate of discount) leads to relatively low rates of discount (around 3% in real terms) and the latter (the market rate of discount) to relatively higher rates (above 10% and, in some cases, very much higher rates).

For climate change one needs to distinguish between the analysis of impacts caused by climate change itself and the assessment of mitigation programmes, which compete with other capital resources for a share of public expenditure.

For the impacts, the long-term nature of the problem is the key issue. Any 'realistic' discount rate -- i.e. one that applies in capital markets in developing countries, would render the damages, which occur over long periods of time, very small. With a horizon of around 200 years, a discount rate of 4 percent implies that damages of one dollar at the end the period are valued at 0.04 cents today. At 8 percent the same damages are worth 0.0002 cents today. Hence at discount rates in this range the damages associated with climate change become very small and even disappear. (Cline, 1993).

More recent thinking on discounting has moved to looking at rates that vary with the time period considered. Weizman (1998), on the basis of a survey of 1700 economists suggests that the appropriate

[8] The issue of discounting is also discussed in the Development Sustainability and Equity Guidance Paper. The reader is referred to that paper for a fuller discussion of some of the issues, including the distinction between social and private rates of discount and differences in time preference rates between developed and developing countries.

[9] The real rate of discount is calculated by dividing the market rate by the rate of inflation. Thus if a market has a discount rate of 12% and inflation is 8% the real rate is (1.12/1.08=1.037) or 3.7%.

discount rate for climate change impacts is less than 2%. This reflects, partly, the 'social rate of discount' view of discounting.

For mitigation effects, the country must base its decisions at least partly on discount rates that reflect the opportunity cost of capital. In developed countries the rates are around 4-6% would probably be justified. Rates of this level are in fact used for the appraisal of public sector projects in the EU and other developed regions. In developing countries the rate could be as high as 10-12%. The international banks use these rates, for example in appraising investment projects in developing countries. Unless the mitigation project is of very long duration, therefore, it is difficult to argue that climate change mitigation projects should face different rates. This reflects the market rate of discount view of discounting.

In addition to discounting future costs and benefits of climate change and mitigation programmes, there is the further issue of whether or not future emission reductions should be discounted when compared to present reductions. The justification for discounting them is that future reductions are worth less than present reductions in terms of reduced impacts. The choice of the appropriate rate, however, remains an unresolved issue. A recent survey of discount rates applied to carbon flows reveals a wide range of values (Boscolo, Vincent and Panayotou, 1998). Some studies do not apply a discount rate but simply take the average amount of carbon stored over the project lifetime (referred to as flow summation) or taking the amount of carbon stored per year (flow summation divided by the number of years). Both these methods are inferior to applying a discount rate to allow for the greater benefit of present sequestration over future sequestration. The actual value, remains a matter of disagreement but the appropriate value is likely to be well below the typical rates of discount used in damage or mitigation assessment.

Finally the case is made for calculating all inter-temporal effects with more than one rate. The arguments outlined above for different rates are unlikely to be resolved, given that they have been going on since well before climate change was even an issue. Hence it is good practice to calculate the costs for more than one rate to provide the policy-maker with some guidance on how sensitive the results are to the choice of discount rate[10].

The other issue related to the time dimension is the need to forecast future costs. Here the key point is to make as clear as possible what assumptions underlie the forecasts. What has been assumed about future population growth, income growth, land use, energy efficiency, technology, trade liberalisation, emissions of pollutants other than GHGs and prices? Furthermore, it is important to know how are these assumptions used to generate the forecasts. In particular, has the researcher allowed for the possibility that changes in some of the variables listed above affect the values of other variables? For example, income growth and population growth are not independent. What linkages or 'feedbacks' have been assumed?

One variable to which cost estimates are particularly sensitive is the rate of technological change. Renewable energy options such as solar power can move from being cost effective to very ineffective, depending on what is assumed about the rate of technological development in the sector. Where some factor such as this is critical to determining future costs, a sensitivity analysis is essential, showing what assumptions about cost evolution are critical to the decision.

Cost Overruns

A cost estimate for a project is often made well in advance of the time at which the project is implemented. By that stage, however, the cost may be larger because of inefficiency or lack of co-ordination in implementing the project. Thus factor should be allowed for in making the estimates of costs, more than has been the case in many projects. The issue is related to uncertainty, which is discussed further below.

[10] It is also useful to display graphically the time path of undiscounted costs as discounting can obscure important information.

Checklist

The above is intended to provide a guideline to the way in which costing should be carried out and cost concepts used. We recommend the following checklist for any cost data be used in the baseline case or in the climate change policy case:

A. Does that data refer to financial or social cost?
B. If data are on financial cost, are all changes in financial flows included? If not, which ones are left out?
C. If data are on social cost:
   (i) To what extent are the costs based on a WTP/WTA basis?
   (ii) What adjustments have been made to market data in arriving at the private cost component?
   (iii) What assumptions have been used to aggregate the individual costs to arrive at total costs
   (iv) What estimation has been made of any changes in external costs?
D. What discount rates have been used in the estimation of costs and are they nominal or real rates?
E. What assumptions underlie the forecasts of future costs and how have they been used to generate the forecast values?

3. Categories of Costs

Project Costs

Most categories of costs, such as labour, equipment, land, materials etc. are obvious and need little further discussion. Table 1 below describes the types of adjustments that may be needed if these components are to be estimated as part of the social cost[11].

The implications of applying the adjustments suggested above to private and external costs vary from policy to policy. Some projects like large-scale power production projects demand primarily capital, foreign exchange and fuel resources. Other projects like many renewable energy projects demand in addition to capital also local resources such as land, labour and materials. A traditional assessment of private project costs will often make the large-scale power production project more attractive in relation to a renewable project compared with the same comparison in an assessment of social costs. This is the case because the social costs or benefits of increased employment, reduced local air pollution, and saved capital and foreign exchange may be more attractive than reflected in the private costs.

Implementation Costs

In addition to the above, the costs of implementation deserve special attention. Many aspects of implementation are not fully covered in conventional cost analyses. Considerable work needs to be done to quantify the institutional and other costs of programmes, so that the reported figures are a better representation of the true costs that will be incurred if the programmes are actually implemented[12].

The implementation of mitigation options should be considered in the specific context where the policy is pursued. In addition to the categories described above, the following areas need to be considered as sources of potential costs:

- Institutional and human changes

[11] Note that the categories in Table 1 are not mutually exclusive. Foreign exchange, for example, may be used for labour and capital. Such an expenditure will then have more than one adjustment made to it.

[12] The term transaction cost is sometimes confused with implementation cost. Transaction cost represents costs associated with carrying out any social arrangements, both changes in the arrangements and implementation of standing arrangements -- e.g. costs of buying and selling goods and services. The implementation cost concept relates specifically to **changes** in arrangements. Hence it is a narrower concept than transactions cost.

- Information requirements
- Market size and opportunities for technology gain and learning
- Economic incentives needed (grants, subsidies and taxes)[13].

Table 1: Types of Adjustment to Market- based Cost Data to Obtain Social Cost

Category	Adjustment to Private Cost	Adjustment to External Costs
Land	Under-pricing or over-pricing of land services	Values of changes in bio-diversity, non-priced forest products etc.
Labour	Opportunity cost may be more or less than wage	Possible external costs arise over occupation and unemployment health effects.
Investments	Capital may be scarce, in which case it will have too low a cost associated with it. Or the opposite may be the case.	
Materials	Taxes on material inputs will result in too high a cost. Subsidies in too low a cost.	Extraction and transport will have some external costs attached.
Energy	Energy prices may be below marginal cost of supply, in which case the cost estimate will be too low. If they are above the cost of supply the cost estimate will be too high.	Use of energy generated external costs in air, water and solid waste emissions.
Environmental services (non-energy)	Water supply, wastewater, hazardous waste services are often under-priced.	External costs are associated with changes in the levels of use of these services.
Foreign exchange	Foreign exchange may be scarce in which case it will have a too low cost. If the currency is over-valued it will have too high a cost.	Use shadow price on foreign exchange to reflect scarcity value

Costs arising from the above can be divided into administration costs and barrier removal costs.

Administration costs are the costs of activities that are directly related and limited to short-term implementation of the project or sectoral strategy. They include the costs of planning, training, administration, monitoring etc.

Barrier removal costs are the costs of activities aimed at correcting market failures directly or at reducing the costs of carrying out transactions in the public and/or private sector. These activities should support processes related to project implementation. Examples of barrier removal are costs of improving institutional capacity, reducing risk and uncertainty, facilitating market transactions, and enforcing regulatory policies.

Typically implementation costs will have a dynamic aspect; they will be incurred over time and the effectiveness of the policies associated with them will, likewise, change over time. Implementation costs can also be closely linked to general economic policies for example related to financial markets, general tax policies, and international economic relations. Studies of implementation costs should therefore include an assessment of economic policies and potential synergies and conflicts in relation to climate change policies.

[13] Taxes and subsidies are not themselves elements of social cost. They are, however, relevant to social cost estimation in so far as they have an impact on the efficiency of resource use. It is this change in efficiency that is relevant to the social cost estimation.

Checklist

In reporting costs, teams should provide information on what estimation has been made of the administration and barrier removal costs of the projects, policies and programmes that are being proposed.

4. Other Issues

The other issues over which a consistent approach to the costing of climate change interventions is necessary are the definition of baselines, reporting of macroeconomic costs and the treatment of uncertainty.

Baseline Scenarios

Baselines are critical in the assessment of the costs of mitigation and adaptation in the climate change area. Each baseline, which gives the emissions of GHGs in the absence of climate change interventions, has some implicit assumptions about the evolution of future policy at the macroeconomic and sectoral levels. These assumptions in turn give rise to costs of implementation, as described in the previous section. The baseline scenario definitions also largely determine the potential for climate change mitigation and adaptation policies. This is the case because the baseline scenario projects future GHG sources and thereby also the potential for changes in production or behaviour and for the application of specific technologies.

Baseline scenarios reflect key assumptions on future use of technologies and other resources. The literature has reported several different baseline scenario concepts including:

1. The efficient baseline case, which assumes that all resources are employed efficient.
2. The inefficient baseline case, where it is assumed that some distortions exists for example in the labour and energy markets.
3. The "business as usual" case, which assumes that future development trends will follow the past and no changes in policies will take place.

As noted, climate change mitigation and adaptation costs will vary according to these baseline scenario definitions. The mitigation costs assessed in relation to an efficient baseline case will often be larger than the costs assessed in relation to an "business as usual" case because the policy in the latter case can imply secondary benefits in the form of improved efficiency of resource use. However, the costs of implementing such "efficiency gains" must be critically assessed.

Teams should be consistent in their definition of baselines, mitigation or adaptation scenarios and implementation costs and in the reporting of any costs associated in moving from a given baseline case to a climate change policy case. Furthermore, when reporting the range of cost estimates for the different baselines, it is important also to provide information about the assumptions underlying each baseline.

Macroeconomic Costs

Previous studies of climate change report costs of measures not only at the project and sectoral level but also at the macroeconomic level. These are usually reported as changes in GDP or growth in GDP, but may also be reported as loss of 'welfare' or loss of consumption. There is a wide range of models used for such an analysis, some of which assume that markets are in equilibrium at all time and others of which allow for disequilibrium, with some rule for resolving the excess demand or supply. The implied costs of different climate change policies are quite sensitive to the underlying model used.

Such estimates, based on dynamic models of the economy, are less precise than the project or sectoral level costs. Typically these models do not work with adjusted prices and do not take account of externalities. Hence the estimates of cost generated by these models are not based on opportunity cost or WTP/WTA. Nevertheless, because they do look at the impacts of policies at an integrated level and allow for inter-sectoral effects, they are an important contribution to the policy debate.

Teams working with, or reporting on, the results of macroeconomic or general equilibrium models should provide the following information:

A. What assumptions underlie the macroeconomic model used. In particular:
   (i) Is the model an 'equilibrium' or 'disequilibrium' model and if the latter, how does it treat non-market clearance? In both cases what is the assumed speed of adjustment to changes in prices?
   (ii) What values have been taken for the key 'elasticities' i.e. the parameters which determine how supply and demand respond to changes in external factors such as prices etc?
   (iii) Does the model permit international trade in emissions rights, fuel energy intensive goods?
   (iv) Does the model permit the 'carry-over' of emissions rights from one period to another?
   (v) What is the base year for the model? This can be critical. For example, a forward-looking model with a base year of 1990 provides 20 years of adjustment to a constraint that begins in 2010. If, however, the base year is 2000, the time for adjustment is only 10 years.
   (vi) What are the assumptions with respect to revenue recycling, costs and availability of future technology, inclusion of a backstop technology, and availability of no-regret options.

B. Has any account been taken of items not normally included in GDP, such as external effects, and over/under valuation of particular resources, inputs and outputs? If so, what variation to the normal national income accounting data does the model used generate?

C. Changes in fiscal regimes, other than those associated with the policy. What are the key assumptions underlying the model with respect to:
   (i) Assumptions about the allocation of tax revenues.
   (ii) Changes in fiscal regimes, other than those associated with the policy being evaluated.

Treatment of Equity

In the debate on climate change there is much concern about the equity aspects of policies for mitigation and adaptation. Who bears the costs of these policies, and is that distribution fair? Furthermore, the impacts of climate change do not fall equally on all groups; there is strong evidence that the poor and vulnerable are disproportionately affected.

In the cost methodology presented here we have argued that, important as equity considerations are, they should not be confused with the cost analysis. It is important to provide information on both the aggregate net costs of impacts and programmes, as well as the distribution of those costs. Decision-makers will need to take account of both. It should be noted, however, that there are cost methodologies that do not take this view. Some writers on benefit cost analysis (Ray, 1984; Banuri, et al, 1996; see also the cross cutting paper on development, equity and sustainability) have argued that costs and benefits should be weighted on the basis of who bears or receives them. Thus a cost imposed on a poor person may have a weight of 2, implying that the cost in the analysis should be $2 for every dollar of nominal cost.

In general we are against such weighting procedures, because there is no agreement as to what the weights should be. This applies especially to estimating the costs of mitigating global warming and adapting to its consequences. For impact cost assessment, however, there is a case to be made for some weighting procedures to be used. For the reasons noted above, international decisions on climate change need to be sensitive to the fact that impacts in poor countries cannot be given less importance than impacts in rich countries, simply because the WTP in the former is less than in the latter. For example, Meyer and Cooper (1995) note considerable opposition to the damage cost assessment chapter of the IPCC Report (Pearce, et al, 1996). The objections arose from the fact that the report presented aggregate damage costs based on WTP without any form of 'equity correction', i.e. damages were aggregated across countries without any weighting of the costs so as to give preference to the 'poor'[14]. The perceived implication is that climate change damages in developing countries are of less consequence than damages in the developed world. This led to the fear that developing countries would have less of say in international negotiations to reduce GHG emissions.

For the above reasons, a number of analysts have rejected the approach of using common values for all countries, i.e. simple additive aggregation. (ExternE, 1999, Azar, 1999). Instead they have opted to address equity concerns in the aggregation process by using weighting factors. The determination of the weights is a complex procedure that is not suitable for discussion in a cross-cutting paper such as this, but essentially it is based on the assumption that the welfare or utility of a dollar of income declines as a person's income level increases. If a dollar has twice as much utility to a poor person than to a rich person, a dollar taken away for the poor person should have twice the weight of that taken away from a rich person. Of course the difficult questions is how these weights should be determined (Markandya, 1998).

A simple and intuitively appealing way of dealing with equity is to take the average of the WTP for a loss of some amenity, or for an increase in some risk, and apply it to members of that group. If one applies this procedure for the Value of a statistical life, for example, EU researchers have come up with a value of around 1 million euros (1.07 million dollars at current exchange rates) (ExternE, 1998). Implicitly this method assumes (a) that the WTP is proportional to income and (b) that the equity weights are inversely proportional to income. Neither assumption may be absolutely correct but what one loses in accuracy of measurement one gains in simplicity and political acceptability. We would argue that such averaging can be a very useful tool for estimating the cost associated with a number of global climate change impacts, including the risks of death[15].

Treatment of Uncertainty

A thread that runs through much of the discussion of costs is that of uncertainty. The whole exercise of estimating mitigation costs is confounded by imprecise information about baselines, and the costs of mitigation and adaptation measures (especially future costs). It is critical that such uncertainties be recognised and conveyed to the policy makers in the best manner possible. The issue of uncertainty is dealt with more fully in the Guidance Paper devoted exclusively to this topic.

As has been noted, uncertainty about baselines is best dealt with by taking more than one baseline and reporting cost estimates for multiple baselines. Hence costs will not be given as single values, but as ranges based on the full set of plausible baselines.

Cost uncertainty can be divided into that related to private and external. Private cost figures are more certain than the external ones, but there remains some imprecision, especially about the rate at which costs of technology will change over time. As with baselines, a scenario approach is recommended, with estimates prepared for a 'mid-value' a 'low value' and a 'high value'. Uncertainty about the external costs is well recognised. As with the private costs, a scenario approach, giving a range, with a low, mid and high value is recommended. In both cases the scenario approach provides a sensitivity analysis for the costing exercise.

5. Conclusions

The concept of cost that has to be adopted in the analysis of climate change interventions has to be a wide one. All changes in the use of resources resulting from the project or policy under consideration

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[14] Willingness to pay (WTP), the standard measure of value in environmental economics, is a function of income and therefore lower in poorer countries. Hence, there are equity objections to simple additive aggregation.

[15] This is a fancy way of saying that we should value all deaths equally in the cost-benefit analysis, something we have done at the national level anyway, for as long as benefit cost analysis has been used in this area.

should be valued. These values form the basis of the costs of the project or policy. These include the obvious resources, such as land, labour and physical capital, but they also include changes in less obvious resources of society, such as clean air, water etc. Finally they include the 'hidden' resources required to achieve changes in policies – the costs of barrier removal and implementation.

This note is intended for discussion. If the recommendations are adopted, each team working with costs in money terms will report the following:

A. Basis of costs (financial or social).
   (a) If data are on financial cost, are all changes in financial flows included? If not, which ones are left out?
   (b) If data are on social cost:
      (i) To what extent are the costs based on a WTP/WTA basis?
      (ii) What adjustments have been made to market data in arriving at the private cost component?
      (iii) What assumptions have been used to aggregate the individual costs to arrive at total costs?
      (iv) What estimation has been made of any changes in external costs?

B. What items of cost, if any, have not been monetised?

C. Choice of discount rates and reasons for the choice.

D. What assumptions underlie the forecasts of future costs and how have they been used to generate the forecast values?

E. Estimates of implementation costs

F. For any baseline adopted, the costs of transition from a business as usual policy assumption to the actual policy assumption and the assumptions underlying the generation of the baseline.

G. For macroeconomic/general equilibrium model based costs, key assumptions on an agreed format

H. Uncertainty bounds for the estimates as indicated above.

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UNCERTAINTIES IN THE IPCC TAR: Recommendations To Lead Authors For More Consistent Assessment and Reporting

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Note

This paper contains recommendations to writing teams of the IPCC Third Assessment Report on how to improve consistency of assessment and reporting of key uncertainties. Part I (Introduction) provides background information, including the rationale for this guidance. Part II lists the specific recommended steps—concisely in Box 1, and more fully in the text itself. Annex 1 contains examples from each of the contributions of the three IPCC Working Groups to the Second Assessment Report (SAR) to illustrate the diversity of approaches used to assess and characterize uncertainty in previous IPCC efforts. This "final" revision responds to comments received during three previous rounds of review. We use quotes around the adjective "final" to describe this published version because we know that work on guidelines such as these will never truly be completed. The chapter writing teams will undoubtedly offer additional comments and criticisms based on their experience in preparing their contributions to the TAR, as the debate on this topic continues. We welcome further opportunities to work with some of those authors in revising the guidance after the TAR is complete, perhaps generalizing the recommendations for use in other assessments.

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1. Introduction

> "The IPCC function is to assess the state of our understanding and to judge the confidence with which we can make projections of climate change and its impacts. These tentative projections will aid policymakers in deciding on actions to mitigate or adapt to anthropogenic climate change, which will need to be re-assessed on a regular basis. It is recognized that many remaining uncertainties need to be reduced in each of [many] disciplines, which is why IPCC projections and scenarios are often expressed with upper and lower limits. These ranges are based on the collective judgment of the IPCC authors and the reviewers of each chapter, but it may be appropriate in the future to draw on formal methods from the discipline of decision analysis to achieve more consistency in setting criteria for high and low range limits."
>
> Climate Change 1995: The Science of Climate Change, Chapter 11 (McBean et al., 1996)

One of the major challenges in preparing the IPCC Third Assessment Report (TAR) is that authors will need to present a clear snapshot of information on climate change, potential impacts, and response options, when the extent of what we know is continuously evolving. Given the needs of decision-makers to weigh potential responses to the risks of climate change before all uncertainties can be resolved, the available information, imperfect as it may be, must be synthesized, evaluated, and presented in a responsible and informative manner. To do this, lead authors will be reviewing the published literature, documenting the ranges and distributions of findings and estimates in the literature, assessing the scientific merit of this information, and explicitly distinguishing and communicating which findings are well understood, which are somewhat understood, and which are speculative. In short, assessment of the relative credibility of a variety of processes and outcomes is a major goal of the Reports.

In the past, writing teams preparing different IPCC reports and methodologies (e.g., IPCC Guidelines for National Greenhouse Gas Inventories) have used a variety of approaches for developing best estimates and ranges, as well as a number of terms for describing the "state of science" or level of certainty attached to a particular finding. Terms such as "almost certain," "probable," "likely," "possible," "unlikely," "improbable," and "doubtful," have been used, along with variations on "high, medium, and low confidence." These terms have not been carefully—or quantitatively—calibrated and thus have been used differently across chapters and reports, let alone in the interpretations of these materials by the general public and the media (e.g., Moss and Schneider, 1997).

The purpose of this guidance paper is to recommend the elements of a common approach for assessing, characterizing, and reporting uncertainties in a more consistent—and to the extent possible, quantitative—fashion across the various chapters of the TAR. It is hoped that the recommendations will enable authors to be more systematic in characterizing the types and sources of uncertainty. In turn, this should help improve communication between the research community, decisionmakers, and interested publics regarding what is known and unknown (and to what degree) about key dimensions of the climate issue.

Attempts to achieve more consistency in assessing and reporting on uncertainties have not received much attention. Some researchers have expressed concern that it is difficult to even know how to assign a distribution of probabilities for outcomes or processes that are laced with different types of uncertainties (a number of studies since the SAR do use probability distributions, e.g., Morgan and Dowlatabadi, 1996;, see also the citations in Schneider, 1997). However, the scientific complexity of the climate change issue and the need for information that is useful for policy formulation present a large challenge to researchers and policymakers alike—it requires both groups to work together towards improved communication of uncertainties. Reaching this goal is especially challenging in an assessment process such as the IPCC, where writing team "group dynamics" adds a great deal of complexity. Note, for example, that uncertainty within a group resulting from conflicting strongly held individual views is qualitatively different from that which exists within a group of uncertain individuals, and that knowledge of this qualitative component of the uncertainty may be valuable to audiences of the report. The research community must also bear in mind that users of IPCC reports often assume for themselves what they think the authors believed to be the distribution of probabilities when the authors do not specify it for themselves. For example, integrated assessment specialists may have to assign probabilities to alternative outcomes (even if only qualitatively specified by natural scientists) since many integrated assessment tools require estimates of the likelihood of a range of events in order to calculate efficient policy responses. We believe it is more rational for scientists debating the specifics of a topic in which they are acknowledged experts to provide their best estimates of probability distributions and possible outliers based on their assessment of the literature than to have users less expert in such topics make their own determinations (e.g., Morgan and Henrion, 1990).

The term "uncertainty" can range in implication from a lack of absolute sureness to such vagueness as to preclude anything more than informed guesses or speculation. Sometimes uncertainty results from a lack of information, and on other occasions it is caused by disagreement about what is known or even knowable. Some categories of uncertainty are amenable to quantification, while other kinds cannot be sensibly expressed in terms of probabilities (see Schneider et al., 1998, for a survey of the recent literature on characterizations of uncertainty). It is important to note that uncertainty is not unique to the domain of climate change research. Even researchers in areas of science confined to the laboratory must confront uncertainties that arise from such factors as linguistic imprecision, statistical variation, measurement error, variability, approximation, subjective judgment, and disagreement. However in climate research, as in other areas such as seismic hazard prediction, ozone depletion, and hazardous wastes, these problems are compounded by additional characteristics. These include their global scale, long time lags between forcing and response, low frequency variability with characteristic times greater than the length of most instrumental records and the impossibility of before-the-fact experimental controls. Moreover, because climate change and other complex, socio-technical policy issues are not just scientific topics but also matters of public debate, it is important to recognize that even good data and thoughtful analysis may be insufficient to dispel some aspects of uncertainty associated with the different standards of evidence and degrees of risk aversion/acceptance that individuals participating in this debate may hold (Casman et al., 1999, and Morgan, 1998).

A final note before turning to the specific recommendations themselves—the paper assumes that for most instances in the TAR, a "Bayesian" or "subjective" characterization of probability will be the most appropriate (see, e.g., Edwards, 1992, for a philosophical basis for Baysian methods; for applications of Bayesian methods, see e.g., Anderson, 1998; Howard et al., 1972). The Bayesian paradigm is a formal and rigorous language to communicate uncertainty. In it, a "prior" belief about a probability distribution (typically based on existing evidence) can be updated by new evidence, which causes a revision of the prior, producing a so-called "posterior" probability. Applying the paradigm in the assessment process involves combining individual authors' (and reviewers') Bayesian assessments of probability distributions and would lead to the following interpretation of probability statements: the probability of an event is the degree of belief that exists among lead authors and reviewers that the event will occur, given the observations, modeling results, and theory currently available. When complex systems are the topic, both prior and updated probability distributions usually contain a high degree of (informed) subjectivity. Thus in the TAR, we expect Bayesian approaches to be what is most often meant when probabilities are attached to outcomes with an inherent component of subjectivity or to an assessment of the state of the science from which confidence characterisations are offered.

Some scientists have expressed concern that scientific investigation requires a long sequence of observational records, replicable trials, or model runs (e.g., Monte Carlo simulations) so that authors can adopt a frequentist approach to characterise the significance of the results. In other words, results should always be specified by a formal statistical characterization of the frequency and frequency distribution of the outcomes being assessed. Such objective or frequentist probabilities are not always possible in the context of scientific assessment intended to help with the policy process. In fact, even in a research setting, the idea of a limitless set of identical and independent trials that is "objectively out there" is a heuristic device that we use to help us quantify uncertainty in one particularly rigorous way—while there may be a large number of trials in some cases, this is not truly the same as a "limitless" number, and rarely are these trials truly identical or independent.

It is certainly true that "science" itself strives for objective empirical information to test theory and models. But at the same time "science for policy" must be recognized as a different enterprise than "science" itself, since science for policy (e.g., Ravetz, 1986) involves being responsive to policymakers' needs for expert judgment at a particular time, given the information currently available, even if those judgments involve a considerable degree of subjectivity. The methods outlined below are designed to make such subjectivity both more consistently expressed (linked to quantitative distributions when possible) across the TAR, and more explicitly stated so that well-established and highly subjective judgments are less likely to get confounded in policy debates. The key point is that authors should explicitly state what sort of approach they are using in a particular case: if frequentist statistics are used the authors should explicitly note that, and likewise if the probabilities assigned are subjective, that too should be explicitly indicated. Transparency is the key in all cases.

2. Options for improving consistency and clarity

This section provides specific recommendations intended to increase the consistency with which authors assess and communicate uncertainties in the TAR. Given the diverse subject areas, methods, and stages of development of the many areas of research to be assessed in the TAR, the paper cannot provide extremely detailed procedures that will be universally applicable. Therefore, this document provides general guidance; writing teams will need to formulate their own detailed approaches for implementing the guidance while preparing their chapters and summaries. The recommended steps are summarized in Box 1 and discussed more extensively in the text.

Note that these steps are intended to be applied to a relatively small number of the major conclusions and/or estimates (of parameters, processes, or outcomes) that will be developed in each of the chapters, for example the main findings discussed in a chapter executive summary or forwarded for inclusion in the summary for policymakers. It is not intended that authors must follow all of these steps every time they use a term such as "likely" or "unlikely" or "medium confidence" in the main text of their chapters or every time a specific result is given. However, one recommendation that should be applied throughout the report is that care should be taken to avoid vague or very broad statements with "medium confidence" that are difficult to support or refute. For example, if we know very little, we often are indifferent to whether climate change will cause a positive or negative response in some variable. In this trivial case, we would actually have at least medium confidence (i.e., near 50%--as defined below in Fig 3) that "warming could alter biodiversity". That says nothing profound unless we add quantitative modifiers on the amount of warming and the direction and severity of the biodiversity change. The point is to phrase all conclusions so as to avoid nearly indifferent statements based on speculative knowledge. In addition, all authors—whether in Working Group I, II or III—should be as specific as possible throughout the report about the kinds of uncertainties affecting their conclusions and the nature of any probabilities given.

Moreover, not all chapters are expected to be able to implement all of the steps for each of the conclusions and/or estimates that will be developed in their assessment of the literature. For example, step 7 in Box 1 ("Use formal probabilistic frameworks…") may be appropriate for only a few key issues in a limited number of chapters.

Box 1
Summary of steps recommended for assessing uncertainty in the TAR

1. For each of the major findings you expect to be developed in your chapter, identify the most important factors and uncertainties that are likely to affect the conclusions. Also specify which important factors/variables are being treated exogenously or fixed, as it will almost always be the case that some important components will be treated in this way when addressing the complex phenomena examined in the TAR.

2. Document ranges and distributions in the literature, including sources of information on the key causes of uncertainty. Note that it is important to consider the types of evidence available to support a finding (e.g., distinguish findings that are well established through observations and tested theory from those that are not so established).

3. Given the nature of the uncertainties and state of science, make an initial determination of the appropriate level of precision—is the state of science such that only qualitative estimates are possible, or is quantification possible, and if so, to how many significant digits? As the assessment proceeds, recalibrate level of precision in response to your assessment of new information.

4. Quantitatively or qualitatively characterise the distribution of values that a parameter, variable, or outcome may take. First identify the end points of the range that the writing team establishes, and/or any high consequence, low probability outcomes or "outliers." Particular care needs to be taken to specify what portion of the range is included in the estimate (e.g., this is a 90% confidence interval) and what the range is based on. Then provide an assessment of the general shape (e.g., uniform, bell, bimodal, skewed, symmetric) of the distribution. Finally, provide your assessment of the central tendency of the distribution (if appropriate).

5. Using the terms described below, rate and describe the state of scientific information on which the conclusions and/or estimates (i.e. from step 4) are based.

6. Prepare a "traceable account" of how the estimates were constructed that describes the writing team's reasons for adopting a particular probability distribution, including important lines of evidence used, standards of evidence applied, approaches to combining/reconciling multiple lines of evidence, explicit explanations of methods for aggregation, and critical uncertainties.

7. OPTIONAL: Use formal probabilistic frameworks for assessing expert judgment (i.e. decision-analytic techniques), as appropriate for each writing team.

1. For each of the major findings you expect to be developed in your chapter, identify the most important factors and uncertainties that are likely to affect the conclusions. Writing teams are most likely fairly far along in this process, but it is worth stressing that this identification process is important and may require several iterations within the writing team to develop a set of well-posed questions or issues. The most important factors affecting the findings could include processes, variables, parameters, different types of data (experimental, observational, historical, field, etc.), and interdependencies that are likely to have a significant bearing on the estimates. In identifying the sources of uncertainty, it is important to consider the types of evidence available to support a finding, for example distinguishing between findings that are well established through observations or well-tested theories versus those that are not so well-established. Identification of the factors and uncertainties affecting the outcomes/estimates is important for being able to gauge the degree of uncertainty that is likely to affect the estimates. Typologies of uncertainties are available in the literature of different disciplines. We will not survey here the many such typologies that exist to classify uncertainty (e.g., see the review and citations in Schneider, et al., 1998), but rather list in Box 2 examples of common types encountered by IPCC authors.

Box 2
Examples of sources of uncertainty

Problems with data

1. Missing components or errors in the data
2. "Noise" in the data associated with biased or incomplete observations
3. Random sampling error and biases (non-representativeness) in a sample

Problems with models

4. Known processes but unknown functional relationships or errors in the structure of the model
5. Known structure but unknown or erroneous values of some important parameters
6. Known historical data and model structure, but reasons to believe parameters or model structure will change over time
7. Uncertainty regarding the predictability (e.g., chaotic or stochastic behavior) of the system or effect
8. Uncertainties introduced by approximation techniques used to solve a set of equations that characterize the model.

Other sources of uncertainty

9. Ambiguously defined concepts and terminology
10. Inappropriate spatial/temporal units
11. Inappropriateness of/lack of confidence in underlying assumptions
12. Uncertainty due to projections of human behavior (e.g., future consumption patterns, or technological change), which is distinct from uncertainty due to "natural" sources (e.g., climate sensitivity, chaos)

In phenomenon that are as complex and multifaceted as those related to climate change, it is likely that some of the processes, variables, and parameters that introduce uncertainty will be treated exogenously (i.e., as assumptions or givens that are inputs) in order to make the problem tractable. This situation is likely to arise frequently in the TAR because of the increased attention to linkages among different subject areas and the use of scenarios developed in one area of research to examine sensitivities and possible outcomes in others. Thus many estimates or outcomes will be affected not only by uncertainties in their immediate substantive domain, but also by uncertainties in the scenarios or parameters generated in other areas of research. For example, in assessing possible effects of climate change on agriculture, it may be useful to assess responses of crop yields to specified changes in climate and to present information on the level of confidence in the projected yield changes. The specified changes in climate may well be treated as exogenous to the impacts analysis in such cases, and it is important in the assessment of uncertainty to note this. Another option available to writing teams (particularly chapters dealing with integration and synthesis) is to "composite" the uncertainties in all aspects of the problem, breaking down the composite uncertainty into its sources, range, and distribution. This step will require coordination across the writing teams and TSUs of different working groups in some cases. Some chapter writing teams may believe that their limited assessment of uncertainties might be misinterpreted as representing a composite distribution by some readers. In such cases authors can both clearly identify the uncertainties they present as limited to a partial set of factors and can provide cross-references to similar partial analyses of uncertainties in other TAR chapters in which parameters or scenarios exogenous to the original chapter contain their own analyses of uncertainty for those exogenous factors. Of course, chapters assigned the task of integration and synthesis will have to consider performing an explicit compositing exercise of their own (see traceable account guidance below for suggestions on making such composite distributions).

A single aggregated damage function or a "best guess" climate sensitivity estimate is a very restricted representation of the wide range of beliefs available in the literature or among lead authors about either climate sensitivity or climate damages. If a causal chain includes several different processes, then the aggregate distribution might have very different characteristics than the various distributions that comprise the links of the chain of causality (see Jones, 2000). Thus, poorly managed projected ranges in impact assessment may inadvertently propagate uncertainty. The process whereby uncertainty accumulates throughout the process of climate change prediction and impact assessment has been variously described as a "cascade of uncertainty" (Schneider, 1983) or the "uncertainty explosion" (Henderson-Sellers, 1993). When an assessment progresses from the biogeochemical cycle to radiative forcing and climate sensitivity calculations through to economic and social outcomes, including valuations of climate damages, considerable uncertainty can be accumulated (see Figure 1).

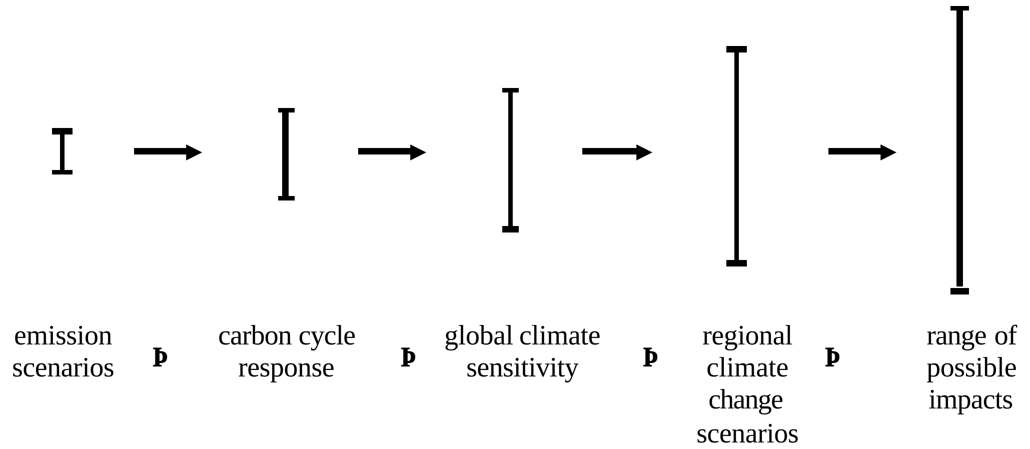


Figure 1. Range of major uncertainties typical in impact assessments showing the "uncertainty explosion" as these ranges are multiplied to encompass a comprehensive range of future consequences, including physical, economic social and political impacts and policy responses (modified after Jones, 2000, and the "cascading pyramid of uncertainties" in Schneider, 1983).

Finally, another source of uncertainty involves ambiguously defined concepts and terminology. An excellent example of this sort of uncertainty concerns the ambiguously defined concept of "surprises" (see Box 3). We suggest that TAR authors be cognizant of the ambiguities of such terms and be as precise as possible in their definitions. When one potential definition of a term is adopted over others, it is important for authors to briefly contrast their preferred definition with the others in the literature. Perhaps early in the assessment process, a glossary of terms with the potential for inconsistent definitions across various chapters and working groups should be constructed to reduce the likelihood of such inconsistent usage. We recommend that Coordinating Lead Authors let their respective Technical Support Units (TSUs) know about such terms as soon as they are identified to improve the consistency of terminology across the TAR as soon as practicable./

Box 3

Surprises

Strictly speaking, a surprise is an unanticipated outcome. However, in the IPCC Second Assessment Report (SAR), "surprises" were defined as rapid, non-linear responses of the climatic system to anthropogenic forcing, and analogies to paleo-climatic abrupt events were cited to demonstrate the plausibility of such a possibility. Moreover, specific examples of such non-linear behaviors that the authors could already envision as plausible were given (e.g., reorganization of thermohaline circulation, rapid deglaciation, fast changes to the carbon cycle). Strictly speaking, it would be better to define these as imaginable abrupt events. Finally, the WGI SAR concluded its SPM with the statement that non-linear systems when rapidly forced are particularly subject to unexpected behavior. Here is an example of unknown outcomes (i.e., true surprises) but imaginable conditions for surprise (Schneider et al., 1998).

2. Document ranges and distributions in the literature, including sources of information on the key causes of uncertainty. Writing teams should document ranges and distribution of estimates in the published literature, describing how the ranges and distributions are constructed, and clearly specifying what they signify, e.g., a 2 sigma range, results not related to a particular confidence interval, etc. Note that it is important to consider the types of evidence available to support a finding (e.g., distinguish findings that are well established through observations and tested theory from those that are not so established). As part of the process of assessing the literature and drafting the chapter, it is critical to characterise not just a single estimate, but a range of estimates and associated probability distributions. This should include attention not only to the central tendency, but also to the end points of the range of outcomes, possible outliers, the likelihood that outcomes beyond the end points of the range might occur, and the type of distribution of potential outcomes, e.g., normal, bimodal, etc.

3. Given the nature of the uncertainties and state of science, make an initial determination of the appropriate level of precision—is the state of science such that only qualitative estimates are possible, or is quantification possible, and if so, to how many significant digits? As the assessment proceeds, recalibrate the appropriate level of precision in response to your assessment of new information. For example, in some cases, lead authors may determine, after summarizing recent literature, that statements such as "increase" or "decrease" may be all that can be justified. In other cases, they may determine that quantification is possible at a high level of precision. Note that it is not necessary early in the group's deliberations to try to determine the estimates or numerical ranges themselves, simply the type of estimate that appears appropriate given the prior information available to the authors about the types and expected levels of uncertainty.

4. Quantitatively or qualitatively characterise the distribution of values that a parameter, variable, or outcome may take. First identify the end points of the range, and/or any high consequence, low probability outcomes or "outliers." Particular care needs to be taken to specify what portion of the range is included in the estimate (e.g., this is a 90% confidence interval) and what the range is based on. Then provide an assessment of the general shape (e.g., uniform, bell, bimodal, skewed, symmetric) of the distribution. Finally, provide your assessment of the central tendency of the distribution (if appropriate). Characterisations may be qualitative and/or quantitative, depending on the authors' assessment of the state of knowledge.

Following this particular order (i.e., identifying end points of the range of probability distributions and possible outliers before best estimates) is important because of the well-documented tendency of assessors to overstate the confidence with which outcomes are likely to lie near the central tendency. This has been shown to happen because of reliance on different subconscious rules of thumb in reaching these judgments. The idea, spelled out in Kahneman et al. (1982), is that, due to limited mental processing capacity, humans rely on strategies of simplification, or mental heuristics, to reduce the complexity of judgment tasks. While facilitating decision-making, these procedures are vulnerable to systematic error and bias. These heuristic devices include "availability" (relating the probability of this outcome to previous occurrences or ease with which one could imagine such occurrences); and "anchoring and adjustment" (judgment of probability of this outcome is overly influenced by the starting estimate, which becomes an "anchor" for subsequent estimates—which may lead to overconfidence in central tendencies or underestimates of range outliers, as mentioned earlier).

Overconfidence is a cognitive illusion that has been reported to bias experts' judgments. A considerable amount of evidence has been amassed for the view that people suffer from an overconfidence bias (Kahneman and Lovallo, 1993, Kahneman and Tversky, 1979, 1996 Kahneman et al., 1982, Tversky and Kahneman, 1974, 1983). The common finding is that respondents are correct less often than their confidence assessments imply. However "ecological" theorists (cf. McClelland and Bolger, 1994) claim that overconfidence is an artefact of the artificial experimental tasks and the non-representative sampling of stimulus materials; thus the appearance of overconfidence may be an illusion created by research and not a cognitive failure by respondents. They (Gigerenzer, 1994, 1996, Gigerenzer et al., 1991, and Juslin, 1994) claim that individuals are well adapted to their environments and do not make biased judgments. Furthermore, in cases of judgments of repeated events (weather forecasters, horse race bookmakers, tournament bridge players), experts make well-calibrated forecasts. In these cases, respondents might be identifying relative frequencies for sets of similar events rather than judging likelihood for individual events (e.g. Wright and Ayton, 1992).

Writing teams should be clear what sort of range and confidence interval they are constructing, or what sorts of possible outcomes are included in the range. For example, do the endpoints (or outliers beyond them) include potential known or imaginable non-linear rapid events? Is the range given by the authors the one in which the "true" value would fall with a two out of three chance (or some other probability)? Or is the range the one in which two thirds of modelled outcomes available in the literature would lie? These are all very different statements, and care should be taken in clarifying exactly what is meant. One suggestion made by several authors in the review comments on earlier drafts of this guidance paper is to establish a uniform standard for probability distributions (e.g., 67%, or one-sigma if a normal distribution), and then to allow the rating of confidence in this distribution to fluctuate to reflect the quality of the evidence available (see step 6 for a discussion of assessment of the quality of scientific information).

On the other hand, different reviewers noted that for some parameters or outcomes, continuous estimates of probability are available in the literature from extensive data analyses, Monte Carlo model runs, or formal decision-analysis elicitations (e.g., see Figure 2). In those cases, cumulative distribution functions (CDFs) can be drawn. These provide the probability that an estimate of a parameter would be less than or equal to given numerical value of that parameter.

It is important to note that by providing only a truncated estimate of the full range of outcomes (e.g., not specifying outliers that include "surprises", and thus making the range of outcomes described smaller), one is not conveying to potential users a representation of the full range of uncertainty associated with the estimate. This has important implications regarding the extent to which the report accurately conveys uncertainties. Some authors are likely to feel uncomfortable with the full range of uncertainty, because the likelihood of a "surprise" or events at the tails of the distribution may be extremely remote or essentially impossible to gauge experimentally, and the range implied could be extremely large. Thus there may be a case to be made for providing a truncated range in addition to outliers for a specific case, provided that it is clearly explained what the provided range includes and/or excludes. It should be stressed that if a truncated range is provided, it is important that authors specify how likely it is that the answer could lie outside the truncated distribution, and what was the basis for specifying such possibilities.

If possible, it would be useful for writing teams to provide an assessment of the shape of the distribution. Is it roughly uniform, such that values that are close to the mean are no more or less likely than values that are slightly more distant from the mean (e.g., we believe that the state of the science is not well-established and thus the climate damages from a few degrees C warming in developed countries aggregated across all market sectors would likely have a uniform distribution within plus or minus a few percentage points of GNP)? Or roughly bell shaped, such that the true value is more likely to lie near the estimated mean than in an interval that is distant from the mean? Is the distribution thought to be symmetric or skewed? If skewed, how?

In deciding whether there is a "best estimate," writing teams should evaluate the shape of the distribution of outcomes, i.e., the chance that different outcomes would occur. Depending on the approach being taken in the chapter, the "best guess" could be the mean, the median, the mode, or some other value. If all outcomes within the range seem equally probable (i.e., the probability distribution is uniform), writing teams may not consider it appropriate to make a "best guess" regarding the outcome. An important consideration is evaluation of the logic from which a best estimate may be based. For example, the values within the range might have been determined by assumptions from equally plausible "what-if" scenarios, or, alternatively, they might be derived by various methodologies whose reliability cannot be simply evaluated. Either way, this should be reported, and no best estimate offered.

In developing a best estimate, authors need to guard against aggregation of results (spatial, temporal, or across scenarios) if it hides important regional or inter-temporal differences. It is important not to combine automatically different distributions into one summary distribution. For example, most participants or available studies might believe that the possible outcomes are normally distributed, but one group might cluster its mean far from the mean of another group, resulting in a bimodal aggregate distribution. In this case, it is inappropriate to combine these into one summary distribution unless it is also indicated that there are two (or more) "schools of thought."

"Costs of mitigation" is an example. Perhaps one sub-group using tools which assume perfect markets would place the costs of achieving some specific GHG concentration targets and timetables at an average 1-2% decrease in annual GDP, whereas another group might estimate that the costs for achieving such targets and timetables would actually be zero or even slightly negative due to the existence of "no regrets" technological options.

Climate sensitivity is another example, as seen in Figure 2. Here scientists 2 and 4 offer a very different estimate of range outliers (i.e., values below the 5th percentile tick mark on the left end of each "box and whisker" plot or the 95th percentile estimate at the right hand end of each box and whisker plot) for imaginable abrupt events. But the means and variance of scientists 2 and 4 are quite similar to 13 of the 14 remaining scientists in this decision analytic survey, the exception being scientist 5. This is an example where it would likely be inappropriate to aggregate all respondents distributions into a single composite estimate of uncertainty since scientist 5 has a radically different mean and variance estimate than the other 15 scientists. If this were to occur in the literature or among lead authors reflecting on the literature, it is not appropriate to aggregate such "schools of thought" into a single distribution, but rather to show the two "paradigms" and mention the amount of support expressed for each distribution.

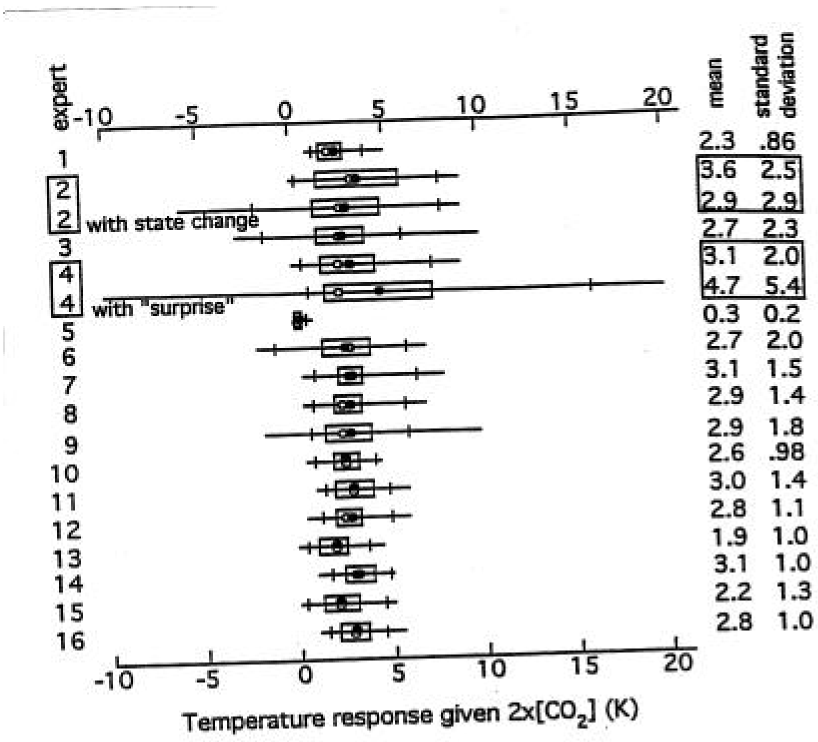


Figure 2. Climate Sensitivity under $2xCO_2$ forcing, °K. Box plots of probability distributions (elicited from 16 climate scientists) of the change in global average surface temperature resulting from a doubling of CO_2 . The horizontal lines denote the range from minimum (1st percentile) to maximum (99th percentile) assessed possible values. Vertical marks indicate the locations of the lower 5th and upper 95th percentiles. The boxes indicate the interval spanned by the 50% confidence interval. The solid dots indicate the mean and open dots, the median. Source: Morgan and Keith, 1995.

This is not simply a reporting of values available in the literature, but rather the assessment of the Lead Authors' about the relative likelihood that different values in the literature represent accurate estimates or descriptions. Writing teams will need to guard against the potential for "gaming" or strategic behavior, in which participants might select outlier estimates to compensate for what they consider to be over- or under-estimates by some of their colleagues or estimates in the literature.

5. Using the terms described below, rate and describe the state of scientific information on which the conclusions and/or estimates (i.e. from step 4) are based. This assessment of the state of knowledge should reflect both the type/amount of evidence (e.g., observations, interpretation of model results, or expert judgement) and the level of peer acceptance/consensus. The text should distinguish between confidence statements based on well-established, "objective" findings versus those based on subjective judgements. Care should be taken not to fall into the trap of widening a confidence interval to take account of outliers and then describing the confidence in the conclusions as low (e.g., as in Figure 2 of the Technical Summary of the Working Group I SAR). If the confidence interval is sufficiently wide, there should be moderate to high confidence that the true value will lie within it.

Conclusions should be phrased in such a way to avoid statements of indifference that are not illuminating. Clear, precise statements with assessed confidence levels are preferable. In particular, meaningless "medium" confidence labels should not be used. For example, it would indeed be "medium confidence," the way we've defined it in Fig. 3 (after 3 rounds of IPCC peer reviews), to say that "global warming could increase El Nino frequency". Knowing virtually nothing more than El Nino is partly driven by large scale forcings makes that statement--or one which replaces the "increase" with "decrease"--an even bet. A much more meaningful statement would be qualified. For instance, "Climate change of more than two degrees warming would cause a substantial increase in the El Nino frequency." Personally, we have low confidence in that clearly bounded conclusion. An expert assessment might disagree, but at least the statement isn't referring to an indifferent outcome (i.e., increase or decrease) from an unspecified climate change. In short, assessors should strive to avoid using language that expresses indifference (change in either direction – increase or decrease – is equally likely) and then assign what amounts to an essentially meaningless "medium confidence" label to the conclusion.

In addition, the language of the text should be consistent with the level of confidence – specifically, avoid using double qualifiers that undermine confidence in the conclusion. For example, if words like could or might are included, then the implication in that the statement is very likely to be true and should not carry an indifferent "medium confidence" label; a "high confidence" label is more consistent with the language. If authors are uneasy about using anything but conditional statements, then they should either include no confidence level label or an appropriately high one, since the conditional language implies the statement is very likely.

Previous drafts of this guidance paper have suggested a variety of options for describing the state of knowledge. In response to calls for a straightforward approach, we suggest that the IPCC agree to test a single set of terms. As the assessment progresses, it will be critical to review these terms and the consistency with which they are applied by various writing teams. As noted by many reviewers of earlier drafts of the guidance paper, consistency in the use of confidence descriptors is critical, and a clear way to assure this is to have a discrete quantitative scale such as that suggested below (Figure 3). Without such a discrete quantitative scale, there is strong experimental evidence that the same uncertainty words often have very different meanings for different people in different circumstances (e.g., Morgan and Henrion, 1990).

(1.00) "Very High Confidence" (0.95)
(0.95) "High Confidence" (0.67)
(0.67) "Medium Confidence" (0.33)
(0.33) "Low Confidence" (0.05)
(0.05) "Very Low Confidence" (0.00)

Figure 3. Scale for Assessing State of Knowledge

We realise from the comments on earlier drafts that some may be uncomfortable with having only one option, and thus we propose a set of qualitative uncertainty terms that can be used to supplement the five point scale and explain why a writing team may express high, medium, or low confidence in a particular finding (see Figure 4). We propose this as a supplement rather than as an alternative because these qualitative terms do not always map well onto a quantitative scale, increasing the likelihood of inconsistent usage.

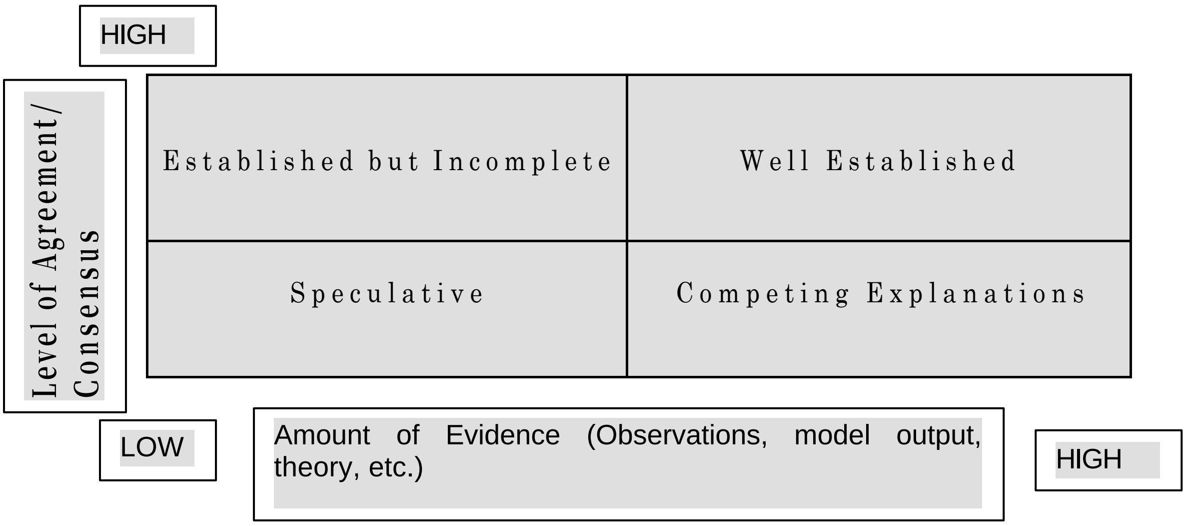


Figure 4. Supplemental Qualitative Uncertainty Terms.

Key to qualitative "state of knowledge" descriptors:

Well-established: models incorporate known processes; observations largely consistent with models for important variables; or multiple lines of evidence support the finding)

Established but Incomplete: models incorporate most known processes, although some parameterizations may not be well tested; observations are somewhat consistent with theoretical or model results but incomplete; current empirical estimates are well founded, but the possibility of changes in governing processes over time is considerable; or only one or a few lines of evidence support the finding

Competing Explanations: different model representations account for different aspects of observations or evidence, or incorporate different aspects of key processes, leading to competing explanations

Speculative: conceptually plausible ideas that haven't received much attention in the literature or that are laced with difficult to reduce uncertainties or have few available observational tests

Graphical approach to communicating the state of knowledge. Several experts have suggested development of a graphical approach for communicating evaluations of the state of knowledge. Simple approaches used in previous assessments have included systems of symbols such as asterisks to denote different levels of confidence in findings.

We explore here another option: a "radar plot" or "snowflake chart" that signifies increasing confidence as it increases in size. For some users, the size of the graphic would be the only interpretation required, but for others who wish to understand more about why a particular level of confidence was assigned, the axes of the plot would provide additional information about the major sub-components of the evaluation of the state of knowledge. In the following examples (Figures 5A-C), produced in a spreadsheet, the overall size of the graphic varies with hypothetical writing teams' assessments (on a scale of 1 to 10) of the amount/quality of theory, observations, and model results available to support a finding. The degree of consensus in evaluations of the members of the writing team is calculated and normalised using a non-parametric statistic. If there were interest in this approach among writing teams, further refinement of the concept would be required. One possible modification would be to drop the "consensus" axis and provide a box and whisker plot on each of the other three axes, thus allowing users to see the actual distribution of evaluations (having an odd number of axes would make it clearer that "consensus" and "observations," for example, are not opposites). The main advantage of such an approach is that it does not attempt to compress several judgments that go into the evaluation of the state of knowledge into one dimension, yet, the graphic also has a simple interpretation. It conveys more information than a single number or word, yet is simpler than the n-dimensional hypercube that would be required to portray independently all the dimensions of the state of science evaluations that writing teams will be making.

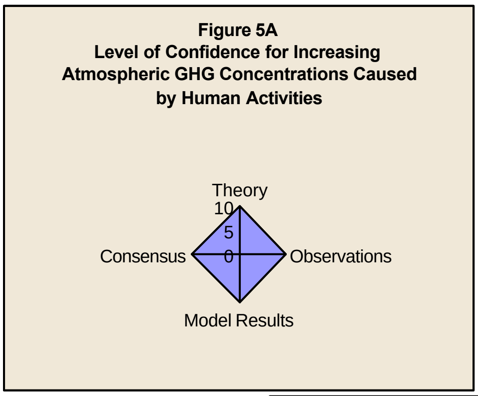


Figure 5A
Level of Confidence for Increasing Atmospheric GHG Concentrations Caused by Human Activities

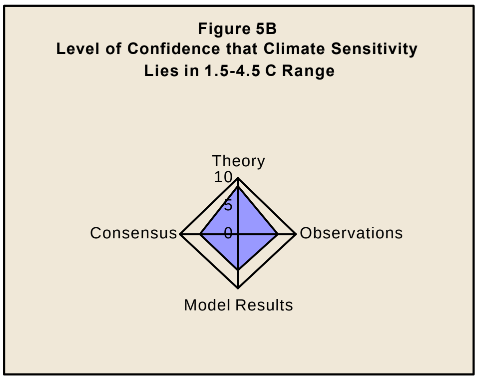
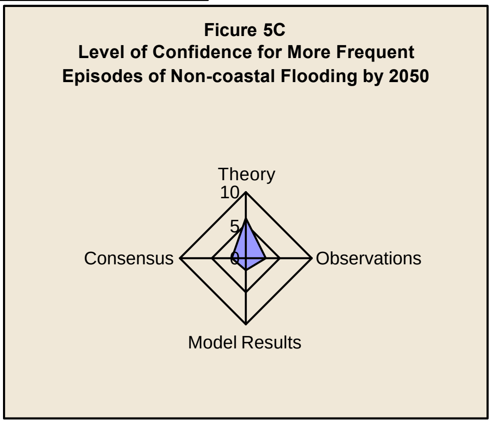


Figure 5B
Level of Confidence that Climate Sensitivity Lies in 1.5-4.5 C Range



Ficure 5C
Level of Confidence for More Frequent Episodes of Non-coastal Flooding by 2050

6. Prepare a "traceable account" of how the estimates were constructed that describes the writing team's reasons for adopting a particular probability distribution, including important lines of evidence used, standards of evidence applied, approaches to combining/reconciling multiple lines of evidence, explicit explanations of methods for aggregation, and critical uncertainties. In constructing the composite distributions, it is important to include a "traceable account" of how the estimates were constructed. For example, if the selection of outliers was based on the results of modeled output, but it is known that the models do not incorporate certain specific processes that are known to operate and that would, in the collective judgment of the authors, increase the range by a certain percentage, the outliers should reflect this information, and the text of the chapter should include a description of how the range was constructed. Or, if regionally heterogeneous distributions are aggregated into hemispheric or global averages, for instance, the data from which the aggregation was made should be given or a reference cited so others can perform different aggregations—a possibility only if such a traceable account is constructed. Or if costs and benefits of some climatic impact event are aggregated into a single measure of value or "numeraire"--typically a monetary unit--but different individuals or cultures might evaluate different numeraires (e.g., loss of species, changes in the distribution of effects across income groups or loss of life) differently, then it is inappropriate to aggregate across these numeraires without first providing a traceable account of how each numeraire was valued before the aggregation obscured those valuation assumptions (e.g., see the "Five Numeraires" discussion in Schneider et al, 2000).

In addition, attention should be given to the logical links generating main conclusions. Assigning confidence levels to various links in a chain of logic that leads to an important conclusion can identify areas of disagreement or limited knowledge. A single confidence level attached to the conclusion may be misleading, especially if confidence in the conclusion is low because one of the links is speculative while the others are well established.

7. OPTIONAL: Use formal probabilistic frameworks for assessing expert judgment (i.e. decision-analytic techniques), as appropriate. In a few cases (e.g., "detection and attribution"), lead authors may wish to use more formal decision analytic techniques to achieve a more consistent assessment of the subjective probability distribution for a particularly important outcome (e.g., as seen on Figure 2 for climate sensitivity estimates). In addition to describing such formal studies (if any) as may already exist in the current literature, some writing teams may choose to formalize development of quantitative cumulative probability distributions of a group of lead authors or other experts they might identify. In this case, decision analysis experts from outside the chapter writing team who are familiar with techniques for and pitfalls associated with elicitation of consistent expert judgments and construction of cumulative probability distributions should be invited to assist the writing team.

In this approach, the outside experts would work with the team of authors to frame a number of explicit questions in which ranges of estimates of outcomes or parameters would be called for from authors and/or other participants (see Nordhaus, 1994; Morgan and Keith, 1995; Titus and Narayanan, 1996 for examples of decision analytic elicitations of climate effects and impacts; see Roughgarden and Schneider, 1999, and Morgan and Dowlatabadi, 1996, for examples of how such elicited subjective probability distributions can be incorporated into integrated assessment models examining "optimal" policies). Formal one-on-one interviews, group interviews, or mail-in questionnaires (perhaps with follow-up contacts) could be used to establish subjective probability distributions for a few key parameters or issues. In addition to soliciting outcomes (e. g., likelihood of biodiversity losses or changes in gross domestic product), processes and major uncertainties in data or theory could also be elicited. Furthermore, questions could be designed to improve the consistency between outcome estimates and process uncertainty estimates made by each individual or group. When the responses of each author are compared, first privately for each respondent and then later as a group, the discussions that follow often very quickly focus on the main points of agreement or disagreement. These discussions can identify literature that some Lead Authors may not have been aware of in their initial responses, and thus can speed up the process of consistent assessment of outcomes or processes. The results of such formal elicitations (with or without re-elicitations) can be used in several ways, including formally in the chapter, but the actual responses of each author/outside expert (or even a group aggregate) need not necessarily be published as part of the final report. The primary goal is to improve the assessment process.

3. Graphical Communication of Uncertainty

More careful approaches to assessing and characterizing uncertainty will increase the clarity of conclusions in the IPCC TAR. The communication of this improved assessment of uncertainty associated with key findings and estimates will be aided by improved graphical representation of the results. Selection of specific approaches for graphical presentation of uncertain quantitative information is left to individual writing teams. However, it may be productive for the TSUs to facilitate an exchange of ideas or approaches at about the middle of the drafting process, so that particularly effective ideas can be propagated across the report. A number of potentially useful displays are available, involving trade-offs between simplicity and sophistication, particularly in the choice of the number of dimensions to use in presenting the information.

One example already discussed in this paper is the use of Tukey "box and whisker" plots, like those on Figure 2 which are meant to represent CDFs of subjective probability of each of 16 scientists on the magnitude of climate sensitivity. The tick marks at the left and right hand ends of the whiskers represent respondents 5th and 95th percentile estimates, respectively, and thus the lines extending beyond the tick marks represent range outliers (the end points of the whiskers being first and 99th percentiles in Figure 2). The box represents 25th and 75th percentiles and the dots mean and median of the distributions drawn by each of the 16 respondents. This graphical representation contains a remarkable amount of information about scientists' opinions about the uncertainties associated with climate sensitivity in an accessible form. Such a graphical representation of uncertainty is a very convenient means to convey information once a writing team has agreed that a quantitative representation of uncertainty is appropriate in their particular application.

Annex. Statement of the problem: developing selfconsistent collective assessments of the state of knowledge

The following examples from each of the contributions of the three IPCC Working Groups to the Second Assessment Report (SAR) illustrate the diversity of approaches used and point to the need for more explicit and consistent treatment of uncertainties in future assessments for all working groups.

Case 1: "Climate Sensitivity"

"Climate sensitivity"—the globally averaged surface temperature response that eventually can be expected to occur (i. e., at equilibrium) if the CO2 concentration were to double from pre-industrial levels and remain at this concentration indefinitely—was first estimated in a 1979 U.S. National Research Council report to be within the range of 1.5-4.5°C. While some changes in the underlying science have occurred (e. g., new formulations of cloud or biophysical parameterizations have been developed), small (±0.5°C) changes to the outliers (end points) of the ranges have seemed unjustified—even frivolous—to many in view of the absence of fundamental new data or a tested theory. Thus, the estimate of the range has remained the same over the first two IPCC reports (IPCC 1996a).

The process of achieving more consistent aggregate scientific judgments is critical to establishing more meaningful and credible ranges of potential outcomes like climate sensitivity. More consistent estimates of the endpoints of a range (e.g., as on Figure 2) for any variable would minimize misunderstandings and reduce the likelihood that interest groups could misunderstand or misrepresent the findings.

Case 2: Impacts of Climate Change on Agriculture and Food Security

A controversial aspect of the WG II SAR (IPCC 1996b) concerned the adaptive potential of agriculture to climatic change and the potential implications for regional and global food security. This assessment involves a wide range of issues, including inherent climate variability (i.e., climatic noise) that masks long term trends (making it difficult for farmers to know to what to adapt); carbon dioxide fertilization effects; crop/climate/insect interactions; the economic modeling of agricultural trade; and the socio-economic and political conditions under which hunger occurs. In the SAR, estimates of the impact of equilibrium, doubled-CO2 climate conditions were made using crop-climate models, and the assessment indicated a wide range of yield changes, from large and positive to large and negative, when compared to results under current climate conditions. The variation in results is accounted for by a variety of factors, including different assumptions about the factors above, as well as potential surprises and different assumptions in different studies regarding the extent to which adaptation is possible.

While the SAR writing team developed a definition of “vulnerability” based on the probability density function for climate change and a damage function that relates impacts to varying levels of climate change, in practice, specific climate model results played little role in the determination of vulnerability. These determinations were based on other factors, such as identifying those populations judged as being vulnerable to hunger or famine, or identifying potential thresholds for different crops.

Clearly, assessing the vulnerability of different populations will not be possible simply by using equilibrium, CO2-doubled climatic change scenarios—transient runs with various aerosol forcings from several modeling groups will also be needed (and are now available through the IPCC Data Distribution Centre established by the Task Group on Climate Scenarios for Impacts Assessment--TGCIA). Because the literature may not yet contain results from a large number of crop-climate model studies using these scenarios for many regions of the world, TAR authors will need to assess the causes of uncertainty explicitly (e.g., those arising from the factors above as opposed to those from neglect of transients or alternative aerosol scenarios). At the same time, they will need to consider (although great caution will likely need to be expressed in their conclusions) the subjective likelihood that crop yields will be altered given the available knowledge in the literature about transient scenarios and aerosol effects. By explicitly specifying the nature of uncertainties regarding agricultural impacts, the authors should be able to develop a carefully hedged set of subjective estimates of their collective judgment of possible impacts given the limited studies available to them (as well as establishing a template for future assessments). Of overarching importance is the need to convey clearly that the collective judgments of the TAR are based on an evolving hierarchy of rather heterogeneous studies, not on a linear progression beginning with a full range of plausible scenarios fed into state-of-the-art transient atmosphere/ocean/biosphere/cryosphere coupled models driving a comprehensive set of impacts models. While the latter may be a desirable goal, in practice assessors will be required to use judgments since such a comprehensive integrated modeling activity is not yet feasible (and would almost certainly have elements of unpredictability embedded).

Case 3: Aggregate Economic Impacts of Climate Change and Emissions Abatement

Working Group III of the SAR estimated "damages" resulting from climate change to range from $5-$125 per ton of carbon emitted, the range stemming from differences in estimation techniques as well as different assumptions about the appropriate "discount rate" to use in assessing future impacts in current monetary terms.[18] The WG III SAR presented a range of "best guess" estimates of aggregate damages. Globally, annual impacts under doubled CO_2 equilibrium climate were estimated to range from 1-2 percent of GDP. Regionally, the annual impacts on GDP were estimated to range from slightly positive (for the former USSR and perhaps China), to mildly negative (for OECD countries), to as high as a 10 percent loss (for Africa).

It is extremely important to note that ranges associated with these impacts estimates simply represented the range of best guesses of the authors, not their estimates of the full range of potential damages from low to high. No estimation of uncertainties with regard to the full social costs of climate change was made, and in fact, no systematic calculations are available in the literature as yet, as far as we know. But generally, the uncertainties are known to be large and difficult to quantify formally because of such issues as valuing non-market impacts in monetary terms. The lack of estimation techniques made the existing uncertainties difficult to communicate.

In the opinion of one SAR lead author, Chapter 6 of WG III (see the discussion in Moss and Schneider, 1997) conveys a message that knowledge is better developed than in fact it is, and that uncertainties are smaller than they actually are. It does seem likely that the ranges would not be nearly as small as portrayed in the chapter had procedures to estimate, say, tenth and ninetieth percentile range outcomes (let alone subjective probability distributions within and beyond those range endpoints) been more formal, thus allowing high and low estimates of benefits/damages to be included with the range of best guesses provided. Since decision makers often devise policies to deal with low probabilities of very consequential outcomes, authors need to provide such estimates to the extent the state of the science permits.

[18] Although the choice of discount rate is a source of significant dispute, it is not a source of uncertainty, because it is a value choice, and the effects of different discount rates on the estimates of climate impacts can be calculated with precision. In fact, such value choices should be treated parametrically so that decision makers can see the implications of adopting different value judgments. However, in another sense, estimating how future generations might assign various discount rates in their assessments is a source of uncertainty, for which only subjective opinions can be offered by this generation of assessors. Advising lead authors of the TAR of the need to make such aspects of uncertainty explicit is part of the purpose of this guidance paper.

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DECISION ANALYSIS FRAMEWORKS IN TAR

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1. Introduction

For the purposes of this Guidance Paper (GP), decision analysis frameworks (DAFs) are defined as analytical techniques aimed at synthesizing available information from many (broader or narrower) segments of the climate problem in order to help policymakers assess consequences of various decision options in their own jurisdictions. DAFs organize climate-relevant information in a suitable framework, apply a decision criterion (both based on some paradigms or theories), and identify options that are better than others under the assumptions characterizing the analytical framework and the application at hand.

DAFs play a critical role in IPCC's Third Assessment Report (TAR) because much of the climate policy debate goes back to differing or outright contradicting results obtained from different DAFs or formulating the same DAF differently, all published in peer-reviewed scientific literature. The value of these results would be much higher if they came together with a pedigree of their source. Thorough analysts always document their application-specific assumptions along their results but the theoretical underpinnings and the possibly arising limitations of the adopted DAF often remain hidden to policymakers. TAR should try to do a better job in serving the decision-making community by assessing the results in the literature originating in applications of diverse DAFs together with their pedigrees. Advantages and limitations of different DAF applications (and not DAFs proper) should be highlighted when writing teams in all Working Groups (WGs) assess the results they produce.

It is a different question how much policymakers and stakeholders know about DAFs and to what extent they believe the numbers they get from them even if they commission the studies. Moreover, even in their most complex implementations, DAFs depict a drastically simplified, ideal world in which they magnify key factors and processes related to the problem they address and ignore issues they consider or assume to be less important. Among other reasons, that is why hardly ever are decisions made on the basis of exact numerical results from any analytical framework. Yet results are important when they are considered, together with many other interests and arguments, in decision-making.

The Second Assessment Report (SAR) used the terms decision analysis (and frameworks) and decision making (and frameworks) largely interchangeably. This has resulted in some confusion among both scientists and policymakers, especially in making the delicate distinction between where policy-oriented scientific analysis of the climate problem ends and where climate policy proposals begin. The latter is clearly not allowed for IPCC whereas the former is explicitly requested, as the list of policy-relevant scientific questions compiled for TAR indicates.

This paper proposes a simple scheme to delineate the realm of climate-related decision making from two kinds of scientific analyses that intend and, in most cases, are commissioned by different stakeholders or public policy agencies, to support climate policy making (Section 2).

A starting point for analysing options and making decisions in any problem area is to identify basic characteristics of the situation. The SAR has emphasized at several points the profound nature of the climate change problem: uncertainties, non-linearities, potentially irreversible damages, very long time lags and planning horizons, global scope with major regional variations in causes and effects, multiple gases. Although different subsets of these features characterize many environmental problems, climate change is one of the few cases in which the complete list applies. This calls for a thorough investigation of both the applicability of off-the-shelf versions of traditional decision analytical frameworks (DAFs) as well as of the relevance and usability of their results, because most of them were developed for and performed reasonably well in problem areas characterized by lesser degree of complexity, shorter time horizons, smaller spatial expanses, etc.

Although climate change is a complex and dynamic process over which human control is partial and based on imperfect information, the ultimate question in climate decision making at the global scale has emerged as "at what level should mankind stabilize the Earth's climate with respect to anthropogenic interference". Article 2 in UNFCCC formulates the fundamental reference point in terms of stabilizing greenhouse gas concentrations with a view to some criteria for selected impacts (ecosystems, food production) and for implications of emissions reductions (sustainable development). As long as the ultimate climate objective cannot be established and/or the associated magic number for a concentration ceiling cannot be specified, listed characteristics of the problem compel that the basic mode of operation is sequential decision making (SDM). The product of each step in this sequence is a portfolio of actions including mitigation, adaptation, and knowledge acquisition. Individual components of this package should ideally be harmonized with each other in order to arrive at a consistent and efficient portfolio. This aspect has received only limited attention so far in decision-making frameworks (DMFs) as they have been largely focusing on mitigation decisions.

Below the global level, national and local decision makers face questions related to implementing GHG mitigation agreed upon at the global level, on the one hand, and to undertaking adaptation measures based on what impacts might be expected as a result of globally agreed mitigation action. DAFs of various sorts have been used on both sides and TAR should assess their results in the appropriate chapters although the bulk of DAFs dealt with mitigation decisions and only a small number of studies addressed adaptation.

The way climate change as a decision problem is structured in TAR, decision analysis frameworks (DAFs) play two important roles. First, chapters in WGII and WGIII should report results of their literature surveys in term of what DAFs were found to be used in exploring decision options on adapting to climate change impacts in different sectors and regions (WGII) and on reducing GHG discharge in different emitting sectors and regions (WGIII). A critical appraisal of new findings since SAR is crucial because different frameworks are better suited to explore specific facets of the problem than others and insights for decision making vary substantially depending on which DAF and in what form is adopted. Concluding chapters in these two reports should also appraise DAFs providing a combined evaluation of adaptation and mitigation options, generally referred to as integrated assessment models (IAMs), from the perspectives of impacts and adaptation (WGII Chapter19) and mitigation (WGIII Chapter10). Second, these two summary chapters might undertake simple analyses of their own by adopting one or more DAFs to synthesize information from preceding chapters in their respective reports. This process could then culminate in the Synthesis Report by selecting appropriate DAFs and using them to provide truly integrated assessments of climate policy (mitigation and adaptation) along the lines of the specified policy-relevant scientific questions.

2. Frameworks for decision analysis and decision-making

Climate change decision-making and decision analysis intended to support it can be structured in three major domains (see Figure 1): decision making per se (the act of formulating decisions), decision analysis (aimed at providing information for decision makers), and process analysis (investigating procedures of decision making). The last two are sometimes difficult to separate and they overlap in certain areas but the distinction is still useful, as it will be explained below.

The middle column in Figure 1 depicts levels of decision-making relevant for the climate problem. It stretches from global and supranational fora through national and regional institutions down to the micro level of families and individuals. In this scheme we take the conveniently general definition: "[A] decision or policymaker is anyone authorized or able to alter the flow of pertinent events" (Brewer and deLeon, 1983:14). At each level, it will be useful to distinguish two parts of these decision-making frameworks (DMFs): institutions providing the boundary conditions (jurisdictions, procedural rules, the body of earlier agreements, etc. on the one hand) and processes befalling within these frameworks (negotiations, lobbying, persuasion). At the global level, for example, UNFCCC provides the institutional part and negotiations represent the process part of the DMF.

A number of supranational DMFs can be identified that shape both global and national scale events. Some of them are long-standing and were established for purposes other than climate change (European Union, OPEC, G77), others are ad hoc and were created to be operational in climate change decisions (AOSIS).

National governments are generally recognized to have the legitimacy to agree on global decisions and the authority to make and implement decisions under their jurisdictions accordingly. The positions they take in the global DMF and the ways they implement global decisions at the national scale are crucially influenced by the positions regions and sectors belonging to their jurisdictions take on the matter.

Finally, myriads of decisions are made daily at the micro level at which a family is deciding to what extent they will consider fuel efficiency in choosing the next car they will buy, or grandma deciding whether to use the pressure cooker or a traditional pan in preparing dinner for tonight.

A well-recognized difficulty in climate-related decisions and in analyses to support them stems from the fact that many decisions across all these scales are taken by largely ignoring or just marginally considering their climatic implications. Energy, agriculture, transport, housing and many other policies at the national level are examples of these kinds of decisions. National climate policy cuts across them to the extent emissions constraints will affect future decisions in those areas. It would go far beyond the scope of this GP (and, in fact, IPCC TAR) to look at non-climate decisions in detail for two reasons: first, and mainly, IPCC's mandate is to prepare its scientific assessment for global climate policy making (UNFCCC and its institutions) and for national actors in this arena. Second, the culture (principles, processes, DAFs accepted and used) of making those crucial non-climate decisions at the national scale is hopelessly diverse to handle in a GP. Fortunately, as argued, this is not needed because it will be up to individual chapters and especially Chapter 10 in WGIII to assess how those different national cultures shape international climate decision-making.

A large variety of decision analysis frameworks (DAFs) has been used or could be used to provide information for actors involved in DMFs at various levels. These are listed in the left column in Figure 1 and will be elaborated in more detail in Section 3. Some of these DAFs are more useful at the global and national scales, while others can be more usefully applied at regional, sectoral or micro scales.

Process analysis frameworks (PAFs) involve assessments of the decision making process and provide guidance for decision making in two main areas. The first one is concerned with the institutional framework design, i.e., how to build policy regimes that will address the problem effectively. The second area looks at procedures of decision making at various levels. The bulk of the literature on climate change addressed global regime building in framework analysis and international negotiations in procedure analysis. Pertinent literature in these areas will be assessed in WGIII Chapters 1 and 10, but it is useful to highlight these issues here as part of the DAF-DMF scheme.

A few important topics cut across the scheme presented in Figure 1 that are important to note before looking at individual DAFs in more detail. First, at each level, most DAFs are formulated from the perspective of a single decision maker. This provides useful information on ideal outcomes in ideal situations that can never be reached in reality. A diverse set of techniques has been developed and different DAFs are available to include unique conditions and specific objectives of key actors at one decision making level below in order to gain insights into how their interactions unfold and to analyse implications of various intervention options at the decision making level at hand.

Second, the long-term nature and dynamics involved in the climate case make necessary that DAFs take a long-term view. This has often been interpreted as an attempt to define optimal policies for decades into the future. TAR should make it clear what are the relative merits of different DAFs for use in SDM under uncertainty and learning. The key criterion for usefulness is to provide the best possible information for formulating a short-term portfolio that offers "optimal hedging", i.e., leads to future state with the largest flexibility to restructure the portfolio at the lowest cost as uncertainties will be resolved. At each step in this sequence, specific sub-problems need to be analysed in more detail, e.g., how best to achieve a short-term emission target like the Kyoto Protocol. These limited-horizon studies should be compatible with the long-term frameworks but do not need to cover hundreds of years.

Third, considering decision making per se, SDM is a bare necessity because there is no way to commit future decision makers to follow any particular course of action set today. At the international scale, countries default on debt or defy their commitments in international agreements. At the national scale, even in stable democracies, we regularly witness new governments eliminating or reversing policies installed by their predecessors even in the absence of any sign of changes in the problem area those policies address. Current DMFs (most importantly, UNFCCC at the global level) do allow for SDM in practice. On the process analysis side, guidance is needed both on framework design and process design that are conform to SDM and offer the possibility for course corrections at various levels.

3. DAFs: an incomplete catalogue

A broad range of DAFs can be used in principle and has been used in practice to provide substantial information for policy makers involved in climate decisions at various levels. Table 1 provides an exemplary rather than an all-encompassing list. Many DAFs overlap in practice and clear classification of practical applications is sometimes difficult.

Different decision making principles can be used individually or in combinations as DAFs are adopted to climate change decision problems. Table 1 attempts to check the compatibility of different principles with and their usability in relevant DAFs. It is apparent from the table that some DAFs can accommodate some decision principles better than others but downright incompatibility is rare. TAR authors should carefully document the often hidden value judgements involved in specific applications of DAFs to issues addressed in individual chapters. Table 1 also contains entries regarding the level for which the given DAF is best suited. Yet another series of entries indicate whether the DAF at hand is applicable for decision analysis on mitigation or adaptation policies, both kinds but separately, or for integrated climate decision analysis setting levels of mitigation and adaptation simultaneously.

Decision analysis (DA) is the product of integrating utility theory, probability, and mathematical optimisation (see Keeney and Raiffa, 1993; Clemen, 1996; French, 1990; Kleindorfer et al., 1993; Morgan and Henrion, 1990). The process starts with problem identification and preparing a possibly comprehensive list of decision options. Structural analysis would organize options into a decision tree carefully distinguishing decision nodes (splitting points at which the outcome is chosen by the decision maker) and chance nodes (splitting points at which the outcome results from stochastic external events). Next, uncertainty analysis would assign subjective probabilities to chance nodes while utility analysis would stipulate cardinal utilities for outcomes. Finally, optimisation analysis produces the best outcome according to a selected criterion, most typically maximizing expected utility, or any other that reflects the risk attitude of the decision maker best.

Decision analysis is a powerful DAF that can provide useful results for any level of climate decision-making and can be formulated according to different decision-making principles. For a global level SDM application see Valverde et al. (1998). Decision analysis has also been successfully adopted as a postprocessor of results from integrated assessment models (Kolstad, 1994). A powerful application of DA is formulated to compute the expected value of information for resolving uncertainties about different components of the climate change-society interaction. These applications provide insights into how probabilistic descriptions of climate change help evaluate knowledge acquisition activities and how they interact with he valuation of hedging strategies. Results from such studies are especially relevant for decisions on the learning component of the climate policy portfolio. See, for example, Kolstad (1993) and Peck and Teisberg (1993).

At this point, some misconceptions about decision analysis should be clarified. Some features (sequential decision making, hedging), specific versions (multicriteria analysis), distinctive applications (risk assessment - RA), or basic components (multiattribute utility theory) of decision analysis are sometimes emphasized and taken as separate DAFs. As indicated, sequential decision-making is an indispensable mode of analysis in climate change in any DAF. It refers to the framing of the analysis rather than to a distinctive DAF. Decision analysis can be performed with single or multiple criteria, multiattribute utility theory providing the conceptual underpinnings for the latter. Finally, decision analyses adopted to managing technological, social or environmental hazards constitute part of RA where a range of other methods is also available and some, more comprehensive versions of RA actually encompass a number of DAFs.

Cost-benefit analysis (CBA) involves valuing all costs and benefits of a proposed project or policy over time (see Ray, 1984; Morgenstern, 1997). Any gain in utility counts as benefit and any loss in utility counts as costs (measured as opportunity cost) irrespective of to whom they accrue. The primary decision criterion to accept or turn down the project is that the sum of discounted benefits should exceed the sum of discounted costs. Many projects tend to fulfil this criterion in the reality leading to the problem of capital rationing. In this case the ratio of benefits over the costs can be used to rank the projects and those with the highest ratios should be selected. In real life they hardly ever are because CBA is good at providing a rough picture but it suffers from many imperfections. The criterion of costs exceeding benefits formally corresponds to the compensation principle implying that those who benefit from the project should be able to compensate the losers, at least hypothetically.

The applicability of CBA as a DAF for determining optimal global climate policy by balancing discounted costs and benefits at a highly aggregated level has been one of the most fiercely debated issues. While the debate continues regarding to what extent can traditional CBA provide useful information for global level decision-making, there is more agreement on its usefulness at the national and regional scales in determining optimal regional adaptation efforts or mitigation strategies.

Cost-effectiveness analysis (CEA) takes a predetermined objective (often an outcome negotiated by key stakeholder groups in a society) and seeks ways to accomplish it as inexpensively as possible. The thorny issue of compensations and actual transfers boil down to less complex but still contentious issues of burden sharing.

CBA will always be controversial due to the intricacies of valuing benefits of many public policies, especially intangible benefits of environmental policies properly. CEA takes the desired level of a public good as externally given (has a vertical marginal benefit curve) and minimizes costs across a range of possible actions. Similarly to other target-based approaches, CEA often turns into an implicit CBA, especially if even the minimum costs turn out to be too high and beyond the ability to pay of the society. In this case the target is iteratively revised until an acceptable solution is found.

The Tolerable Windows Approach (TWA) and the Safe Landing Analysis (SLA) approach have been developed to reconcile the difficulties between the long-term dynamics of climate change and the short-term nature of decision making and in response to the difficulties involved in adopting traditional DAFs to the climate problem (see Toth et al., 1997; 1998; Petschel-Held et al., 1999 for TWA; Alcamo and Kreileman, 1996; Kreileman and Berk, 1997 for SLA). Both approaches formulate the climate issue as a control problem by taking impacts, climate attributes or concentrations as state variables for any of which constraints are imposed externally by decision makers. The analyses then identify boundaries for the control variables (typically greenhouse gas emissions) within which decision makers can choose their preferred course of action with a view to other considerations not included in the analysis. Given that models are devised appropriately, TWA/SLA can be transferred into a cost-effectiveness problem with the objective to find the least-cost option to reach the environmental target.

Game theory investigates interactions between agents and predicts outcomes by simultaneously accounting for their objectives, costs and benefits (see Bacharach, 1976; Shubik, 1982; Friedman, 1986). The emphasis is on the strategic behaviour of players, each of whom is assumed to consider two points: first, impacts of his action on other players, and second, the fact that other players do the same in making their own decisions.

Game theory has provided useful insights as a DAF in climate change, but its major contribution has been to process analysis both in framework design (especially at the global level) as well as in procedure design (strategic behaviour in negotiations).

Portfolio theory is concerned with creating under a budget constraint an optimal composition of assets characterized by different returns and different levels of risks. Decision options (portfolio elements) are represented by a probability distribution of expected returns while risks are estimated on the basis of the variability of expected returns, and only these two factors determine the decision makers utility function. The decision rule is to choose the efficient portfolio compared to which no other portfolio offers higher expected return at the same or lower level of risk or lower risk with the same (or higher) expected return.

Portfolio theory originates in (private) financial investments but there is nothing to preclude its application in public policy decision-making. An appropriate formulation of the climate change problem in this conceptual framework is a worthy idea to consider in TAR.

Public finance theory is mainly concerned with the choice of second best. Its applications seek a compromise between efficiency and equity. Benefits theory of taxation, impact and tax burden analyses are possible uses in climate change mitigation.

Behavioural decision theory (BDT) combines economics and psychology to describe human decision-making (see Hogarth, 1990; Einhorn and Hogarth, 1988). It is utilitarian to the extent that it tries to understand human behaviour as a purposeful attempt to improve well-being but it recognizes that people's information processing capacity and decision-making skills are limited. BDT has been applied as a DAF to a broad variety of social issues and situations. It rests on the basic assumption that people usually (re)act rationally in order to solve a problem. Collective human behaviour represents the efforts people undertake in order to find solutions to problem they jointly face. BDT provides important insights into the discrepancies between stylised assumptions of economics and real-world decision-making. These insights might be especially relevant in the case of a complex and controversial problem of climate change.

Ethical and cultural prescriptive rules as a DAF can be traced back to the cultural theory of risk and related concepts in sociology and social anthropology (Douglas and Wildavsky, 1982). Cultural theory is concerned with forms of social organization that are largely ignored by economists and political scientists and emphasizes the importance of including in DAFs social organizations that are usually excluded by conventional social science dichotomies (see Jaeger et al., 1998). In their contributions to analysing public decision problems, cultural theorists emphasize three kinds of social organization pursuing their own positions: egalitarians, hierarchists, and entrepreneurs. Jaeger and his co-authors also propose to use other approaches associated with the social amplification of risks, notably arena theory. There are several attempts to devise the climate problem (in fact, the whole problem of global change) in integrated assessment models by adopting concepts and tools of cultural theory (see Rotmans and Vries, 1997).

The Policy Exercise (PE) approach involves a flexibly structured process designed as an interface between academics and policymakers. Its function is to synthesize and assess knowledge accumulated in several relevant fields of science for policy purposes in the light of complex practical management problems. At the heart of the process are scenario writing ("future histories", emphasizing non-conventional, surprise rich but still plausible futures) and scenario analyses via the interactive formulation and testing of alternative policies that respond to challenges in the scenario. These scenario-based activities take place in an organizational setting reflecting the institutional features of the addressed issues. Throughout the exercise, a wide variety of hard (mathematical and computer models) and soft methods are used (Brewer, 1986; Toth, 1986; 1988a,b).

The product of a PE is not necessarily new scientific knowledge or a series of explicit policy recommendations, but rather a new, better-structured view of the problem in the minds of the participants. Successful applications serve policymakers by preparing them for participation in official decision making processes and summarize the most important policy insights in the form of a Cabinet Briefing Document. The exercises also produce statements concerning priorities for research to fill gaps of knowledge, institutional changes that are needed to better cope with the problems, technological initiatives that are necessary, and monitoring and early warning systems that could ease some of the problems in the future. In recent years we have witnessed increasing use of the PE approach to address climate change both as a DAF at the national scale (see Klabbers et al. 1996; Toth, 1992) and as a PAF at the global scale (Parson, 1997).

Integrated Assessment (IA) Focus Groups combine computer models with a monitored social process to allow citizens to express their judgements on (global) environmental policies in a form that provides useful information for policymakers. This very "soft" kind of DAF has been tested in the context of urban lifestyles and sustainability, with the main focus on global warming. Computer models include global IA models of climate change as well as regional IA models to help explore energy- and emissions-related implications of different lifestyles. The social process draws on small-group techniques used in applied social science research (see Krueger, 1988) and in political decision-making (see Stewart et al., 1994).

It is too early to tell whether and to what extent can IA Focus Groups become contemporary equivalents of the ancient agorae. Initial results are promising (see Jaeger et al., 1997; Kasemir et al., 1999), but it will take a lot of research and experimentation to reach the level of maturity of the other DAFs covered in this section. If they turn out to be successful, IA Focus Groups could become one possible avenue to creating willingness to pay based benefit functions as proposed by Portney (1998) in his mock referendum approach.

Simulation-Gaming (S&G) exercises define decision situations, roles, rules and procedures in order to study particular social situations in which individual decisions and their interactions are crucial to the outcome. As opposed to game theory where consistent and rational behaviour is taken for granted for all actors at all times, simulation-gaming is more concerned with human behaviour as it unfolds in an artificial microcosm. In contrast to PEs where institutional settings and procedures defined for the exercise closely imitate reality, decision situations in S&G sessions are significantly simplified emphasizing just a few selected features of reality. Two aspects are particularly relevant for climate change. The first is on the DAF side and entails the potential offered by simulation-gaming to communicate and teach complex issues to participants (Vries et al., 1993). The second is on the PAF side and is related to the so far largely under-utilised potential to gain insights about processes of negotiating complex issues among parties with widely diverging values and interests.

4. DAFs in TAR

A) Assessment of available literature

The primary task for authors of Chapters 4-9 and 10-17 in WGII is to review huge amounts of studies conducted to assess possible impacts and adaptation options in selected impact sectors and geographical regions, respectively. Authors of these chapters should carefully look for studies that went beyond the level of elementary impact assessment and adopted a DAF (any framework, not necessarily one of those listed in the previous section) to inform relevant decision makers on how, to what extent, and at what cost could possible unfavourable impacts be reduced or countervailed. A preliminary assessment of the linkages between DAFs and WGII chapters is presented in Table 2.

Among the DAFs listed in the previous section, the following are likely to turn out to be the most relevant and most frequently used ones in assessing options for adaptation policy:

- different forms and specifications of decision analysis: decision nodes corresponding to single adaptation decisions, chance nodes denoting possible outcomes of regional climate change and impacts, assessments of probabilities and utilities of different outcomes, and the selection of one or more decision criteria chosen by a targeted decision maker or assumed by the analysts to reflect risk attitudes of stakeholders to identify optimal adaptation policies;

- CBA formulated from a regional or sectoral perspective and set up to determine, for any given level of regional climate change and associated impacts, the optimal adaptation policy that would balance marginal benefits of adaptation measures with their marginal costs;

- CEA on the adaptation side would be used when, under different climate change and related impact scenarios, a required minimum level of public good or service (e.g., flood protection) is specified and the option to deliver this good at the lowest cost is sought;

- PEs would be used to assess adaptation options especially in early phases of regional impact and adaptation studies when there is strong need to structure the problem or in later phases if no integrated model is available to evaluate cross-sectoral and indirect impacts but sectoral policy responses might support or undermine each other.

WGII Chapter 18 might include a short section on comparative evaluation of the different DAFs as applied in adaptation studies across sectors and regions: what are the relative advantages and drawbacks of different DAFs in different contexts with a view to preparing a credible assessment of adaptation options for relevant policymakers. This might also be the place for an honest evaluation of cultural determination of selecting DAFs and decision criteria in appraising adaptation policies that has been frequently speculated about but hardly any evidence presented.

Literature about analysing climate change adaptation decision is scanty. It might be useful for authors in Chapter 4 to 18 to consider studies that adopted DAFs to cope with climate variability. What DAFs have been used in different regions/sectors? Are their results relevant for climate change? Or, at least, are the same DAFs good candidates for analysing climate change adaptations?

The relationship between DAFs and individual chapters is more intricate in WGIII. A preliminary assessment of the linkages between DAFs and WGIII chapters is presented in Table 3. While each chapter will provide important information for analysing mitigation decisions, it is less clear at this point to what extent different DAFs are used and/or could be used in analysing issues addressed by these chapters. Chapters 2 (Scenarios) and 7 (Costing methodologies) would clearly serve as vital input to any DAF whereas the consistency of the theoretical foundations should be carefully checked between various DAFs and their particular applications, on the one hand, and the different costing methodologies and their specific utilization, on the other.

Chapters 3, 4, and 5 might want to look for studies employing different DAFs in assessing potentials and barriers of technologies to reduce emissions or enhance sinks. Here again, DA, CBA, and CEA are the most likely candidates to be found in the literature. In principle, these approaches could be used to distinguish realistically usable potentials from theoretically possible but hardly ever exploitable potentials. Jeopardizing to cross the fine borderline between assessment and new research, closing sections in each of these chapters may want to consider a simple exercise by selecting at least two DAFs and examine key options and barriers they have identified in their particular chapters.

Comparing merits and shortcomings of different policies, measures, and instruments (Chapter 6), as well as counting net costs at different regional scales (mainly national and global – Chapter 8) and in different sectors (Chapter 9) are the next issues. As it is likely to be found in the literature, results of all three kinds of studies inevitably spread across a broad spectrum depending on which DAF and which decision criterion was chosen for the study, in addition to the usual dependency of results on a wide range of assumptions on the boundary conditions of the specified problem. Demonstrating and explaining sensitivity of results to both (DAFs adopted and exogenous assumptions used) is an important task for these chapters. The key question is how results from the same DAF spread in response to plausible variations in the boundary conditions, and vice versa, how results disperse if the same exogenous assumptions are implemented in different DAFs. More specific questions should also be explored. Do studies, which employ different DAFs, look for assessing potentials and barriers of technologies to reduce emissions or enhance sinks? What are the net costs associated with different climate stabilization levels? How do these costs depend upon different policy instruments, and varying degrees if flexibility?

As it has been argued above, writing teams in both WGII and WGIII should check and report the DAF heredity of the results they cite from the literature, not just the results. Relevant questions for both working groups include the following. When DAFs are used in chapters, is the extent to which different DAFs are used and/or could be used in analysing issues addressed? Is the consistency of the theoretical foundations carefully checked between various DAFs and their particular applications? Are different results from the same DAF spread in response to plausible variations in the boundary conditions available and compared? Are dispersed results drawn from applying different DAFs to the same exogenous assumptions explored? Is the sensitivity of results to key assumptions demonstrated and explained?

B) Synthesizing results from different DAFs: WG Syntheses and TAR Synthesis Report

Among fulfilling other tasks, WGII Chapter 19 should synthesize available information for main impact sectors in all world regions along the following scheme: what are the net impacts (unaverted damages plus net adaptation costs)

- under different scenarios of socio-economic development (e.g., IPCC IS92 or the new SRES series) implying differing degrees of climate vulnerability,
- associated with different climate stabilization levels (1.0, 2.0, 3.0 °C global mean temperature increase, or 450, 550, 650, 750 ppmv CO_2-equivalent concentration),
- each attained along different emission paths (smooth versus spiky).

This in itself is a rather demanding task. Just taking fast-slow development scenarios, low-high vulnerabilities, 2-3 levels of climate stabilization, and drastic-modest near-term reduction paths to each level would involve preparing 16-24 net impact estimates. Regrettably, many cells in this multi-dimensional array will be empty because hardly any impact assessment has been conducted along the specified features, not to mention a systematic effort to apply a DAF to support adaptation decisions. Yet the exercise would be immensely useful as it could massively demonstrate how limited is our current knowledge about climate change impacts and adaptation measures.

Correspondingly, among performing other functions, WGIII Chapter 10 should contain a summary of what are the net costs of mitigation

- under different scenarios of socio-economic development (comparable to those above) implying differing economic growth patters, resource and technological endowments,
- associated with different climate stabilization levels (1.0, 2.0, 3.0 °C global mean temperature increase, or 450, 550, 650, 750 ppmv CO_2-equivalent concentration),
- each attained along different emission paths (smooth and spiky), and
- implemented through different policy instruments characterized by varying degrees of flexibility.

This is no less demanding than the impact side, if we consider the number of possibilities.

These two sides could then be brought together in the Synthesis Report to explore many of the key policy-relevant scientific questions. The prerequisite is, however, consistency of the two sides in terms of scenarios, vulnerability-technological endowments, etc.

Chapter authors and Synthesis Report contributors might select different DAFs to conduct meaningful studies in order to answer the agreed policy-relevant questions. DA, CBA, CEA, and TWA/SLA are the top candidates although some questions might be best explored by game theoretical techniques. Nevertheless, IPCC WGII and WGIII leaders need to make some strategic decisions regarding to what extent and in what form these activities should take place. They are extremely resource intensive, even if all affected chapters do their requested homework properly and the value of the outcome is difficult to predict as the synthesizers would need to use output from earlier DAF applications and subject them to a supplementary processing.

5. Other GPs and some recommendations

While it is important to maintain the survey and summary of existing scientific literature as the main objective for TAR, a creative assessment should include attempts to put the collected information to work in order to enhance the policy relevance of the report. The most promising way to achieve this objective appears to be to select and use different DAFs in summary sections of selected chapters, the concluding chapters of WGII and WGIII, and the Synthesis Report.

Material covered in other Guidance Papers might be utilized in DAF applications as follows: rigorous uncertainty analysis should be a crucial part of all DAF results. The ability of different DAFs to cope with uncertainties varies widely and the implications should be part of the reported results. Various costing methodologies can be used in estimating both costs and damages of climate change. Which costing methodology is appropriate depends on the temporal, spatial, sectoral scales of the analysis and numerous other factors. When results from various cost and benefit studies are used as input to DAFs, the theoretical consistency between the costing study and the selected DAFs must be ensured.

The GP on development, sustainability and equity (DSE) addresses issues that might be easily integrated into DAFs as binding constraint or as decision criteria. Contrary to popular belief, DAFs rooted or most widely used in economics are not indifferent to issues like preservation of nature or fairness. Characterizing socio-economic development by the convenient shorthand of growth in per capita national income prevails for practical reasons but economists have long discovered and acknowledged human, institutional, and political dimensions of development. As long as these factors are important parts of the decision problem at hand, they can and should be included in applications of relevant DAFs. Sometimes the dilemma arises whether the inclusion of DSE and related issues is proposed to obtain a better insight into climate policy or in order to push solution of other problems in the disguise of climate policy. TAR authors should be aware of this possible source of confusion and report their assessment of the pertinent literature accordingly.

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Table 1. DAFs: compatibility with decision making principles, applicability at geopolitical levels and in climate policy domains

DAFs	Decision principles				Level of application	Domain of application
	Optimisation/ Efficiency	Precau-tionary principle	Equity	……		
Decision analysis	*	+	+		X	X
Cost-benefit analysis	*	-	+		X	X
Cost-effectiveness analysis	*	+	+		X	B
Tolerable windows/Safe landing approach	+	*	+		G	I
Game theory	+	-	+		G	M
Portfolio theory	*	+	-		G-N	I
Public finance theory	*	-	*		N-M	B
Behavioural decision theory	-	+	+		G-R	B
Ethical and cultural prescriptive rules	-	+	+		G-R	B
Policy exercises	+	+	+		N-M	X
Focus groups	-	+	+		R-M	I
Simulation-gaming	-	+	+		X	X

Compatibility with/usability of decision principles in DAFs:
- - weak but not impossible
- + possible but not central
- * essential feature of DAF

Level of application:
G = Global N = (Supra)National R = Regional/Sectoral
M = Micro X = All

Domain of application:
M = Mitigation, A = Adaptation B = Both, but separately
I = M & A integrated X = All

Table 2. Linkages between DAFs and WG-II chapters

	1. Overview	2. Methods & tools	3. Scenarios in CC	4. Hydrology & water resources	5. Natural & managed ecosystems	6. Coastal zones & marine ecosystems	7. Energy, industry, & settlements	8. Financial services	9. Human health	10-17. Regional	18. Adaptability to CC	19. Synthesis & integration
Decision analysis				*	*	*	*	*	*	*	*	*
Cost-benefit analysis				*	*	*	*	*	+	+	*	+
Cost-effectiveness analysis				*	*	*	*	*	*	*	*	*
Tolerable windows/Safe landing approach												+
Game theory				-	-	-	-	-	-	+	+	+
Portfolio theory				+	+	+	+	+	+	+	+	+
Public finance theory				+	+	+	+	+	+	+	+	+
Behavioural decision theory				+	+	+	+	+	+	+	+	+
Ethical and cultural prescriptive rules				-	-	-	-	-	-	-	-	-
Policy exercises										*	*	*
Focus groups				+	+	+	+	+	+	*	*	-
Simulation-gaming				-	-	-	-	-	-	-	-	-

Notes:

* essential DAF to support adaptation decisions or synthesis

\+ suitable DAF to support adaptation decisions or synthesis

\- less suitable DAF to support adaptation decisions or synthesis

This assessment is preliminary and it is based on so far scanned applications of any DAFs in climate change adaptation decisions.

Table 3. Linkages between DAFs and WG-III chapters

	1. Scope	2. Scenarios (emissions mitigation)	3. Technological & economic potential of emissions reduction	4. Technical & economic potential: reservoirs &	5. Barriers, opportunities & market for technologies	6. Policies, measures & instruments	7. Costing methodologies	8. G/R/N costs & ancillary benefits of mitigation	9. Sector costs & ancillary benefits of mitigation	10. Decision making frameworks
Decision analysis			+	+	*	*		*	*	*
Cost-benefit analysis			+	+	+	*		*	*	*
Cost-effectiveness analysis			*	*	*	*		*	*	*
Tolerable windows/Safe landing approach										*
Game theory			+	+	+	*		*	*	*
Portfolio theory			+	+	+	*		*	*	*
Public finance theory			+	+	+	*		*	*	*
Behavioural decision theory			*	*	*	+		-	-	-
Ethical and cultural prescriptive rules			+	+	+	+		-	-	-
Policy exercises			+	+	+	*		-	-	*
Focus groups			*	*	*	+		+	+	+
Simulation-gaming			+	+	+	+		-	-	+

Notes:

* essential DAF to support specified aspects of mitigation decisions or synthesis

\+ suitable DAF to support specified aspects of mitigation decisions or synthesis

\- less suitable DAF to support specified aspects of mitigation decisions or synthesis

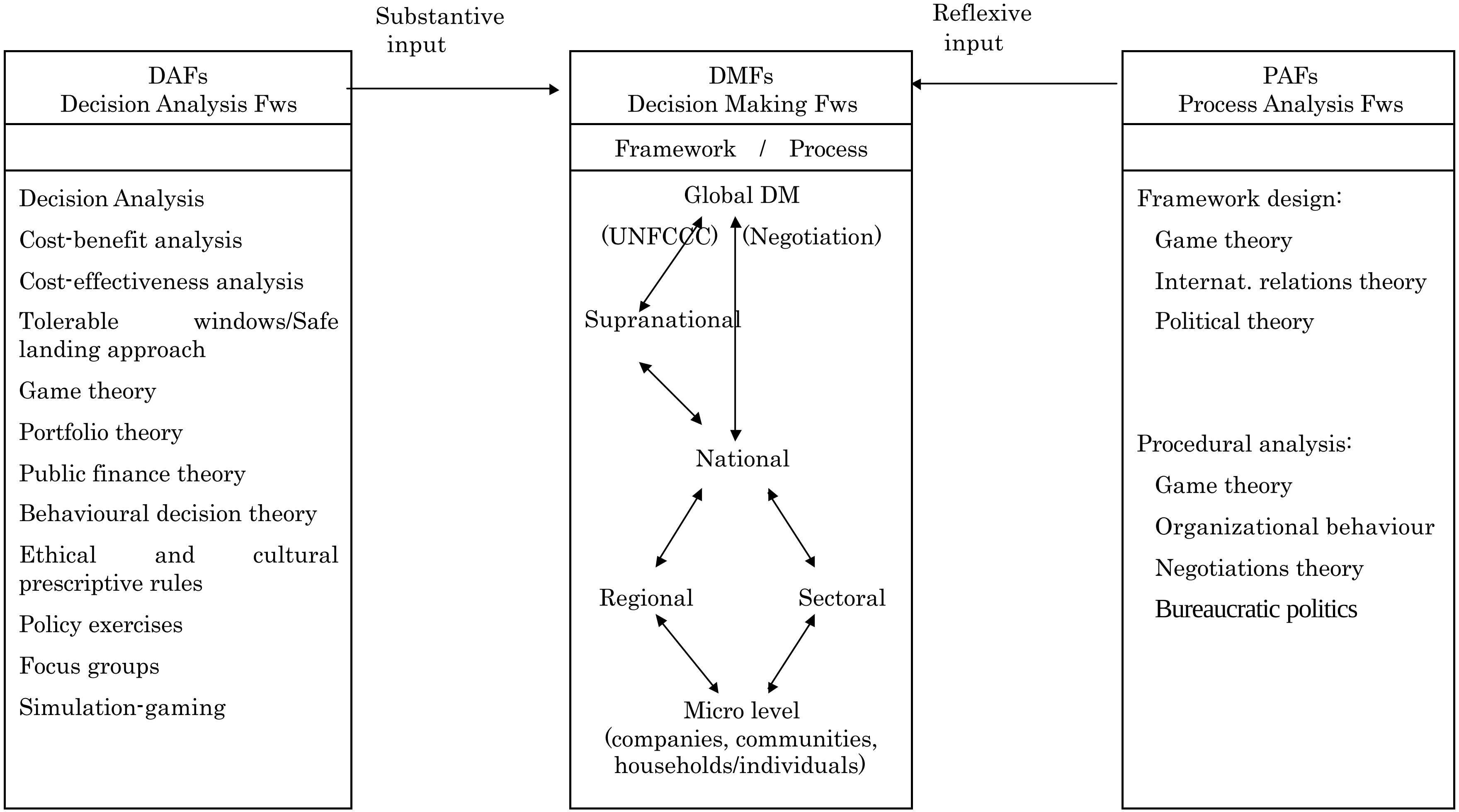

Figure 1. Three domains of climate change decision frameworks

DEVELOPMENT, EQUITY AND SUSTAINABILITY (DES) IN THE CONTEXT OF CLIMATE CHANGE

Prepared by

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Note

This IPCC guidance paper has been revised based on comments received at the IPCC Expert Meeting on Development, Equity and Sustainability, held in Colombo, Sri Lanka, 27-29 April 1999. Both the paper and the meeting were designed to help provide guidance to lead authors in dealing consistently with the cross-cutting themes of development, equity and sustainability, which are pervasive throughout the WG2 and WG3 reports. This draft has also benefited from comments gratefully received from many colleagues (too numerous to mention here), at the first WG3 and WG2 Lead Authors Meetings (in Bilthoven, December 1998; and Geneva, January 1999 respectively), as well as via e-mail. All shortcomings are my responsibility.

1. Overview and Objectives

Development, equity and sustainability (DES) are key cross-cutting issues that pervade the IPCC Third Assessment Report (TAR) -- especially chapters of WG2 and WG3. They are also important concepts that are well established world-wide (but not always well-defined), in the minds of both decisionmakers and the general public. Relating these issues more explicitly to climate change is important, for two reasons. First, there are fundamental scientific and epistemological links between DES issues and climate change phenomena. Second, such an analysis will add to the cogency of arguments and ultimate acceptability of strategies to address climate change problems. It will help to underline the essential point that climate change is a key element of the broader search for sustainable development paths -- a universal goal already enshrined in the post-Rio consensus on Agenda 21 (WCED 1987; UNFCCC 1993). Strengthening these linkages in the TAR will also offset criticisms that past efforts to develop climate change strategies have focused too narrowly on technical analyses, without paying adequate attention to the socioeconomic aspects (Newby 1993; Cohen et al. 1999).

Accordingly, this paper seeks to outline an integrative framework that links the themes of development, equity and sustainability in the context of national decision making today. A holistic approach is necessary because these broad themes overlap and are not easily separable. The concept of sustainable development (including its economic, social and environmental dimensions) provides a useful starting point, and hence the TAR authors might consider the following broad and long term questions, in relation to DES issues:

1. How will expected development patterns and scenarios affect climate change?
2. How will climate change impacts, adaptation and mitigation affect sustainable development prospects?
3. How could climate change responses be better integrated into sustainable development strategies?

A major challenge for the TAR is to find the appropriate balance between the larger tapestry and its constituent threads. Ideally, the TAR should provide an overall meta-framework which could coherently integrate the different elements relating to DES (i.e., key issues, disciplinary viewpoints, etc.)[19]. This would be more persuasive -- especially to decisionmakers and non-specialist readers. At the same time, each specific element or discipline needs to be represented as accurately as possible, within the broader framework – to satisfy scientific and professional readers. If different disciplinary approaches and methodologies predict different outcomes, this should be explained clearly in the TAR. Furthermore, there is likely to be some dilution of rigour as we start from concepts and theory, and move through practical models, to field level implementation of methodologies. Clearly, this paper is far too short to provide exhaustive coverage of all aspects of these wide-ranging isues. Instead, it focuses on providing some helpful insights, by setting out several underlying unifying concepts that will help to ensure consistency in the treatment of DES issues as they recur across different chapters. The intention is to provide individual lead authors greater flexibility in building on these ideas from their own disciplinary viewpoints, as appropriate for their chapters.

The paper is organised as follows. In Section 2, the close relationship between DES and the rather elusive concept of sustainable development is described. The focus here is on synthesizing a holistic and balanced approach that defines and integrates development, equity and sustainability in relation to the

[19] Three special reports prepared as a prelude to the TAR, have already explored links with DES issues -- see IPCC (2000a), IPCC (2000b), and IPCC (2000c).

three key elements of sustainable development -- economic, social and environmental. Two broad integrative approaches involving optimality and durability are outlined. Section 3 summarises the potentially severe impacts of climate change on long term sustainable development and human welfare. The TAR could help to better inform decisionmakers by analysing the extent to which climate change could threaten future prospects for achieving fundamental national goals involving DES. Section 4 explores the links between macroeconomic and sectoral development policies, and climate change mitigation and adaptation. It examines how climate change measures could be incorporated more smoothly into conventional economic policies without undermining human welfare and growth potential -- especially in the poorer countries. The TAR could help to clarify how more priority might be placed on restructuring development to reduce GHG emissions while maintaining growth (e.g., using win-win and no-regrets strategies). Finally, in Section 5 an attempt is made to provide guidance to authors by identifying the relevance of the foregoing for the different chapters of the TAR (see Table 1 and Annex 1). Several other annexes provide further details about selected topics.

2. Development, Equity and Sustainability as Integral Elements of Sustainable Development

2.1. Sustainable Development

The world is currently exploring the concept of sustainable development or "development which lasts" -- an approach that will (inter-alia) permit continuing improvements in the present quality of life at a lower intensity of resource use, while leaving behind for future generations enhanced stocks of assets (i.e., manufactured, natural and social capital) that will provide undiminished opportunities for improving their quality of life. While no universally acceptable practical definition of sustainable development exists as yet, current approaches to the concept of sustainable development draw on the experience of several decades of development efforts.

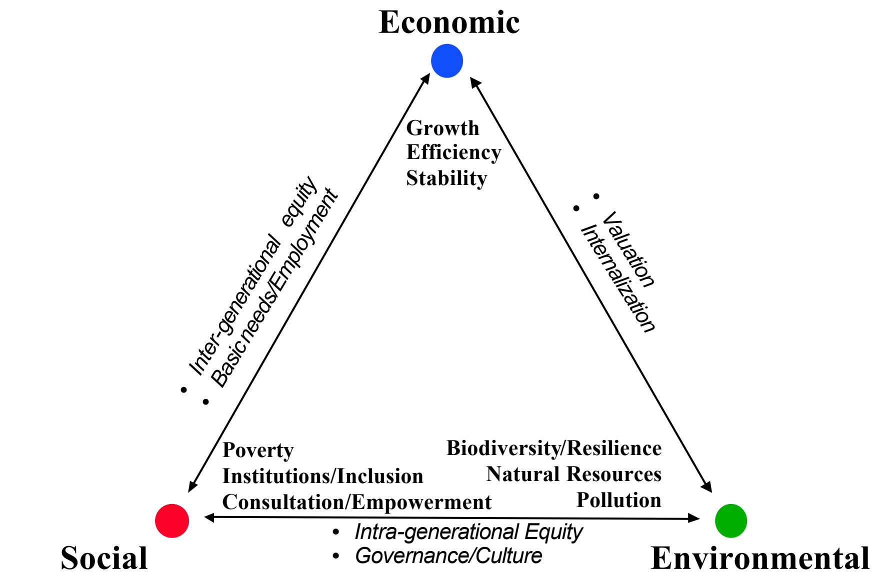
Historically, the development of the industrialised world focused on material production. Not surprisingly, most industrialised and developing nations have pursued the economic goal of increasing output and growth, during the twentieth century. By the 1960s the large and growing numbers of poor in the developing world, and the lack of "trickle-down" benefits to them, resulted in greater efforts to directly improve income distribution. The development paradigm shifted towards equitable growth, where social (distributional) objectives, especially poverty alleviation, were recognised as distinct from, and as important as economic efficiency. Protection of the environment has now become the third major objective of development. Through the 1970s, a large body of evidence accumulated that environmental degradation was a major barrier to development, and new proactive safeguards were gradually introduced (such as the environmental impact assessments).

Currently therefore, the concept of sustainable development has evolved to encompass three major points of view: economic, social and environmental, as shown in Figure 1 (see for example, Munasinghe 1993). Furthermore, there is increasing agreement that these three critical elements need to be treated in a balanced manner, and one may envision sustainable development in terms of an appropriate vector of economic, social and environmental attributes..

It is useful to review how the treatment of sustainable development (and DES issues) has evolved during the IPCC process, as depicted in Figure 2. The first assessment report (FAR) dealt almost exclusively with the science of climate change. The domain of climate change issues was perceived to be distinct from the domain of DES issues. In the second assessment report (SAR), the overlap between climate change and DES issues was recognised, but attempts to address DES problems were not very satisfactory. The intent of the TAR is to explore the intersection between climate change and DES issues more systematically. The effects of climate change response options on DES, and conversely, the impact of sustainable development strategies on climate change, need to be explicitly analysed. Ultimately, a feasible climate change response needs to be integrated seamlessly with an overall sustainable development strategy for humankind (rather than having separate and inconsistent climate change and sustainable development strategies).

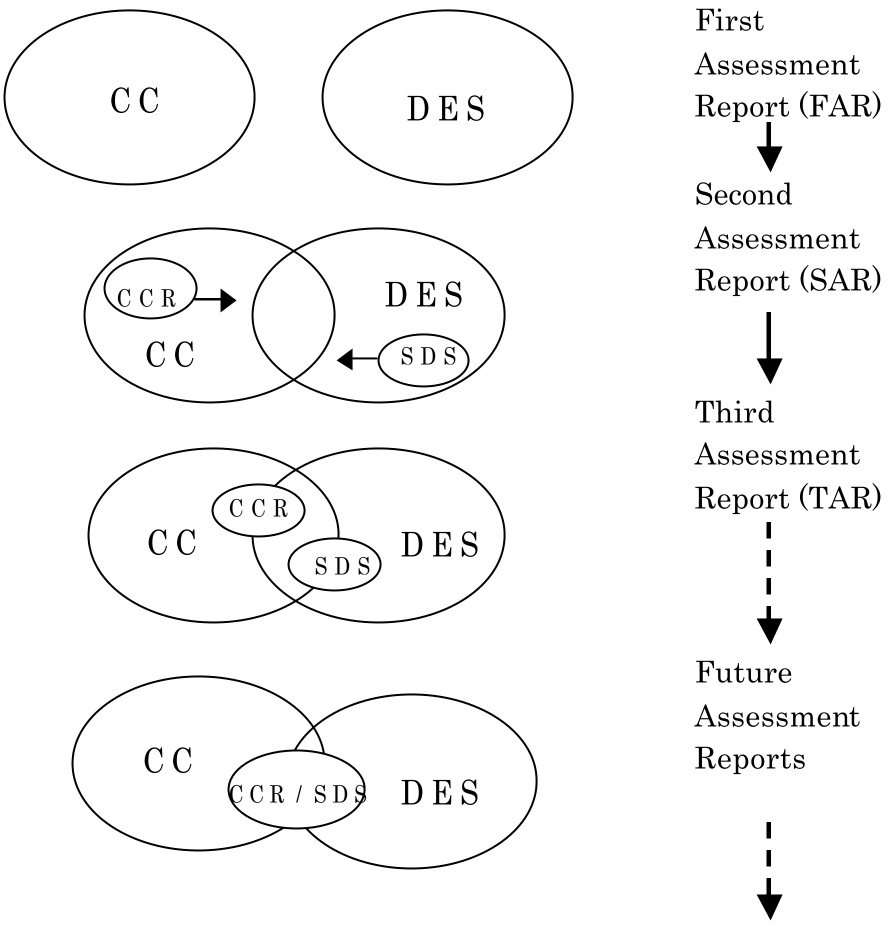
As summarised in Table 1, it is also helpful to define the three key cross-cutting issues in the TAR -- development, equity and sustainability -- in terms of the economic, social and environmental dimensions of sustainable development. The various writing teams need to determine the appropriate interpretation, depending on the specific context in which the ideas of development, equity and

Figure 1. Elements of Sustainable Development



Source: M. Munasinghe (1993)

Figure 2. Climate Change and Sustainable Development



CC = Climate Change Issues
CCR = Climate Change Response
DES = Development, Equity and Sustainability Issues
SDS = Sustainable Development Strategy

sustainability are used in the different chapters of the TAR. Although the exact definition of sustainable development paths is not within the scope of the TAR, it may be more feasible to assess whether climate change and potential response strategies might make future development prospects more or less sustainable.

2.2. Development

Development is strongly associated with economic growth, but has important social dimensions as well (see also, the section on equity below). Economic progress is often evaluated in terms of welfare (or utility) -- measured as willingness to pay for goods and services consumed.[20] Many economic policies typically seek to enhance income, and efficient production and consumption of (mainly marketed) goods and services. The stability of prices and employment are among other important objectives. The degree of economic efficiency is measured in relation to the ideal of Pareto optimality which encourages actions that will improve the welfare of at least one individual without worsening the situation of anyone else. The idealised, perfectly competitive economy is an important (Pareto optimal) benchmark, where efficient prices play a key role in both allocating productive resources to maximise output, and ensuring optimal consumption choices which maximise consumer utility. The well known cost-benefit criterion that accepts all projects whose net benefits are positive (i.e., aggregate benefits exceed costs), is based on the weaker "quasi" Pareto condition -- which assumes that such net benefits could be redistributed from the potential gainers to the losers, so that no one is worse off than before. More generally, interpersonal comparisons of (monetised) welfare are fraught with difficulty (both within and across nations, and over time) – e.g., the value of human life.

Social development usually refers to improvements in both individual well-being and the overall welfare of society (more broadly defined), that result from increases in social capital -- typically, the quantity and quality of social interactions that underlie human existence. Institutional capital refers mainly to the formal laws as well as traditional or informal understandings that govern behaviour. Organisational capital is embodied in the entities (both individuals and social groups) which operate within these institutional arrangements. The level of mutual trust and extent of shared social norms help to determine the stock of social capital. There is an important element of equity and poverty alleviation as well (see below). Thus, the social dimension of development includes protection strategies that reduce vulnerability, improve equity and ensure that basic needs are met. It implies that socio-political institutions will adapt to meet the challenges of modernisation, which often destroy traditional coping mechanisms that have evolved in the past (especially to protect disadvantaged groups).

Development in the environmental sense is a more recent concern relating to the need to manage scarce natural resources in a prudent manner – because human welfare ultimately depends on ecological services. Ignoring safe ecological limits will increase the risk of undermining long-run prospects for economic growth and consumption (see Section 4). Dasgupta and Maler (1997) point out that until the 1990s, the mainstream development literature hardly mentioned the topic of environment (see for example, Stern 1989; Chenery and Srinivasan 1988 & 1989; and Dreze and Sen 1990). An even more recent review paper on economic growth in the prestigious Journal of Economic Literature mentions the role of natural resources only in the passing (Temple 1999). One important implication of the foregoing is that TAR authors addressing DES issues need to systematically search well beyond the mainstream journals – in as many different countries and languages as possible.

2.3. Equity

Equity is an ethical and usually people-oriented concept with primarily social, and some economic and environmental dimensions (see Annex 3 for details). It focuses on the basic fairness of both the

[20] However, the equation of welfare with monetary income/consumption has been challenged. For example, Buddhist philosophy (over 2500 years old) still stresses that mental contentment is not necessarily synonymous with material consumption. More recently, Maslow (1970) and others have identified hierarchies of needs which provide psychic satisfaction, beyond mere goods and services.

processes and outcomes of decisionmaking – i.e., procedural and consequential equity, mentioned in the UNFCCC (1993). The equity of any action may be assessed in terms of a number of generic approaches, including parity, proportionality, priority, utilitarianism, and Rawlsian distributive justice (IPCC 1996c:chapter 3).[21] Societies normally seek to achieve equity by balancing and combining several of these criteria. Poverty alleviation, improved income distribution and intra-generational (or spatial) equity are key aspects of economic policies seeking to increase overall human welfare (Sen 1981, 1984). Brown (1998) points out shortcomings in utilitarianism, which underlies much of the economic approach to equity. Broadly speaking, economic efficiency provides guidance on producing and consuming goods and services more efficiently, but is unable to provide a means of choosing (from a social perspective) among alternative patterns of consumption which are efficient. Equity principles provide better tools for making judgements about such choices.

Social equity is also linked to sustainability, because highly skewed or unfair distributions of income and social benefits are less likely to be acceptable or lasting in the long run. Equity is likely to be strengthened by enhancing pluralism and grass-roots participation in decisionmaking, as well as by empowering disadvantaged groups (defined by income, gender, ethnicity, religion, caste, etc.) (Rayner and Malone 1998). In the long term, considerations involving inter-generational equity and safeguarding the rights of future generations, are key factors. In particular, the economic discount rate plays a key role with respect to both equity and efficiency aspects (Arrow et al. 1995; IPCC 1996c:chapter 4).

Equity in the environmental sense has received more attention recently, because of the disproportionately greater environmental damages suffered by disadvantaged groups. In the same vein, poverty alleviation efforts (which traditionally focused on raising monetary incomes), are being broadened to address the degraded environmental and social conditions facing the poor. In short, both equity and poverty have not only economic, but also social and environmental dimensions, and in turn, they will need to be assessed within the TAR using a more comprehensive set of indicators (rather than income distribution alone). An even broader approach to equity involves the concept of fairness in the treatment of non-human forms of life or even inanimate nature. One view asserts that humans have the responsibility of prudent "stewardship" (or "trusteeship") over nature, which goes beyond mere rights of usage (see for example, Brown 1998).

2.4. Sustainability

Sustainability has emerged most strongly in the environmental context, but may be defined also in economic and social terms (Munasinghe 1993). The environmental interpretation of sustainability focuses on the overall performance or health of ecological systems – defined in terms of a comprehensive, multiscale, dynamic, hierarchical measure of resilience, vigour and organization (Costanza 1999). The classic definition of system resilience was provided by Holling (1973), in terms of the ability of an ecosystem to persist despite external shocks -- where both the magnitude of the stress which the system can withstand, and the time to recovery, are key indicators.[22] Vigour is associated with the primary productivity of an ecosystem. Organization depends on complexity and structure. In this context, natural resource degradation, pollution and loss of biodiversity are detrimental because they increase vulnerability, undermine system health, and reduce resilience (Perrings and Opschoor 1994, Munasinghe and Shearer 1995). The notion of a safe threshold (and the related concept of carrying capacity) are important – often to avoid catastrophic ecosystem collapse (Holling 1992). It is useful also to think of sustainability in terms of the normal functioning and longevity of a nested hierarchy of ecological and socioeconomic systems (see Annex 2 for details).

Social sustainability is able to draw on the foregoing ideas, since habitats may be interpreted broadly to also include man-made environments like cities and villages (UNEP et al. 1991). Reducing vulnerability and maintaining the health (i.e., resilience, vigour and organization) of social and cultural systems, and their ability to withstand shocks, is also important (Chambers, 1989, Bohle et al, 1994, Ribot et al, 1996).

[21] For example Rawls (1971) stated that "Justice is the first virtue of social institutions, as truth is of systems of thought".

[22] Petersen et al (1998) argue that the resilience of a given ecosystem depends on the continuity of related ecological processes at both larger and smaller spatial scales (Annex 2). See also, Pimm (1991), and Ludwig et al. (1997).

Enhancing human capital (through education) and strengthening social values and institutions (like trust and behavioural norms) are important tools to increase the resilience of social systems and improve governance. Another key requirement is social inclusion -- which seeks to ensure equitable access to the full range of benefits of sustainable development, both within and across nations. Preserving cultural capital and diversity across the globe, strengthening social cohesion and networks of relationships, and reducing destructive conflicts, are integral elements of this approach. An important aspect of empowerment and broader participation is subsidiarity – i.e., decentralisation of decisonmaking to the lowest (or most local) level at which it is still effective. In summary, for both ecological and socioeconomic systems, the emphasis is on improving system health and their dynamic ability to adapt to change across a range of spatial and temporal scales, rather than the conservation of some "ideal" static state (see Annex 2).

The modern concept underlying economic sustainability seeks to maximize the flow of income that could be generated while at least maintaining the stock of assets (or capital) which yield these beneficial outputs (Solow 1986, Maler 1990).[23] Economic efficiency continues to play a key role – in ensuring both efficient allocation of resources in production, and efficient consumption choices that maximize utility. Problems of interpretation arise in identifying the kinds of capital to be maintained (for example, manufactured, natural, and human resource stocks, as well as social capital have been identified) and their substitutability (see next section). Often, it is difficult to value or compare these assets and the services they provide, particularly in the case of ecological and social resources (IPCC 1996c:chapter 5). Even key economic assets may be overlooked, for example, in informal or subsistence economies where non-market based transactions are important. The issues of uncertainty, irreversibility and catastrophic collapse pose additional difficulties, in determining dynamically efficient development paths (Pearce and Turner 1990). Many commonly used microeconomic approaches rely heavily on marginal analysis based on small perturbations (e.g., comparing incremental costs and benefits of economic activities). Such methods assume smoothly changing variables and are therefore rather inappropriate for analysing large changes and discontinuous phenomena. More recent work (especially at the cutting edge of the economics-ecology interface) has begun to explore the behaviour of large, non-linear, dynamic and chaotic systems, as well as newer concepts like system vulnerability and resilience.

2.5. Consistent Integration of Development, Equity and Sustainability Considerations

Many national policy decisions taken today could well affect future climate change prospects significantly (see Section 4 for details). In order to develop an effective and practical climate change strategy that is more convincing to decisionmakers, the various chapters of the TAR need to integrate and reconcile the development, equity and sustainability aspects within a holistic and balanced sustainable development framework. Economic analysis has a special role in contemporary national policymaking, since some of the most important decisions fall within the economic domain. While mainstream economics which is used for practical policymaking has often ignored many crucial aspects of the environmental and social dimensions of sustainable development, there is a small but growing body of economic analysis and applications which seeks to address such shortcomings.

To synthesise a more holistic framework for analysing DES issues, TAR lead authors need to make a special effort to identify the type of literature which attempts to bridge interdisciplinary gaps -- not only in the economic but also the ecology and sociology literature.[24] Environmental and resource economics attempts to incorporate environmental considerations into traditional neoclassical economic analysis. The growing field of ecological economics goes further in combining ecological and economic methods to address environmental problems, and emphasises the importance of key concepts like the scale of economic

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[23] This approach is based on the pioneering work of Lindahl and Hicks. For example, Hicks (1946) implies that peoples' maximum sustainable consumption is "the amount that they can consume without impoverishing themselves". Much earlier Fisher (1906) had defined *capital* as "a stock of instruments existing at an instant of time", and *income* as "a stream of services flowing from this stock of wealth".

[24] See for example, recent issues of journals like Ecological Economics, and Conservation Ecology (an internet publication).

activities (for a good introduction, see Costanza et al. 1997). Some areas of ecological science such as conservation ecology have proposed alternative approaches to the problems of sustainability (primarily of ecological systems) -- including the crucial concept of system resilience. Recent thinking in sociology has explored ideas about the integrative glue that binds societies together, while drawing attention to the concept of social capital and the importance of social inclusion. Munasinghe (1993, 2000) proposed the more neutral term "sustainomics", which focuses explicitly on sustainable development, and envisages "a comprehensive, integrative, balanced, transdisciplinary framework for making development more sustainable".[25]

Two broad approaches are relevant for integrating the economic, social and environmental dimensions of sustainable development. They are distinguished by the degree to which the concepts of optimality and durability are emphasised. While there are overlaps between the two approaches, the main thrust is somewhat different in each case. Uncertainty often plays a key role in determining which approach would be preferred. Thus, relatively steady and well-ordered conditions may encourage optimising behaviour that attempts to control and even fine-tune outcomes, whereas chaotic and unpredictable circumstances are likely to favour more durable responses that simply enhances survival prospects (e.g., a subsistence farmer facing uncertain conditions).

Optimality: The optimality-based approach has been widely used in economic analysis to broadly maximise utility (or welfare), subject to the requirement that the stock of productive assets (or welfare itself) is non-decreasing in the long term.[26] In practice, utility is often measured mainly in terms of the net benefits of economic activities, i.e., the benefits derived from development activities minus the costs incurred to carry out those actions (see Markandya and Halsnaes 1999; and IPCC 1996c:chapter 5; for more details about valuation and costing). More sophisticated economic optimisation approaches seek to include environmental and social variables (e.g., by attempting to value environmental externalities, system resilience, social capital, etc). However, given the difficulties of quantifying and valuing many such "non-economic" assets, the costs and benefits associated with market-based activities tend to dominate in most economic optimisation models.

Basically, any growth path characterised by non-decreasing stocks of assets (or capital) is sustainable -- the optimal one maximises economic growth as well. Some analysts support a "strong sustainability" constraint, which requires the separate preservation of each category of critical asset (for example, manufactured, natural, socio-cultural and human capital), assuming that they are complements rather than substitutes[27]. One version of this rule might correspond roughly to maximising economic output, subject to side constraints on environmental and social variables that are deemed critical for sustainability (e.g., biodiversity loss, or meeting the basic needs of the poor). Other researchers have argued in favour of "weak sustainability," which seeks to maintain the aggregate monetary value of the total stock of assets, assuming that the various asset types may be valued and that there is some degree of substitutability among them (see for example, Nordhaus and Tobin 1972).

Side constraints are often necessary, because the underlying basis of economic valuation, optimisation and efficient use of resources may not be easily applied to ecological objectives like protecting biodiversity and improving resilience, or to social goals such as promoting equity, public participation and empowerment. Thus, such environmental and social variables cannot be easily combined into a single valued objective function with other measures of economic costs and benefits. Moreover, the price system (which has time lags) often fails to reliably anticipate irreversible environmental and social harm, as well as non-linear system responses that could lead to catastrophic collapse. In such cases, non-economic indicators of environmental and social status would be helpful -- e.g., area under forest cover, and incidence of conflict (see for example, Munasinghe and Shearer 1995, Hanna and Munasinghe 1995, UNDP 1998, World Bank 1998a). The constraints on critical environmental and social indicators are proxies that

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[25] Sustainomics attempts to integrate key elements of the economic, social and ecological dimensions of sustainable development (including the optimality and durability approaches), and maintain stocks of these three types of capital, while balancing southern concerns about continuing development, growth and equity, with the northern emphasis on sustainability.

[26] Pezzey (1992) and Islam (1998) provide useful reviews of sustainable economic growth models. Some ecological models also optimize variables like energy use, nutrient flow, or biomass production – giving more weight to system vigour.

[27] Measuring some of these types of assets poses significant problems (e.g., see Atkinson et al. 1997).

represent safe thresholds which help to maintain the viability of those systems. In this context, techniques like multicriteria analysis may be required, to facilitate trade-offs among a variety of non-commensurable indicators. Risk and uncertainty will also necessitate the use of decision analysis tools (Moss and Schneider 1999; Toth 1999; IPCC 1996c:chapter 2).

Durability: The second broad integrative approach would focus primarily on sustaining the quality of life -- e.g., by satisfying environmental, social and economic sustainability requirements. Such a framework favours "durable" development paths which permit growth, but are not necessarily economically optimal. There is a greater willingness to trade off some economic optimality for the sake of greater safety, especially among more risk-averse and vulnerable societies or individuals who face chaotic and unpredictable conditions -- in order to stay within critical environmental and social limits (see later discussion on the precautionary principle). The economic constraint might be framed in terms of maintaining consumption levels (defined broadly to include environmental services, leisure and other "non-economic" benefits) – i.e., per capita consumption that never falls below some minimum level, or is non-declining. The environmental and social sustainability requirements may be expressed in terms of indicators of "state" that seek to measure the vulnerability or health (resilience, vigour and organization) of complex ecological and socio-economic systems. There is clear potential for interaction here due to linkages between the sustainability of social and ecological systems -- e.g., social disruption and conflict could exacerbate damage to ecosystems, and vice versa. In fact, long-standing social norms in many traditional societies have helped to protect the environment (Colding and Folke 1997).

Constraints based on sustainability could be represented also by the approach discussed earlier, that focuses on maintaining stocks of assets. This approach views the various forms of capital as a bulwark that decreases vulnerability to external shocks and reduces irreversible harm, rather than mere accumulations of assets that produce economic outputs. System resilience, vigour, organization and ability to adapt will depend dynamically on the capital endowment as well as the magnitude and rate of change of a shock.

Complementarity and Convergence of Approaches: The determination of an appropriate target trajectory for future global GHG emissions (and corresponding target GHG concentration) provides a useful illustration of these two approaches (for details, see IPCC 1996c or Munasinghe 1998a). Under an economic optimising framework, the ideal solution would be to first estimate the long-run marginal abatement costs (MAC) and the marginal avoided damages (MAD) associated with different GHG emission profiles -- see Figure 3(c), where the error bars on the curves indicate measurement uncertainties. The optimal emission levels would be determined at the point where future benefits (in terms of climate change damage avoided by reducing one unit of GHG emissions) equal or just exceed the corresponding costs (of mitigation measures required to reduce that unit of GHG emissions), i.e., MAC = MAD at point R_{OP}.

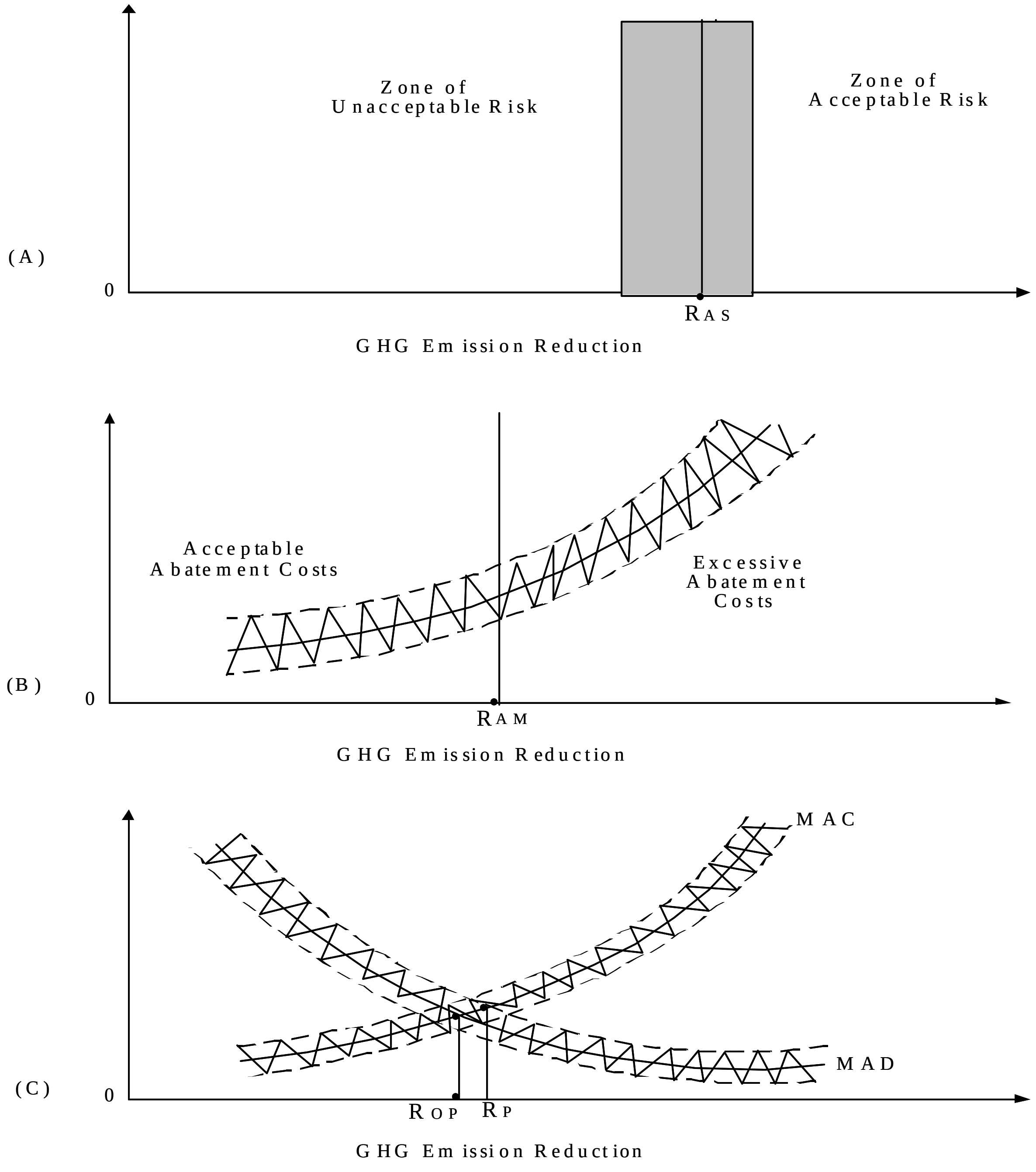
Durable strategies become more relevant when we recognise that MAC and/or MAD might be poorly quantified and uncertain. Figure 3(b) assumes that MAC is better defined than MAD. First, MAC is determined using techno-economic least cost analysis -- an optimising approach. Next, the target emissions are set on the basis of the affordable safe minimum standard (at R_{AM}), which is the upper limit on costs that will still avoid unacceptable socioeconomic disruption -- this is closer to the durability approach.

Finally, Figure 3(a) indicates an even more uncertain world, where neither MAC nor MAD is defined. Here, the emission target is established on the basis of an absolute standard (R_{AS}) or safe limit which would avoid an unacceptably high risk of damage to ecological (and/or social) systems. This last approach would be more in line with the durability concept.

Another example involves national level policymaking and macroeconomic management, which often involves a combination of optimal economic modelling and more fuzzy sociopolitical considerations, to arrive at a pragmatic decision.

It would be useful to explore the potential for convergence of the optimising and durability approaches, in practice. Such a process could be facilitated by the TAR. This implies that wastes ought to be generated at rates less than or equal to the assimilative capacity of the environment -- in particular, GHG emissions into the global atmosphere. Renewable resources, especially if they are scarce, should be utilised at rates less than or equal to the natural rate of regeneration. Non-renewable resource use should be managed in relation to the substitutability between these resources and technological progress. Both wastes and natural resource input use might be minimised by moving from linear throughput to closed loop mode. Thus, factory complexes are being designed in clusters -- based on the industrial ecology concept -- to maximize the circular flow of materials and recycling of wastes among plants. Finally, both inter- and intra-generational equity (especially poverty alleviation), pluralistic and consultative decisionmaking, and enhanced social values and institutions, are important additional aspects that should be considered (at least in the form of safe constraints). Such an integrative framework would help to incorporate climate change response measures within a national sustainable development strategy.

Figure 3. Determining abatement targets: (a) absolute standard; (b) affordable safe minimum standard; (c) cost-benefit optimum



Source: **Adapted from IPCC 1996c, Figure 5.10**

The rate of total GHG emissions (G) may be decomposed by means of the following identity:

$$G = [Q/P] \times [Y/Q] \times [G/Y] \times P ;$$

where [Q/P] is quality of life per capita; [Y/Q] is the material consumption required per unit of quality of life; [G/Y] is the GHG emission per unit of consumption; and P is the population. A high quality of life can be consistent with low total GHG emissions, provided that each of the other three terms on the right hand side of the identity could be minimised (see also Section 4.2 and Figure 4 on "tunneling" and "leapfrogging"). Reducing [Y/Q] implies "social decoupling" (or "dematerialisation") whereby satisfaction becomes less dependent on material consumption -- through changes in tastes, behaviour and social values. Similarly [G/Y] may be reduced by "technological decoupling" (or "decarbonisation") that reduces the intensity of GHG emissions in consumption and production. Finally, population growth needs to be reduced, especially where emissions per capita are already high. The linkages between social and technological decoupling need to be explored (see for example, IPCC 2000a). For example, changes in public perceptions and tastes could affect the directions of technological progress, and influence the effectiveness of mitigation and adaptation policies.

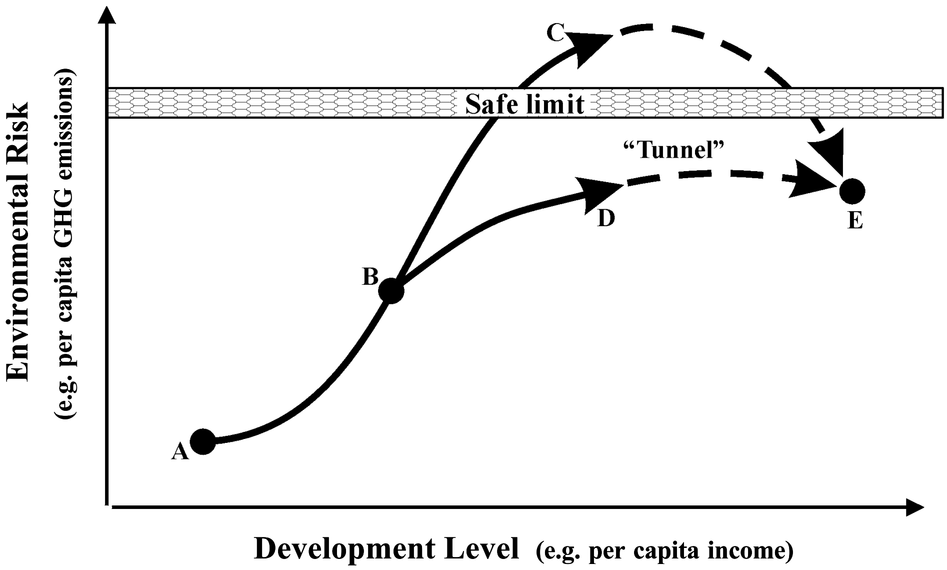


Figure 4. Environmental Risk versus Development Level

Source: M. Munasinghe (1995) "Making Growth More Sustainable," *Ecological Economics*, 15:121-4.

3. The Potential Impacts of Climate Change on Development, Equity and Sustainability, and Principles Underlying Response Strategies

The climate change problem fits in quite readily within the rather broad conceptual framework described above. Decisionmakers would be especially interested in the TAR's assessment of how serious a threat climate change poses to the future basis for improving human welfare -- in relation to DES. Some of the potential linkages, and the principles and concepts that apply in such cases are outlined below.

3.1. Development

First, global warming poses a significant potential threat to future development activities and the economic well being of large numbers of human beings. In its simplest from, the economic efficiency viewpoint will seek to maximize the net benefits (or outputs of goods and services) from the use of the global resource represented by the atmosphere. Broadly speaking, this implies that the stock of atmospheric assets which provide a sink function for GHGs needs to be maintained at an optimum level. As indicated earlier, this target level is defined at the point MAC = MAD. The underlying principles are based on optimality and the economically efficient use of a scarce resource, i.e., the global atmosphere.

When considering climate change response options, several ideas and principles which are widely used in environmental economics analysis would be useful -- these include the polluter pays principle, economic valuation, internalisation of externalities, and property rights. The polluter pays principle argues that those who are responsible for damaging emissions should pay the corresponding costs. The economic rationale is that this provides an incentive for polluters to reduce their emissions to optimal (i.e., economically efficient) levels. Here, the idea of economic valuation becomes crucial. Quantification and economic valuation of potential damage from polluting emissions is an important prerequisite. In the case of a common property resource like the atmosphere, GHG emitters can freely pollute without penalties. Such externalities need to be internalised by imposing costs on polluters that reflect the damage caused.[28] In this context, the notion of property rights is also relevant to establish that the atmosphere is a valuable and scarce resource which cannot be used freely and indiscriminately.

3.2. Equity

Second, climate change could also undermine social welfare and equity in an unprecedented manner. In particular, both intra- and inter-generational equity are likely to be worsened (IPCC 1996c). Existing evidence clearly demonstrates that poorer nations and disadvantaged groups within nations are especially vulnerable to disasters (Clarke and Munasinghe 1995, Banuri 1998). Climate change is likely to result in inequities due to the uneven distribution of the costs of damage, as well as of necessary adaptation and mitigation efforts. A more disaggregate analysis in the TAR would contribute significantly to our understanding of differential effects among and within countries.[29] Inequitable distributions may not only be ethically unappealing, but also unsustainable in the long run (Burton, 1997). For example, a future scenario that restricts per capita carbon emissions in the south to 0.5 tons per year while permitting a corresponding level in the north of over 3 tons per year, is unlikely to be durable -- because it will not facilitate the co-operation of developing countries (see also Annex 3). More generally, inequity could erode social capital, undermine cohesion and exacerbate conflicts over scarce resources.

One starting point is the principle that climate change should not be allowed to worsen existing inequities -- although climate change policy cannot be expected to address all prevailing equity issues. Some special aspects include: (a) the establishment of an equitable and participative global framework for making and implementing collective decisions about climate change; (b) reducing the potential for social disruption and conflicts arising from climate change impacts; and (c) protection of threatened cultures and preservation of cultural diversity. The polluter pays principle (mentioned earlier) is based not only on economic efficiency, but also on equity and fairness. An extension of this idea is the principle of recompensing victims -- ideally by using the revenues collected from polluters. There is also the moral/equity issue concerning the extent of the polluters obligation to compensate for past emissions (i.e., a form of environmental debt). Weighting the benefits and costs of climate change impacts according to the income levels of those who are affected, has also been suggested as one way of redressing inequitable outcomes (Squire and Van der Tak 1975). Kverndokk (1995) argued that conventional justice principles would favour the equitable allocation of future GHG emission rights on the basis of population. Equal per capita GHG emission rights (i.e., equal access to the global atmosphere) is consistent also with the UN human rights declaration underlining the equality of all human beings. Some equity related issues are

[28] An externality occurs when the welfare of one party is affected by the activity of another party who does not take these repercussions into account in his/her decisionmaking (e.g., no compensating payments are made). Externalities were defined and treated in rigorous fashion, originally by Pigou (1932).

[29] Some of the DES implications of recent large scale disasters like El Nino might provide useful case study material.

elaborated in Annex 3 -- including potential efficiency-equity and equity-equity tradeoffs.[30]

3.3. Sustainability

Third, the sustainability viewpoint draws attention to the fact that increasing anthropogenic emissions and accumulations of GHGs might significantly perturb a critical global subsystem -- the atmosphere (UNFCCC 1993). In fact, climate change policy is more likely to achieve its goals if it is an integral part of sustainable developement strategy and well integrated with sustainability objectives at appropriate decisionmaking levels. Sustainability will depend on several factors, including: (1) climate change intensity (e.g., magnitude and frequency of shocks); (2) system vulnerability (i.e., sensitivity to impact damage); and (3) system resilience (i.e., ability to recover from impacts). Changes in the global climate (e.g., mean temperature, precipitation, etc.) could well threaten the stability of a range of critical physical, ecological and social systems and subsystems (IPCC 1996b). More attention may need to be paid to the vulnerability of social values and institutions which are already stressed due to rapid technological changes (Adger 1999). Especially within developing countries, loss of social capital is undermining the basic glue that binds communities together -- e.g., the rules and arrangements which align individual behaviour with collective goals (Banuri et al. 1994). Existing international mechanisms and systems to deal with transnational and global problems are fragile, and unlikely to be able to cope with worsening climate change impacts.

Several concepts from contemporary environmental and social analysis are relevant for developing climate change response options, including the concepts of durability, optimality, safe limits, carrying capacity, irreversibility, non-linear responses, the precautionary principle, and adaptive and mitigative capacity. Durability and optimality could be developed as complementary and potentially convergent approaches (see earlier discussion). Under the durability criterion, an important goal would be to determine the safe limits for climate change within which the resilience of global ecological and social systems would not be seriously threatened. In turn, the accumulations of GHGs in the atmosphere would have to be constrained to a point which prevented climate change from exceeding these safe margins. It is considered important to avoid irreversible damage to bio-geophysical systems and prevent major disruption of socio-economic systems. Some systems will respond to climate change in a non-linear fashion, with the potential for catastrophic collapse. Thus, the precautionary principle argues that lack of scientific certainty about climate change effects should not become a basis for inaction, especially where relatively low cost steps to mitigate climate change could be undertaken as a form of insurance (UNFCCC 1993).

The notion of strengthening the ability of ecological, social and economic systems to adapt has been proposed as a means of decreasing their vulnerability to climate change. Such adaptive capacity would depend on underlying system characteristics such as technological options, resources and their distribution, institutions, human and social capital, risk spreading mechanisms, and information management ability. Similarly, mitigative capacity measures the ability of a system to reduce its contribution to climate change. Mitigative capacity might be influenced by the availability of technological and policy options, abundance and distribution of resources, and stocks of human and social capital.

4. Incorporating Climate Change Strategies into Conventional Decisionmaking

As seen in the previous section, climate change is likely to undermine the sustainability of future development. The procedures for conventional environmental and social impact assessment at the project/local level (which are now well-accepted world wide), may be readily adapted to assess the effects of micro-level activities on GHG gas emissions (World Bank 1998b). The OECD (1994) has pioneered the "Pressure-State-Response" framework to trace socioeconomic-environment linkages. This P-S-R approach begins with the pressure (e.g., population growth), then seeks to determine the state of the environment

[30] Traditionally, economic analysis has addressed efficiency and distributional issues separately – i.e., the maximisation of net benefits is distinct from who might receive such gains. Recent work has sought to interlink efficiency and equity more naturally. For example, environmental services could be considered public goods, and incorporated into appropriate markets as privately produced public goods (Chichilnisky and Heal, 1999).

(e.g., ambient pollutant concentration), and ends by identifying the policy response (e.g., pollution taxes).

At the same time, national policymakers routinely make many key macro-level decisions that could have (often inadvertent) impacts on both climate change mitigation and adaptation, which are far more significant than the effects of local economic activities. These pervasive and powerful measures are aimed at addressing economic development, environmental sustainability and social equity issues -- which invariably have much higher priority in national agendas, than climate change. For example, many macroeconomic policies seek to induce rapid growth, which in turn could potentially result in greater levels of GHG emissions, or increase vulnerability to the future impacts of climate change. The TAR could help to focus more attention on such economywide policies, whose environmental and social linkages have not been adequately explored in the past.

TAR authors should bear in mind that climate change strategies and policies that are consistent with other national development measures, are more likely to be effective, than isolated technological or policy options. In particular, the highest priority needs to be given to finding win-win policies which yield not only DES benefits, but also enhance climate change adaptation and mitigation efforts (see for example, Jochen and Hohmeyer 1992). Such policies could help to build support for climate change strategies among the traditional decisionmaking community, and conversely make climate change specialists more sensitive to sustainable development needs. They would reduce the potential for conflict between two powerful current trends -- the growth oriented, market based economic reform process, and protection of the global environment.

4.1. National Economywide Policies

The most powerful economic management tools currently in common use are economywide reforms (which include structural adjustment packages). Economywide (or countrywide) policies consist of both sectoral and macroeconomic policies which have widespread effects throughout the economy. Sectoral measures mainly involve a variety of economic instruments, including pricing in key sectors (for example, energy or agriculture) and broad sectorwide taxation or subsidy programs (for example, agricultural production subsidies, and industrial investment incentives). Macroeconomic measures are even more sweeping, ranging from exchange rate, interest rate, and wage policies, to trade liberalisation, privatisation, and similar programs. Since space limitations preclude a comprehensive review of interactions between economywide policies and climate change, we briefly examine several examples which provide a flavour of the possibilities involved (for details, see Munasinghe 1997; Jepma and Munasinghe 1998).

On the positive side, liberalising policies such as the removal of price distortions and promotion of market incentives have the potential to improve economic growth rates, while increasing the value of output per unit of GHG emitted (i.e., so called “win-win” outcomes). For example, reforms which improve the efficiency of energy use could reduce economic waste and lower the intensity of GHG emissions. Similarly, improving property rights and strengthening incentives for better land management not only yields economic gains but also reduces deforestation of open access lands (e.g., due to “slash and burn” agriculture).

At the same time, growth inducing economywide policies could lead to increased GHG emissions, unless the macro-reforms are complemented by additional environmental and social measures. Such negative impacts on climate change are invariably unintended and occur when some broad policy changes are undertaken while other hidden or neglected economic and institutional imperfections persist. In general, the remedy does not require reversal of the original reforms, but rather the implementation of additional complementary measures (both economic and non-economic) that mitigate climate change. For example, export promotion measures and currency devaluation might increase the profitability of timber exports. This in turn, could further accelerate deforestation that was already under way due to low stumpage fees and open access to forest lands. Establishing property rights and increasing timber charges would reduce deforestation, without interrupting the macroeconomic benefits of trade liberalization. Similarly, market-oriented liberalization could lead to economic expansion and the growth of wasteful energy-intensive activities in a country where subsidized energy prices persisted. Eliminating the energy price subsidies could help to reduce net GHG emissions while enhancing macroeconomic gains.

Countrywide policies could also influence adaptation, negatively or positively. For example, national policies that encouraged population movement into low-lying coastal areas might increase their vulnerability to future impacts of sea level rise. On the other hand, government actions to protect citizens from natural disasters – such as investing in safer physical infrastructure or strengthening the social resilience of poorer communities -- could help to reduce vulnerability to extreme weather events associated with future climate change (Clarke and Munasinghe 1995).

In this context, economic-environmental-social interactions need to be identified and analyzed, and effective sustainable development policies formulated, by linking and articulating these activities explicitly. Implementation of such an approach would be facilitated by constructing a simple Action Impact Matrix or AIM (Munasinghe 1997). As explained in Annex 4, such a matrix could help to promote an integrated view, by meshing development and climate related decisions with priority economic, environmental and social issues.

4.2. Restructuring Growth

Economic growth continues to be a widely pursued objective of most governments, and therefore, reducing the intensity of GHG emissions of human activities is an important step in mitigating climate change. Given that the majority of the world population lives under conditions of absolute poverty (e.g., over 3 billion persons subsist on less than USD1 per day), a climate change strategy that did not unduly constrain growth prospects in those areas would be far more attractive to decisionmakers. In this vein, the TAR might help to identify approaches that would modify the structure of growth (rather than restricting it), so that GHG emissions are mitigated and adaptation options enhanced.

The above approach is illustrated in Figure 4, which shows how a country's GHG emissions might vary with its level of development. One would expect carbon emissions to rise more rapidly during the early stages of development (along AB), and begin to level off only when per capita incomes are higher (along BC). Typically, a developing country would be at a point such as B on the curve, and an industrialised nation might be at C. The key point is that if the developing countries were to follow the growth path of the industrialised world, then atmospheric concentrations of GHGs would soon rise to dangerous levels. The risk of exceeding the global safe limit (shaded area) could be avoided by adopting sustainable development strategies that would permit developing countries to progress along a path such as BD (and eventually DE), while also reducing GHG emissions in industrialised countries along CE.

As outlined in Section 4.1 and elaborated in Annex 4, growth inducing economywide policies could combine with imperfections in the economy to cause environmental harm. Rather than halting economic growth, complementary policies may be used to remove such imperfections and thereby protect the environment. The TAR might be able to encourage a more proactive approach whereby the developing countries could learn from the past experiences of the industrialized world and leapfrog in terms of both technologies and policies. Thus, they may be able to adopt sustainable development strategies and climate change measures which would enable them to follow "tunnelling" development paths such as BDE, as shown in Figure 4 (Munasinghe 1997). Thus, the emphasis is on identifying measures that will help delink carbon emissions and growth, with the curve in the figure serving mainly as a useful metaphor or organizing framework for policy analysis.

This representation also illustrates the complementarity of the optimal and durable approaches discussed earlier. It has been shown that the higher path ABC in Figure 4 could be caused by economic imperfections which make private decisions deviate from socially optimal ones (Munasinghe 1998b). Thus the adoption of corrective policies that reduce such divergences and thereby reduce GHG emissions per unit of output, would facilitate movement along the lower path ABD. From the durability viewpoint, reducing the higher level of environmental damage at C would be especially desirable to avoid exceeding the safe limit or threshold representing dangerous accumulations of GHGs (shaded area in Figure 4).

Several authors have econometrically estimated the relationship between GHG emissions and per capita income using cross-country data and found curves with varying shapes and turning points (Holtz-Eakin and Selden 1995; Sengupta 1996, Unruh and Moomaw 1997; Cole et al. 1997). One reported outcome is an inverted U-shape (called the environmental Kuznet's curve or EKC) – like the curve ABCE in Figure 4. In this case, the more socially optimal path BDE could be viewed as a sustainable development "tunnel" through the EKC (Munasinghe 1995).

5. Scope for Application of DES Considerations in TAR Chapters

DES issues have been identified as central elements of the TAR, and it is expected that these considerations will be addressed in most of the chapters of WG2 and WG3. The TAR authors might consider the following broad and long term questions, in relation to DES issues:

1. How will expected development patterns and scenarios affect climate change?
2. How will climate change impacts, adaptation and mitigation affect sustainable development prospects?
3. How could climate change responses be better integrated into sustainable development strategies?

In this context, development, equity and sustainability are integral elements of sustainable development, which suggests that individual human beings, communities and economies need to be developed (e.g., through quantitative and/or qualitative improvements), while sustaining ecological, geophysical and social systems. The economic, social and environmental dimensions of sustainable development need to be given balanced treatment (although the emphasis will vary by chapter). To achieve this outcome, TAR authors should make a special effort to systematically search well beyond the mainstream journals, for the small but growing volume of literature in economics, sociology and ecology which seeks to bridge interdisciplinary gaps – in as many different countries and languages as possible.

Table 1 contains a preliminary evaluation of how the various issues relating to development, equity and sustainability discussed earlier, might be relevant for different chapters of the WG2 and WG3 reports, and Annex 1 sets our more specific questions for the chapter authors. The many impacts of climate change and alternative strategies to address the issue might be evaluated broadly in terms of their long term effects on: (a) human welfare and equity (b) the durability and resilience of ecological, geophysical and socioeconomic systems (even in the face of sudden, non-linear system shocks); and (c) the stocks of different kinds of capital (e.g., manufactured, natural, human and socio-cultural assets). The various chapters will need to identify specific economic, social and environmental indicators, at different levels of aggregation ranging from the global/macro to local/micro, that are relevant to such an assessment. It is important that the indicators be multi-dimensional in nature, practical, comprehensive in scope, and account for regional and scale differences. A wide variety are described already in the literature (Liverman et al. 1988, Kuik and Verbruggen 1991, Opschoor and Reijnders 1991, Holmberg and Karlsson 1992, Adriaanse 1993, Alfsen and Saeba 1993, Bergstrom 1993, Gilbert and Feenstra 1994, Moffat 1994, OECD 1994, Munasinghe and Shearer 1995, Azar et al. 1996,UN 1996, CSD 1998; UNDP 1998; World Bank 1997, 1998a).

Measuring economic, environmental (natural) and social capital raises various problems. Manufactured capital may be estimated using conventional neoclassical economic analysis. Market prices are useful when economic distortions are relatively low, and shadow prices could be applied in cases where market prices are unreliable (e.g., Squire and Van der Tak 1975). Natural capital needs to be quantified first in terms of key physical attributes. Typically, damage to natural capital may be assessed by the level of air pollution (e.g., concentrations of suspended particulate, sulphur dioxide or GHGs), water pollution (e.g., BOD or COD), and land degradation (e.g., soil erosion or deforestation). Then the physical damage could be valued using a variety of techniques based on environmental and resource economics (e.g., see Annex 5, Freeman 1993, Munasinghe 1993, Teitenberg 1992). Human resource stocks are often measured in terms of the value of educational levels and earning potential. Social capital is the one which is most difficult to assess (Grootaert 1998). Putnam (1993) described it as "horizontal associations" among people, or social networks and associated behavioral norms and values which affect the productivity of communities. A somewhat broader view was offered by Coleman (1990), who viewed social capital in terms of social structures which facilitate the activities of agents in society -- this encompassed both horizontal and vertical associations (like firms). The institutional approach espoused by North (1990) and Olson (1982) provides an even wider framework, which includes not only the mainly informal relationships implied by the earlier two viewpoints, but also the more formal frameworks provided by governments, political systems, legal and constitutional provisions, etc.

Equity issues (within and among nations, and across generations) deserve careful consideration -- in view of the wide differences in income and GHG emission levels, as well as potential climate change impacts across the globe. A useful starting point would be to assess whether climate change will worsen existing inequities, even though a climate strategy cannot be expected to address all equity-related problems. The TAR needs to assess the fairness of alternative outcomes with regard to climate change impacts, mitigation and adaptation, as well as the distribution of emissions rights across nations and over time. Also, there are fundamental differences in the roles of developing and industrialised countries -- e.g., eventually, the former may well have to reduce their emission levels below some "business-as-usual" baselines while the latter will need to make significant cuts in emissions with respect to current levels. This raises important opportunities for mutually beneficial (and also harmful) interactions among countries in a closely linked global economy, that deserve to be assessed in the TAR.

While much of the work on climate change issues has focused on the global or regional level, its eventual impact and ultimate responses will be relevant mainly at the national and subnational levels. Therefore, climate change strategy needs to be harmonised with national sustainable development policies. Correspondingly, the choice of development paths will have as great an (indirect) influence on climate change as mitigation and adaptation policies designed explicitly for climate change. The TAR could help to clarify how greater priority might be placed on adjusting the development path to reduce GHG emissions, without undermining prospects for improving human welfare.

The TAR will be more useful as a practical guide for decisionmakers if it is able to assess the viewpoints of not only governments but also civil society, business, NGOs and other stakeholders. In matters affecting the implementation of adaptation and mitigation measures, institutional and governance issues will be crucial. From the operational viewpoint, so-called "win-win" climate change strategies are the most desirable -- i.e., those that enhance all three elements of sustainable development (economic, social and environmental). Policies and measures which advance one element at the expense of another need to be analysed within a framework that permits variations in the time frame for implementation, and facilitates trade-offs (e.g., increase manufactured capital while depleting both social and natural capital; or improve the resilience of a social system while increasing the vulnerability of an ecosystem).

If material growth is the main issue, while uncertainty is not a serious problem, and relevant data is available, then the focus is more likely to be on optimising economic output, subject to (secondary) constraints based on social and environmental sustainability. Alternatively, if sustainability is the primary objective, while conditions are chaotic, and data is rather weak, then the emphasis would be on paths which are economically, socially and environmentally durable or lasting, but not necessarily growth optimising. The TAR analysis could help to clarify the different viewpoints and explore the potential for greater convergence and complementarity of these approaches. In the same vein, the TAR could also better reconcile the natural science view which relies more on flows of energy and matter, with the sociological approach that focuses on human activities and behaviour -- by examining the relative advantages of using such alternate viewpoints in addressing the various aspects of climate change (e.g., in the application of integrated assessment models or IAMs, which contain submodels that represent ecological, geophysical and socioeconomic systems; Newby 1993, IPCC 1997).

Atmospheric GHG accumulation is basically depleting one critical environmental asset. Adaptation strategies which are aimed at offsetting this disinvestment by increasing other kinds of assets (e.g., building higher sea walls or developing salt resistant crops to combat sea level rise), suggest that the weak sustainability rule might be relevant. Basically, if some degree of climate change is inevitable, then the enhancement of coping mechanisms will become especially critical, especially for the most vulnerable groups. Mitigation strategies which seek to slow down or eventually reverse GHG accumulations (at lowest cost) imply that the strong sustainability rule should apply to the atmospheric asset.

When all important impacts of a specific climate change option may be valued in economic terms, the usual approach of comparing the corresponding costs and benefits will provide useful insights.[31] Where

[31] Markandya and Halsnaes (1999) provide a good review of climate change costing methodologies. Annex 5 provides a brief summary of the crucial topic of valuing environmental externalities and assets. The economic valuation of environmental impacts is a key step in incorporating the results of project level environmental impact assessment into economic decisionmaking (e.g., cost-benefit analysis). At the macroeconomic level, recent work has focused on incorporating environmental considerations such as depletion of natural resources and pollution damage into the system of national accounts (*UNSO 1993,*

certain critical impacts cannot be valued (i.e., reduced to a single monetary "numeraire"), other techniques such as multicriteria analysis could be helpful. High levels of uncertainty and risk might be dealt with through the use of modern decision analysis frameworks (Moss and Schneider 1999; Toth 1999; IPCC 1996c:chapter 2).

Two IPCC expert meetings on development, equity and sustainability, were held respectively in Colombo, Sri Lanka in April 1999, and in Havana, Cuba in February 2000. The results of these meetings are summarised in appendices, and provide further useful guidance to TAR lead authors[32].

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[32] For detailed proceedings of the Colombo IPCC expert meeting, see Munasinghe and Swart (2000). The proceedings of the follow-up expert meeting, held in Havana, is in preparation.

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Table 1: Development, equity and sustainability – Links with Sustainable Development and Relevance for TAR Chapters

Issue	Sustainable Development Link	*UNFCCC principles*	Checklist of DES context issues for IPCC TAR chapters	WG2 Chapters	WG3 Chapters
Development	Economic: Trad. development economics; Neoclass. economics. Social: Social development; Social impact assessment. Environmental: Envir. Impact assessment; Environmental economics.	Article 5: sustainable economic growth	• Diverse views on management of economic development (markets, governments, communities) • Maximize net benefits of economic activities (optimality) • Costs and benefits of climate change response • Influence of different discount rates	• 1,2,3,10-17, 18, 19 • 2,18,19 • 2,18,19 • 2,10-17,18,19	• 1, 2, 10 • 7,8,9 • 5,6,7,8,9 • 7,8,9
Equity	Economic: Income distributional analysis; institutional economics. Social: Social justice; Juridical equity. Environmental: Natural resource trusteeship; Deep ecology; Animal rights.	Article 3: specific needs and special circumstances of developing countries Article 4: developed nations to take lead; socioeconomic development and poverty eradication are the first and overriding priorities of developing countries	• Diverse views on social goals of development and especially on ways to achieve these (markets, governments, communities) • Interregional, intraregional, intertemporal/intergenerational equity • Fair burden sharing in mitigation ("common but differentiated responsibilities") • Fair burden sharing in adaptation (reducing social disruption, protection of vulnerable/threatened cultures) • Procedural and consequential issues related to equity • Equitable and participatory decisionmaking	• 1,2,10-17 ,18,19 • 2,18,19 • NA • 1,2,18,19 • 18,19 • 2,18,19	• 1,2,3,4,5, 6,10 • 1,2,7,8,9, 10 • 1,2,6,10 • NA • 10 • 10
Sustainability	Economic: Hicks-Lindahl/weak sustainability rule, Natural resource management. Social: Social systems stability and resilience; Social capital. Environmental: Ecological systems resilience/vulnerability; Natural capital; Strong sustainability rule	Article 2: ultimate objective is to avoid dangerous interference with the climate system	• Diverse views on environmental sustainability: weak and strong sustainability frameworks • Local, sectoral, national and global environmental pressures • Ultimate objective of UNFCCC: stabilization of GHG concentrations • Uncertainty, irreversibility and non-linearity (catastrophe)	• 2,10-17,18,19 • 10-17 • 18,19 • all	• 1,2,10 • 1,2,5,6,7, 8,9 • 1,2,3,4,10
Synthesis	Integrate with sustainable development strategies	Article 3: policies to be integrated into national (sustainable) development programs	• Durable and optimal approaches • Synergies, conflicts, trade-offs • Regional differences • Appropriate sustainable development indicators	• all • 18,19 • 10-17, 18,19 • all	• all • 1,2,10 • all • all

Source: Rob Swart, Mohan Munasinghe, John Robinson, and Deborah Herbert.

DEVELOPMENT, EQUITY AND SUSTAINABILITY (DES)
IN THE CONTEXT OF CLIMATE CHANGE

ANNEX 1: SOME QUESTIONS ON DEVELOPMENT, SUSTAINABILITY AND EQUITY TO BE ADDRESSED IN WG2 and WG3 (prepared by Rob Swart)

1A. WG2 Chapters

PART I. SETTING THE STAGE FOR IMPACTS, ADAPTATION AND ULNERABILITY: CHAP. 1- 3

- What is the diversity of views on development, sustainability and equity that forms the backdrop for the assessment of impacts, adaptation and vulnerability?
- How do the WGII policy-relevant scientific questions relate to the context of development, sustainability and equity?
- How do various methods for assessing impacts, adaptation and vulnerability relate to the economic, social and environmental aspects of development, e.g. durable and optimal approaches, weak and strong sustainability methods?
- What do alternative methods of incorporating uncertainty in the assessment imply for decision making in the perspective of development, sustainability and equity?
- What are appropriate economic, social and environmental indicators for assessing impacts, adaptation and vulnerability?
- What are the development, sustainability and equity implications of the impact and adaptation aspects of the various scenarios that have been assessed
-

PART II. SECTORS AND SYSTEMS - IMPACTS, ADAPTATION AND VULNERABILITY: CHAP. 4-9

- General: what do potential impacts and adaptation options imply for human welfare, durability of biogeophysical and socio-economic systems, and stocks of capital?
- What do the potential impacts or vulnerabilities imply for development opportunities in the associated societal sectors?
- What do the potential impacts or vulnerabilities imply for environmental sustainability, e.g. local pollution, resilience of ecosystems in view of gradual and/or irreversible or non-linear environmental changes?
- What are the economic, social and environmental implications of adaptation options in the various sectors and systems?
- Which adaptation options are also useful for economic, social or environmental reasons other than climate change?
- What are key uncertainties and how sensitive are the findings for different key assumptions, such as discount rates?

PART III. REGIONAL ANALYSIS - IMPACTS, ADAPTATION AND VULNERABILITY: CHAP. 10-17

Taking into account the specific regional priorities, perspectives and circumstances:

- What do the potential impacts or vulnerabilities imply for economic and social development opportunities, e.g. size and distribution of income?
- What do the potential impacts or vulnerabilities imply for environmental sustainability, e.g. local

pollution, resilience of ecosystems in view of gradual and/or irreversible or non-linear environmental changes?

- What are the economic, social and environmental implications of adaptation options, for example in terms of equitable burden sharing amongst sub-regions and major sectors/actors?
- What are key uncertainties and how sensitive are the findings for key assumptions, such as discount rates?
-

PART IV. GLOBAL ISSUES AND SYNTHESIS: CHAP. 18-19

- What kind of generic conclusions can be drawn with respect to
  - ♦ The implications of adaptation options in the context of development, sustainability and equity
  - ♦ The vitality of vulnerable social, cultural and environmental systems?
  - ♦ The role of adaptation options in an overall development strategy that takes into account economic, social and environmental sustainability?
- What kind of generic conclusions can be drawn for decision making processes dealing with vulnerability, impacts and adaptation, including
  - ♦ Procedural and consequential issues related to equity, e.g. as referred to in UNFCCC Articles 3 and 10?
  - ♦ Equitable and participatory decision making processes?
  - ♦ Interregional, intraregional, and intergenerational equity?
  - ♦ The evaluation of "dangerous interference of the climate system" including the environmental, social and economic dimensions of UNFCCC Article 2?

1B. WG3 Chapters

SCOPING AND SCENARIOS: CHAPTERS 1-2

- What is the diversity of views on alternative development pathways, sustainability, equity and the role of different actors, that forms the backdrop for the assessment of climate change mitigation?
- How do the WGIII policy-relevant scientific questions relate to the context of development, sustainability and equity?
- How do various methods for assessing mitigation options relate to the economic, social and environmental aspects of development, e.g. durable and optimal approaches, weak and strong sustainability, inter- and intraregional and intergenerational equity?
- What are appropriate economic, social and environmental indicators for climate change mitigation?
- What are the development, sustainability and equity implications of the mitigation aspects of the various scenarios that have been assessed, including burden sharing in scenarios that lead to stabilisation of GHG concentrations?

OPTIONS, BARRIERS AND OPPORTUNITIES, POLICIES AND MEASURES: CHAP. 3-6

- What are economic, social and environmental implications of possible GHG mitigation options at different levels of scale (projects, systems)?
- What are key economic, social and environmental barriers and opportunities from the different perspectives on development, sustainability and equity mentioned in chapters 1-2?
- how can policies, instruments, and measures be evaluated from these different viewpoints on development, sustainability and equity?
- For different (combinations of) options, opportunities, policies and measures, what are ("win-win") synergies for more than one - or all - aspects of development, sustainability and equity?

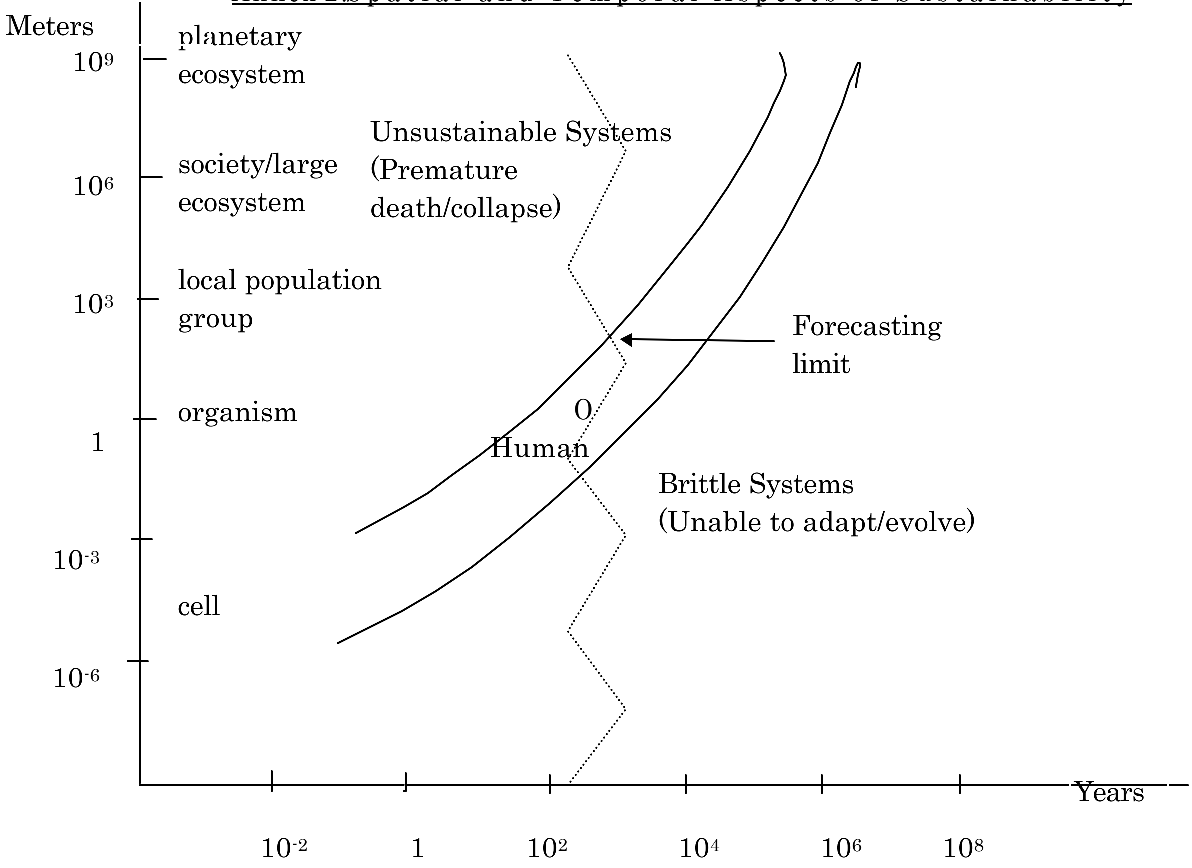
COSTS AND ANCILLARY BENEFITS OF MITIGATION: CHAP. 7-9

- How do different costing methodologies relate to different views on development, sustainability and equity (e.g. durability versus optimality)?
- What are the economic, social and environmental costs and ancillary benefits of the various options discussed in the chapters 3-7 at various geographic levels and for different sectors/actors?
- How may (combinations of) options affect the common but differentiated responsibilities of countries over time, including a fair sharing of the burden?
- How equitable do (combinations of) options affect different societal sectors?
- How do different perspectives on development, sustainability, and equity lead to different assessment of costs and ancillary benefits of climate change mitigation?
- What are the considerations to apply particular discount rates in assessing costs of mitigation options in view of development, sustainability and equity issues?
- How do measures in some countries affect the development, sustainability and equity perspectives in other countries?

DECISION MAKING FRAMEWORKS: CHAPTER 10

- How do different decision principles, decision making frameworks and decision analytical frameworks relate to the economic, social and environmental aspects of development, sustainability and equity, e.g. from a durability or optimality viewpoint?
- How can the mitigation-related policy-relevant scientific questions be addressed in this context?
- What kind of generic conclusions can be drawn for decision making processes dealing with climate change mitigation, including
  - ♦ Procedural and consequential issues related to equity, e.g. as referred to in UNFCCC Articles 3 and 10?
  - ♦ Equitable and participatory decision making processes?
  - ♦ Interregional, intraregional, and intergenerational equity?
  - ♦ The environmental, social and economic dimensions of UNFCCC Article 2?
- What do alternative methods of incorporating uncertainty in the mitigation assessment imply for decision making in the perspective of development, sustainability and equity?
- What are synergies and trade-offs in the assessment of climate change mitigation in the context of development, sustainability and equity?

Annex 2. Spatial and Temporal Aspects of Sustainability



An operationally useful concept of sustainability must refer to the persistence, viability and resilience of organic or biological systems, over their "normal" life span. In this ecological context, sustainability is linked with both spatial and temporal scales, as shown in the figure. The X axis indicates lifetime in years and the Y axis shows linear size (both in logarithmic scale). The central O represents an individual human being -- having a longevity and size of the order of 100 years and 1 meter, respectively. The diagonal band shows the expected or "normal" range of lifespans for a nested hierarchy of living systems starting with single cells and culminating in the planetary ecosystem. The bandwidth accommodates the variability in organisms as well as longevity.

Environmental changes that reduce lifespans below the normal range imply that external conditions have made the systems under consideration, unsustainable. In short, the regime above and to the left of the normal range denotes premature death or collapse. At the same time, it is unrealistic to expect any system to last forever. Indeed, each sub-system of a larger super-system (such as single cells within a multi-cellular organism) generally has a shorter life span than the super-system itself. If subsystem lifespans increase too much, the encompassing super-system is likely to lose its plasticity and become "brittle" -- as indicated by the region below and to the right of the normal range (Holling 1992). In other words, it is the timely death and replacement of subsystems that facilitates successful adaptation, resilience and evolution of larger systems. Holling (1973) defined resilience in terms of the ability of an ecosystem to persist despite external shocks, while Petersen et al. (1998) argued further that the resilience of a given ecosystem depends on the continuity of ecological processes at both larger and smaller scales.

We may summarize the foregoing by arguing that sustainability requires biological systems to be able to enjoy a normal life span and function normally, within the range indicated in the figure. Thus, leftward movements would be especially undesirable. For example, the horizontal arrow might represent a case of infant death -- indicating an unacceptable deterioration in human health and living conditions. In this context, extended longevity involving a greater than normal life-span would not be a matter for particular concern. On the practical side, forecasting up to a time scale of even several hundred years is rather imprecise. Thus, it is important to improve the accuracy of scientific models and data, in order to make very long-term predictions of sustainability (or its absence) more convincing -- especially in the context of persuading decisionmakers to spend large sums of money to reduce unsustainability. One way of dealing with uncertainty, especially if the potential risk is large, relies on a precautionary approach -- i.e., avoiding unsustainable behavior using low cost measures, while studying the issue more carefully.

ANNEX 3. Equity Issues

Equity in the context of a social decision requires a fair and just outcome. It is an important element of the collective decisionmaking framework needed to respond to global climate change (see Box 3.1 for details).

Box 3.1 Why Is Equity Important?

Equity considerations are important in addressing global climate change for a number of reasons, including: (a) moral and ethical concerns; (b) facilitating effectiveness; (c) sustainable development; and (d) the UNFCCC itself.

First, the principles of justice and fair play are important in themselves, in all types of human interactions. In particular, practically most modern international agreements, including the UN Charter, enshrine moral and ethical concerns relating to the basic equality of all human beings and the existence of inalienable and fundamental human rights. Equity is also embodied explicitly or implicitly, in many of the decisionmaking criteria used by policymakers.

Second, equitable decisions generally carry greater legitimacy and encourage parties with differing interests to cooperate better in carrying out mutually agreed actions. The successful implementation of a collective human response to the problem of global climate change will require the sustained collaboration of all sovereign nation states and many billions of human beings over long periods of time. While penalties and safeguards will play a role, decisions that are widely accepted as equitable are likely to be implemented with greater willingness and goodwill than those enforced under conditions of mistrust or coercion. In brief, co-operative and effective outcomes are more likely when all parties to the decision feel that it is fair.

Third, as explained earlier, equity and fairness are extremely important elements of the social dimension of sustainable development. Thus the impetus for sustainable development provides another crucial reason for finding equitable solutions to the problem of global warming.

Fourth, the UNFCCC has several specific references to equity in its substantive provisions. To begin with, Article 3.1 states that "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." Other equity-related principles emphasised in Article 3 include: (a) the right to promote sustainable development; (b) the need to take into account the specific needs and special circumstances of developing country and vulnerable parties; (c) the commitment to promote a supportive and open international economic system; and (d) the precautionary principle (to protect the rights of future generations).

According to Article 4.2(a), all developed country parties, including those with economies in transition, are required to take the lead in mitigating climate change. Furthermore they are required to transfer technology and financial resources to developing country parties that are particularly vulnerable to the adverse effects of climate change in meeting the costs of adaptation (Article 4.4). Another reference to equity in Article 4.2 (a) requires developed country parties to commit themselves to: "adopt national policies and take corresponding measures on the mitigation of climate change.... These policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention...taking into account the difference in the Parties" starting points and approaches, economic structures, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of the Parties to the global effort regarding that objective." Finally, Article 11.2 requires the Convention's financial mechanism to "have an equitable and balanced representation of all Parties within a transparent system of governance."

The foregoing provisions of the UNFCCC provide important guidance on how equity considerations should influence or modify the achievement of the Convention's objectives. While protecting the climate system is considered to be a "common concern of humankind", the developed countries (and transition economies) are expected to take a lead in initiating actions and assume a greater share of the burden. Furthermore, in burden sharing emphasis is placed on applying equity considerations among developed countries as well. The responsibilities of the present generation with respect to those of future generations are also referred to. Finally, equity is mentioned in the context of governance, to emphasise the importance of including procedural elements which guarantee distributive outcomes that are perceived to be equitable.

Procedural and Consequential Equity

The requirements of the UNFCCC indicate that equity principles must apply to: (a) procedural issues -- how decisions are made; and (b) consequential issues -- the outcomes of those decisions. Both aspects are important because equitable procedures need not guarantee equitable decisions, and conversely, equitable outcomes could well arise from quite inequitable decisionmaking processes. Support for the convention and acceptance of it's recommended course of action will depend largely on widespread participation by the global community and on how equitable it is perceived to be, by all participants.

Procedural equity itself has two components. First, pertaining to participation, equity implies that those who are affected by decisions should have some say in the making of these decisions either through direct participation or representation. Second, relating to the process, equity must ensure equal treatment before the law -- similar cases must be dealt with in a similar manner, and exceptions must be made on a principled basis.

Consequential equity also has two elements, relating to the distribution of the costs and benefits of: (a) impacts and adaptation to climate change; and (b) mitigating measures (including the allocation of future emissions rights). Both the elements (a) and (b) have implications for burden sharing among and within countries (intragenerational and spatial distribution); and between present and future generations (intergenerational and temporal distribution). The equity of any specific outcome may be assessed in terms of a number of generic approaches, including parity, proportionality, priority, classical utilitarianism, and Rawlsian distributive justice. Societies normally seek to achieve equity by balancing and combining several of these criteria. Self interest also influences the selection of criteria and the determination of equitable decisions. Consequential equity as applied in the international arena is derived largely from these principles which were developed originally in the context of human interactions within specific societies.

A human response to climate change requires the application of equity at an even more elevated (global) level, where there is far less practical experience. Cultural and societal norms and views about ethics, the environment, and development complicate efforts to achieve a worldwide consensus on matters of both procedural and consequential equity. Even the urgency of a response to climate change is subject to dispute. Given the different meanings, philosophical interpretations, and policy approaches associated with equity, judgement plays an important role in resolving potential conflicts. Ultimately, any global response strategy will be a compromise between different world views, each of which is also influenced by self interest and attempts to shift the compromise in ones own favour. As an example, the practical difficulties of allocating future emissions rights among nations are explored in Box 3.2 (Munasinghe 1998a)

Box 3.2 How Might GHG Emissions Rights be Allocated Fairly?

Suppose that the analysis of climate change yielded a target level of desirable world-wide GHG emissions in the future (e.g., see the section on the global optimisation process). To illustrate the issue more clearly, we will take a single constant level of emissions that will achieve some desired stabilization case (e.g., S550 or stabilisation of atmospheric GHG concentrations at 550 ppm of CO_2 equivalent before year 2150). The principles of allocation discussed below would apply in exactly the same way to any other case involving an alternative emissions profile such as IS92c (see IPCC 1996a). One method of allocating constant emissions might be based on ethics and basic human rights -- i.e., equal per capita (EPC) emission rights for all human beings. The total national "right to emit" would then be the product of the population and the basic per capita emissions quota.

Figure B.7 illustrates the dynamics of this allocation issue in simplified form. The line EPC indicates the constant level of per capita emissions, if the total global emissions target were allocated equally to all human beings during the decisionmaking time horizon. If we assume a total permissible accumulation of 800 GtC during the 100 year period 2000-2100 corresponding to the S550 case (see IPCC 1996a), shared equally among the global population of about 6 billion persons (in 2000), then the constant average per capita emission right would amount to 1.33 tonnes of carbon (TC) per year, up to 2100 -- as shown by the solid line EPC in the figure. A more precise calculation might seek to aggregate both past and future emissions (using discounting techniques), to yield the grand total over any given period of time.

The points IC and DC represent the average current per capita GHG emissions of the industrialised (i.e., OECD nations, Eastern Europe and former Soviet Union), and developing countries, respectively. Although the figure is not exactly to scale, IC (about 3.5 TC per capita per year) is both above EPC and considerably larger than DC (about 0.5 TC per capita). Thus, the industrialised countries would need to cut back GHG emissions significantly if they were to meet the EPC criterion -- which would entail economic costs (depending on the severity of the curtailment in each country). On the other hand, the developing countries have considerable room to increase their per capita emissions, as incomes and energy consumption grow.

An alternative allocation rule is based on equi-proportional reductions (EPR) of emissions. In this case, all countries would reduce emissions by the same percentage amount relative to some pre-agreed baseline year, to achieve the desired global emissions target. Assuming a global average emission rate of about 1.47 TC per capita per year in 2000 (indicated by the broken line E2000 in the figure), implies that all countries would need to curtail carbon emissions by about 10% to meet the EPR criterion (as shown by the broken lines ICEPR and DCEPT in the figure). Clearly, given the primary impetus provided by energy to economic development, such a solution would severely restrict growth prospects in the developing world -- where per capita energy consumption is low, initially.

Thus the EPC and EPR approaches would result in some hardship and inequity to the developed and developing countries, respectively. Another related equity issues is whether past emissions should be considered also or ignored in deciding the current and future quotas. Suppose we assume that the future global atmospheric concentration of CO_2 must be stabilised at 550 ppmv. Over 80% of carbon accumulated up to 1990 have resulted from fossil fuel use in the industrialized world. Clearly the industrialized countries have used up a significant share of the "global carbon space" available to humanity while driving up atmospheric CO_2 concentrations from the pre-industrial norm of 280 ppmv to the current level of about 360 ppmv. Therefore, the developing countries argue that responsibility for past emissions should be considered when future rights are allocated. Correspondingly, it would be in the industrialized countries interest to use a fixed base year population (e.g., in the year 2000) as the multiplier of the per capita emissions right (e.g., EPC) in determining total national emission quotas. This would penalise those countries which had high population growth rates, since their allowed national quota (determined by the base year population) would have to be divided up among more people in the future.

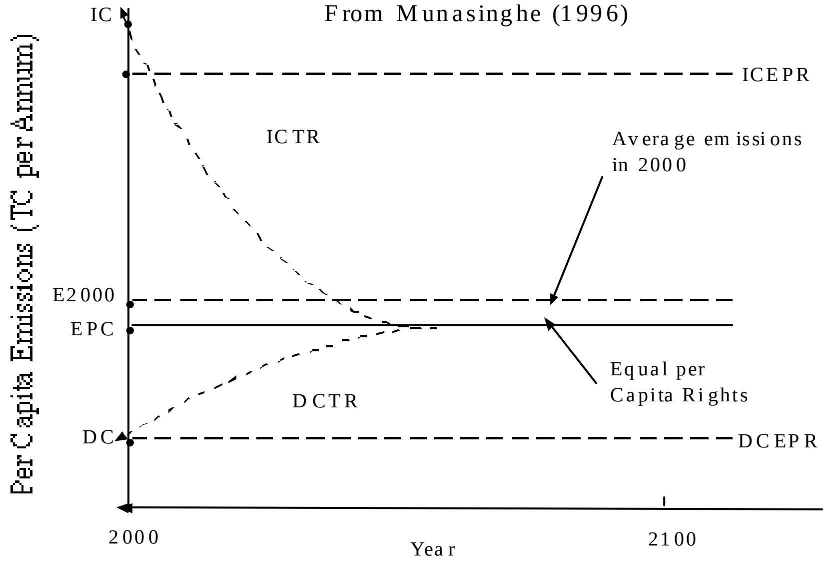
In practice, it is possible that some intermediate requirement which falls between EPC and EPR might emerge eventually from the collective decisionmaking process. For example, EPC may be set as a long term goal. In the shorter run, pragmatic considerations suggest that both the industrialised and transition countries be given a period of time to adjust to the lower GHG emissions level, in order to avoid undue economic disruptions and hardship -- especially to poorer groups within those countries (see transition emissions paths ICTR and DCTR in the figure). Even if some industrialised nations might argue that the goal of EPC emissions rights for all individuals is too idealistic or impractical, the directions of adjustment are clear. Net CO_2 emissions per capita in industrialised countries should trend downwards, while such emissions in developing countries will increase with time. This result emerges even if the objective is a more equitable distribution of per capita emissions, rather than absolute equality of per capita emissions.

Another adjustment option might be the facilitation of an emissions trading system. For example, once national emissions quotas have been assigned, a particular developing country may find that it is unable to fully utilize its allocation in a given year. At the same time, an industrialised country might find it cheaper to buy such 'excess' emissions rights from the developing nation, rather than undertake a much higher cost abatement program to cut back emissions and meet its own target. More generally, the emissions trading system would permit emissions quotas to be bought and sold freely on the international market, thereby establishing an efficient current price and even a futures market for GHG emissions (burden reallocation is also possible through activities implemented jointly).

Note: Numerical values in this box have been chosen for illustrative purposes only.

Source: Munasinghe (1998a).

Figure B7 Allocating emission rights. From Munasinghe (1996)



Nevertheless, from a pragmatic viewpoint significant progress towards a global consensus would be made if the decisionmaking framework could harness enlightened self-interest to support equitable or ethical goals. For example, developed countries are likely to have a self-interest in taking the lead and shouldering the major burdens of addressing climate change issues because their own citizens have shown greater willingness to pay to solve environmental problems, Similarly, developed nations would enjoy greater opportunities for trade and export if developing country markets grew without being disrupted by climate change, and the former could also avoid the significant negative spillover impacts of world-wide instability arising from disasters associated with climate change. At the same time, the higher risks and vulnerability faced by developing countries provides them an incentive to seek common solutions to the climate change problem.

Equity and Economic Efficiency

While the previous section reviewed some arguments for reconciling equity and economic self interest, among nations, conflicts between economic efficiency and equity may arise due to assumptions about the definition, comparison and aggregation of the welfare of different individuals or nations. For example, efficiency often implies maximisation of output subject to resource constraints. This approach can potentially result in an inequitable income distribution. Overall welfare could drop depending on how welfare is defined in relation to the distribution of income. Conversely, total welfare might increase if appropriate institutions can ensure appropriate resource transfers -- usually from the rich to the poor.

In the same context, aggregating and comparing welfare across different countries is a disputable issue. Gross National Product (GNP) is simply a measure of the total measurable economic output of a country, and does not represent welfare directly. Aggregating GNP across nations is not necessarily a valid measure of global welfare. However national economic policies frequently focus more on the growth of GNP rather than it's distribution, indirectly implying that additional wealth is equally valuable to rich and poor alike, or that there are mechanisms to redistribute wealth in a way that satisfies equity goals. Attempts have been made to incorporate equity considerations within a purely economic framework, by the weighting of costs and benefits so as to give preference to the poor. Although systematic procedures exist for determining such weights, often the element of arbitrariness in assigning weights has caused many practical problems. At the same time, it should be recognised that all decisionmaking procedures do assign weights (arbitrarily or otherwise). For example, approaches based on economic efficiency which seek to maximize net benefits assigns the same weight of unity to all monetary costs and benefits -- irrespective of income levels. More pragmatically, in most countries the tension between economic efficiency and equity is resolved by keeping the two approaches separate, e.g., by maintaining a balance between maximising GNP, and establishing institutions and processes charged with redistribution, social protection, and provision of various social goods to meet basic needs.

The lack of proper institutions to carry out such a redistributive role on an international scale, raises concerns over how -- if at all -- national welfare levels can be compared internationally. The extreme viewpoints are that: (a) welfare levels should be compared as though all countries value each others' welfare equally (i.e., equivalent welfare functions exist across countries, and equal weights might be assigned to each); and (b) that each country is concerned primarily with its own welfare and bears no responsibility for the welfare of any other (i.e., welfare cannot be aggregated and compared across countries). Since climate change constitutes situations where the activities of one country affect others. a convention on climate change must arrive at some compromise between these two extremes.

Intragenerational (Spatial) Equity

While equity is not synonymous with equality, differences between countries clearly affect issues of international equity. International response strategies will eventually translate into actions adopted at the national level, and therefore should reflect equity concerns within countries as well. Several categories of differences between countries that are relevant to the question of equity, are discussed next.

<u>Wealth and Consumption:</u> Wealth is perhaps the most obvious and prevalent difference between (and within) countries. Measured in terms of GNP, the World Bank's 1994 World Development Report (World Bank 1994) states that more than half the world's population (58.7 percent) live in countries classified as "low income". These countries have an average per capita GNP of $390. In contrast, 15.2 percent of the world's population live in 'high income economies' which have an average per capita GNP of $22,160. The remaining 26.1 percent of the population live in the "middle income economies" which have an average per capita GNP of $2,490. Such wide variations in per capita income between countries imply that simply comparing this measure of welfare may be inappropriate (as explained in the previous section).[33]

These differences have direct implications for the way climate change is addressed. For instance, activities in developing countries that produce greenhouse gases are generally related to fulfilling "basic needs". They may result from generating energy for cooking or keeping tolerably warm, engaging in agricultural practices, consuming energy to provide barely adequate lighting, and occasionally for travel by public transport. In contrast emission of greenhouse gases in developed countries is likely to result from activities such as operating personal vehicles and central heating or cooling, and energy embodied in a wide variety of manufactured goods and the use of such goods. Therefore, the level of personal wealth is directly related to the welfare impacts of reducing greenhouse gas emissions (WCED, 1987). Furthermore, wealth has a direct bearing on the vulnerability to the

[33] One method of comparing incomes across countries is to use purchasing power parities (PPPs) instead of market exchange rates. PPPs are used to adjust exchange rates, such that the monetary value of a standard basket of commodities (typically including food, clothing and shelter) is equalized across all countries. Such a correction tends to provide a better assessment of the ultimate welfare provided by income levels in different nations. However even when incomes are adjusted based on purchasing power parities, wide differences in real per capita income are still evident among countries.

impacts of climate change. By virtue of being richer, some countries will be able to adapt more effectively to climate change. A similar relationship between the poor and the rich also prevails within countries.

Poorer countries may be less prepared, to adopt mitigation and adaptation strategies due to several reasons. First, poverty has implications for urgency of other national priorities and of time scales used in policy planning. Wealth has a direct correlation to personal discount rates (i.e., discount rates decline with rising wealth). The more affluent have a greater share of disposable wealth to invest in the future, and therefore are able to conceptualize longer planning time horizons. The poor are forced to focus on shorter term objectives such as basic survival necessities.

A similar phenomenon applies to national level economic and political systems as well. Consequently, interest rates are higher in poorer countries, capital is more scarce, and the emphasis of policy planning is on the short term needs, such as poverty alleviation, and employment generation. The focus of government may be to keep up with infrastructure needs due to rapidly rising demands. They may not have the luxury to consider optimal development strategies as some richer countries may be able to. Thus national wealth affects both actual investment decisions as well as broader public policy planning capability.

The IPCC Special Report on Developing Countries addresses this concern by stating that, "the priority for the alleviation of poverty continues to be an overriding concern of the developing countries; they would rather conserve their financial and technical resources for tackling their immediate economic problems than make investments to avert a global problem which may manifest itself after two generations." Similarly, Article 4.7 of the FCCC states that, "economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties" and thus their commitments to implementing climate change responses will be influenced by these. considerations. Even though concerns about climate change are likely to grow in the developing countries (especially those who consider themselves the most vulnerable), they are likely to lack the resources to address the issue.

<u>Contributions to Climate Change:</u> Countries vary in the nature and degree of contribution to climate change. Many different gases and sources contribute towards climate change. The capacity of sinks to absorb carbon emissions also differs widely between countries. The range of sources and sinks may not be an issue of equity, but different ways of aggregating and presenting the data can have implications for equity considerations. In particular, developing countries emit much less per capita and have contributed less to past emissions. In this context, some authors have argued that the industrialized countries owe the developing world a “carbon debt”, due to disproportionately high GHG emissions in the past (see for example, Munasinghe 1993; and Jenkins 1996). The developing countries also need considerable "headroom" to allow for the growth of future economic output and energy consumption, since they are starting from a much lower base (see also Box 3.1). At the same time, there are many variations within developed and developing countries which must be acknowledged as well. Simply differentiating along the lines of developed and developing countries will exclude many important issues from the analysis. The incorporation into the decisionmaking process, of equity issues associated with variations in the contributions to climate change, would be critical both in facilitating the reaching of a world-wide consensus on burden sharing, and in subsequently implementing difficult mitigation and adaptation measures.

<u>Incidence of and Vulnerability to Impacts:</u> The incidence of impacts may bear no relationship to the pattern of GHG emissions, which violates equity principles and is inconsistent with the "polluter pays" and "victim is recompensed" approach that has been applied already to more local environmental pollution problems. In particular, the negative effects of climate change are likely to be most pronounced in tropical regions typically occupied by developing countries. In addition to asymmetries in the incidence of impacts, many developing countries are more vulnerable to the effects of global warming,

because of fewer resources, weaker institutional capacity, and smaller pool of skilled human resources, to draw on in times of crisis. The plight of poor and subsistence level communities, or low lying small island nations subject to sea level rise, will be quite bleak. Therefore, both humanitarian and equity principles need to be invoked to provide them some relief, along the lines of the principles and procedures established during the United Nations international decade for natural disaster relief (IDNDR).

Equity Within Countries: Almost all the arguments mentioned above in the context of equity across countries, also apply to equity within individual nations. Fortunately, there are many existing mechanisms within countries (such as subsidised food, healthcare and schooling, social security, or progressive taxation) to ensure action consistent with what is considered acceptable and proper, and achieve proper redistribution of resources. Equity issues, especially in the form of views about what constitutes justice, will influence the formation, decisions and credibility of these institutions. Although the capacity and legitimacy of these institutions may vary, they provide a useful framework within which climate change issues can begin to be addressed at the national and sub-national levels.

Intergenerational (Temporal) Equity and Discounting

Most of the points enumerated earlier with respect to spatial equity also affect equity across time, and in very similar ways. First, future generations may be richer or poorer than the present generation. Second, those living in the past and the present would undoubtedly be the contributors to future climate change impacts. Third, while future generations will have to bear the consequences of GHG emissions made in the past, they will also benefit from sacrifices and investments made by their forbears. At the same time, it is unclear whether our descendants will be more or less vulnerable to the effects of climate change.

At the same time, there are two fundamental issues that require us to pay special attention to intergenerational equity. First, all decisions relating to climate change are made by the generation living at that time. To the extent that future generations are not represented in the ongoing decision making process, particular care needs to be exercised to ensure that their rights are protected. Second, once a chain of events unfolds, it will be difficult to compensate future generations for past mistakes or miscalculations. Once again, extra prudence is required to avoid imposing future burdens that are both irreversible and impossible to compensate. Nevertheless, generations do overlap in practice (e.g., parents and children), and this is likely to result in the automatic incorporation of some intergenerational concerns into the discount rate and decision making in general.

Social Rate of Discount: There are various equity-related mentioned earlier that may be used to ensure a desirable measure of temporal equity. From an economic viewpoint, one of the principle instruments available to influence the allocation of resources across time is the social rate of discount (see Box 3.3). Indeed, the conclusions derived from any long term analysis of climate change policy will depend crucially on the numerical value of discount rate that is selected. It is important to bear in mind that we are discussing the real discount rate where the effects of inflation are netted out. Furthermore, conceptually the interest rate (at which present day capital will grow into the future) is the exact mirror image of the discount rate (at which future expenditures should be discounted to the present date).

Since discounting is a method for comparing economic costs and benefits that occur at different times, it will have a direct bearing on intergenerational equity. In the case of climate change analysis, the effects of discounting will be especially pronounced for two reasons: (a) the relevant time horizons are extremely long; and (b) many of the costs of mitigation occur relatively early, while potential benefits lie in the distant future. In brief, as far as present-day decisions are concerned, a higher discount rate will reduce the importance of future benefits (of avoided climate change damages) relative to the near term costs (of mitigation measures).

There are two main approaches to practically determining a value for the social rate of discount in climate change analysis – one based on the social rate of time preference (SRTP) and the other on the (risk-free) market returns to investment (MRI). While the concepts underlying these two approaches may appear to diverge, when practical adjustments are made both the SRTP and MRI tend to produce estimates for the social rate of discount that are comparable. Thus estimates for SRTP vary from 1 to 4% and MRI from 3 to 6% per annum (for details, see Arrow et al. 1995).

Box 3.3 Discount Rate

Basic Concepts

The social rate of discount (SRD) is defined as the one used by decisionmakers in determining public policy. The main text indicates that some fundamental issues of value and equity are involved in the choice of such a social discount rate. In addition to the technical aspect of comparing economic costs and benefits over time, the sustainable development dimension described earlier provides a more overarching guideline -- that each generation has the right to inherit a set of economic, social and environmental assets that are at least as good as the one enjoyed by the preceding generation. In subsequent discussions, mention of the discount rate refer to the social rate of discount, unless otherwise specified.

Even in traditional cost benefit analysis used in project evaluation which is far less complicated than climate change decisionmaking, the choice of a discount rate is not clear cut (see for example, Munasinghe 1993). Discount rates vary across countries, depending on behavioural preferences and economic conditions. Furthermore, it is considered prudent to test the sensitivity of the results by using a range of discount rates (usually about 4 to 12 percent per annum), even for a project within a given country.

Starting from the theoretically ideal (or first best) situation of perfectly functioning, competitive markets and an optimal distribution of income, it is possible to show that the discount rate should be equal to the marginal returns to investment (or marginal yield on capital) which will also equal the interest rate on borrowing by both consumers and producers (Lind 1982). More specifically, there are three conditions to ensure an efficient (or optimal) growth path. First, the marginal returns to investment between one period and the next should equal the rate of interest (i) charged from borrowing producers. Second, the rate of change of the marginal utility of consumption (or satisfaction derived from one extra unit consumed) from one period to the next should be equal to the interest rate (r) paid out to lending consumers. Third and finally, the producer and consumer rates of interest are equal (i.e., $i = r$), throughout the economy and over all time periods.

As we deviate from the ideal market conditions and optimal income distribution, the determination of the discount (or interest) rate becomes less clear. For example, taxes (subsidies) may increase (decrease) the borrowing rate to producers above (below) the interest rate paid to consumers on their savings (i.e., i unequal to r). More generally, if the three conditions do not hold because of economic distortions, then efficiency may require project or sector specific discount rates that would include so-called second-best corrections to compensate for the various economic imperfections. In extreme cases, there is no theoretical basis for linking observed market interest rates to the social rate of discount. Nevertheless, market behaviour would still provide useful information to estimate the social rate of discount.

ANNEX 4. Linkages Between Countrywide Policies and the Environment

Countrywide policies consist of both sectoral and macroeconomic policies which have widespread effects throughout the economy, and therefore, it is not surprising that their environmental and social consequences could be both positive and negative (see for example, Munasinghe 1997). Sectoral measures mainly involve a variety of economic instruments, including pricing in key sectors (for example, energy or agriculture) and broad sectorwide taxation or subsidy programs (for example, agricultural production subsidies, and industrial investment incentives). Macroeconomic policies and strategies are even more sweeping, ranging from exchange rate, interest rate, and wage policies, to trade liberalization, privatization, and similar programs. Such economywide policies are often packaged within programs of structural adjustment and sectoral reform, aimed at promoting economic stability, efficiency and growth, and ultimately improving human welfare. Although the emphasis is on economic policies, other noneconomic measures (such as social, institutional and legal actions), are also relevant.

Some Stylized Results and Analysis

It is difficult to generalize about the environmental and social impacts of economywide policies, because the linkages tend to be extremely complex and country specific. For example, a recent study indicated that even the purely economic impacts of structural adjustment programs are difficult to trace comprehensively (Tarp 1993). Nevertheless, we attempt to summarize below some stylized results concerning the impacts of countrywide policies on various indicators of sustainability, in three broad categories -- beneficial, harmful and unknown effects. In the first group are the so-called "win-win" policies, where it is possible to achieve simultaneous gains in all three areas of sustainable development (i.e., economic, social and environmental) when economywide reforms are implemented. The second category recognizes important exceptions where such potential gains cannot be realized unless the macro-reforms are complemented by additional environmental and social measures which protect both the environment and the poor. The third and final category consists of impacts that are less predictable, mainly because of the complexity of the linkages involved, and the long-run time perspective. This section ends with a theoretical analysis of the various linkages between economywide policies and the environment.

Impacts of Economywide Policies on Sustainability

Beneficial Impacts

Several studies indicate that liberalizing reforms which seek to make desirable alterations in the structure of the economy, often contribute to both economic and sustainability gains. Such changes include the removal of price distortions, promotion of market incentives, and relaxation of trade and other constraints (which are among the main features of adjustment-related reforms). For example, reforms which improve the efficiency of industrial or energy related activities could reduce economic waste, increase the efficiency of natural resource use and limit environmental pollution. Similarly, improving land tenure rights and access to financial and social services not only yields economic gains but also promotes better environmental stewardship and helps the poor.

In the same vein, there is evidence to show that shorter-run policy measures aimed at restoring macroeconomic stability will generally yield economic, social and environmental benefits, since instability undermines sustainable resource use and especially penalizes the poor. For example, price, wage and employment stability encourage a longer term view on the part of firms and households alike. Lower inflation (and discount) rates not only lead to clearer pricing signals and better investment decisions by economic agents, but also protect fixed income earners.

Avoiding Harm

A number of researchers have pointed out how economywide structural reforms have had adverse environmental and social side effects. Such negative impacts are invariably unintended and occur when some broad policy changes are undertaken while other hidden or neglected policy, market or institutional imperfections persist. The remedy does not generally require reversal of the original reforms, but rather the implementation of additional complementary measures (both economic and non-economic) that remove such policy, market and institutional difficulties. These complementary measures are not only socially and environmentally beneficial in their own right, but also help to broaden the effectiveness of economywide reforms. Typical examples of potential environmental damage caused by remaining imperfections include:

Policy distortions: Export promotion measures that increase the profitability of natural resource exports, might encourage excessive extraction or harvesting of this resource if it were underpriced or subsidized (for example, low stumpage fees for timber). Similarly, trade liberalization could lead to the expansion of wasteful energy-intensive activities in a country where subsidized energy prices persisted.

Market failures: Economic expansion induced by successful adjustment may be associated with excessive environmental damage -- for example, if external environmental effects of economic activities (such as air or water pollution), are not adequately reflected in market prices that influence such activities.

Institutional constraints: The benefits of countrywide reforms could be negated by unaddressed institutional problems, such as the poor accountability of state-owned enterprises (which would allow them to ignore efficient price signals), weak financial intermediation, or inadequately defined property rights. Such issues tend to undermine incentives for sustainable resource management and worsen equity.

Stabilization: The shorter term stabilization process also may have unforeseen adverse environmental and social impacts. For example, general reductions in government spending are often required to limit budgetary deficits and bring inflation under control. However, unless such cutbacks are carefully targeted, they may disproportionately penalize expenditures on environmental protection or poverty safety nets. Another important linkage is the possible short-term adverse impact of adjustment induced recession on poverty and unemployment, whereby the poor are forced to increase their pressures on fragile lands and "open access" natural resources -- due to the lack of economic opportunities elsewhere. As before, complementary measures to limit the adverse consequences of adjustment would be justified -- on both social and environmental grounds.

Less Predictable and Longer Term Effects

Economywide policies will have additional longer term effects on sustainability, whose net impacts are often unpredictable. Some of these effects need to be traced through a general equilibrium framework that captures both direct and indirect links. For example, several studies confirm that adjustment-induced changes often succeed in generating new economic opportunities and sources of livelihood, thereby raising incomes and helping to break the vicious cycle of environmental degradation and poverty. However, while such growth is an essential element of sustainable development, it will necessarily increase the overall pressures on environmental resources. At the same time, properly valuing resources, increasing efficiency and reducing waste, will help to reshape the structure of economic growth and limit undesirable environmental impacts. Finally, environmental policies themselves could have impacts on income distribution and employment.

Up to now, we have focused on the use of complementary policies to limit environmental and social harm, without interfering with the economywide reforms themselves. However, it is prudent to recognize that if the threat to long term sustainability is great enough, the countrywide policy reform process itself may need to be modified directly.

Action Impact Matrix (AIM): A Tool for Policy Analysis, Formulation and Coordination

Economic-environmental-social interactions may be identified and analyzed, and effective sustainable development policies formulated, by linking and articulating these activities explicitly. Implementation of such an approach would be facilitated by constructing an Action Impact Matrix (AIM) -- a simple example is shown in Table A4.1, although an actual AIM would be very much larger and more detailed (Munasinghe 1997). Such a matrix helps to promote an integrated view, meshing development decisions with priority economic, environmental and social impacts. The far left column of the table lists examples of the main development interventions (both policies and projects), while the top row indicates some of the main sustainable development issues (including GHG emissions). Thus the elements or cells in the matrix help to: (a) identify explicitly the key linkages; (b) focus attention on valuation and other methods of analyzing the most important impacts; and (c) suggest action priorities. At the same time, the organization of the overall matrix facilitates the tracing of impacts, as well as the coherent articulation of the links between a range of development actions - that is, policies and projects.

A stepwise procedure, starting with readily available data, has been used effectively to develop the AIM in several country studies that have been initiated recently (for instance, Brazil, Chile, Nepal, Philippines, and Sri Lanka). This process has helped to harmonize views among those involved (economists, environmental specialists and others), thereby improving the prospects for successful implementation.

Screening and Problem Identification: One of the early objectives of the AIM-based process is to help in screening and problem identification -- by preparing a preliminary matrix that identifies broad relationships, and provides a qualitative idea of the magnitudes of the impacts. Thus, the preliminary AIM would be used to prioritize the most important links between policies and their sustainability impacts. For example, in the top row of Table A4.1, a currency devaluation aimed at improving the trade balance, may make timber exports more profitable and lead to deforestation of open access forests and increased GHG emissions. The appropriate remedy might involve complementary measures to strengthen property rights and restrict access to the forest areas.

A second example might involve increasing energy prices closer to marginal costs -- to improve energy efficiency and decrease GHG and other emissions (second row of Table 2). A complementary measure involving the addition of pollution (carbon) taxes to marginal energy costs will further reduce emissions. In the same vein, a major hydroelectric project is shown lower down in the table as having two adverse impacts -- inundation of forested areas and villages - as well as one positive impact - the replacement of thermal power generation (thereby reducing GHG emissions). A re-afforestation project coupled with adequate resettlement efforts may help not only to address the negative impacts, but also enhance carbon fixing.

This matrix-based approach therefore encourages the systematic articulation and coordination of policies and projects to achieve sustainable development goals. Based on readily available data, it would be possible to develop such an initial matrix for many countries. Furthermore, a range of social impacts could be incorporated into the AIM, using the same approach.

Analysis and Remediation: This process may be developed further to assist in analysis and remediation. For example, more detailed analyses and modeling may be carried out for each matrix element in the preliminary AIM which represented a high priority linkage between economywide policies and environmental impacts that had been already identified in the cells of the preliminary matrix. This, in turn, would lead to a more refined and updated AIM, which would help to quantify impacts and formulate additional policy measures to enhance positive linkages and mitigate negative ones.

The types of more detailed analyses which could help to determine the final matrix would depend on planning goals and available data and resources. They may range from the application of conventional sectoral economic analysis methods (appropriately modified in scope to incorporate environmental impacts), to fairly comprehensive system or multisector modeling efforts -- including CGE models that include both conventional economic, as well as environmental or resource variables. Sectoral and partial equilibrium analyses are more useful to trace details of direct impacts, whereas CGE modeling provides a more comprehensive but aggregate view, and insights into indirect linkages.

ANNEX 5. Environmental Valuation

Economic valuation of environmental assets and services is an important input to the decisionmaking process. There has been some modest progress in recent years, in both the theory and application of valuation methods. The conceptual basis for valuation and various practical techniques are briefly summarised below (for details, see Munasinghe 1993).

Valuation Concepts

The basic purpose of valuation is to determine the total economic value (TEV) of a resource. TEV consists of two broad categories: use value (UV) and non-use value (NUV); i.e., TEV = UV + NUV. Use values may be broken down further into: (1) direct use value (DUV); (2) indirect use value (IUV); and (3) potential use value or option value (OV). Direct use value is the immediate contribution an environmental asset makes to production or consumption (e.g., food or recreation). Indirect use value includes the benefits derived from functional services that the environment provides to support production and consumption (e.g., recycling nutrients or breaking down wastes). Option value is the willingness to pay now for the future benefit to be derived from an existing asset. Non-use values are based generally on altruistic, non-utilitarian motives (Schechter and Freeman 1992), and occur although the valuer may have no intention of using a resource -- one important category called existence value arises from the satisfaction of merely knowing that the asset exists (e.g., a rare and remote species).

For the practitioner, what is important is not necessarily the precise conceptual breakdown of economic value, but rather the various empirical techniques that permit us to estimate a monetary value for environmental assets and impacts. However, the results derived from some of these techniques are uncertain even in developed economies, and therefore, their use in developing countries should be tempered by caution and sound judgment.

The willingness to pay (WTP) of individuals for an environmental service or resource is the economic basis for a variety of available valuation techniques (Kolstad and Braden 1991). WTP is strictly defined as the area under the compensated or Hicksian demand curve which indicates how demand varies with price while keeping the user's utility level constant. Equivalently, the difference between the values of two expenditure (or cost) functions could be used to measure the change in value of an environmental asset. The former are the minimum amounts required to achieve a given level of utility -- for a household (or output -- for a firm) before and after varying the quality of, price of, and/or access to, the environmental resource in question. All other aspects are kept constant. However, the commonly estimated demand function is the Marshallian one -- which indicates how demand varies with the price of the environmental good, while keeping the user's income level constant. In practice, it has been shown that the Marshallian and Hicksian estimates of WTP are comparable under certain conditions (Willig 1976). Furthermore, in a few cases once the Marshallian demand function has been estimated, the equivalent Hicksian function may be derived in turn. The payments people are willing to accept (WTA) in the way of compensation for environmental damage, is another measure of economic value that is related to WTP. WTA and WTP could diverge significantly (Cropper and Oates 1992). In practice either or both measures are used for valuation.

Valuation Techniques

Valuation methods may be categorized according to which type of market they rely on, and by considering how they make use of actual or potential behavior (see Table A5.1). The most useful methods are based on how environmental quality changes affect directly observable actions, with the consequences valued in conventional markets.

Table A4.1. Example of a Simple Action Impact Matrix (AIM).

ACTIVITY/POLICY	MAIN OBJECTIVE	IMPACTS ON KEY SUSTAINABLE DEVELOPMENT ISSUES			
		Land Degradation	GHG Emission	Resettlemen t	Others
Macro-economic & Sectoral Policies	Macroeconomic and sectoral improvements	Positive impacts due to removal of distortions Negative impacts mainly due to remaining constraints			
· Exchange Rate	· Improve trade balance and economic growth	(-H) (deforests open-access areas)	(-M) (releases carbon stocks)		
· Energy Pricing	· Improve economic and energy use efficiency		(+M) (energy effic. reduces emissions)		
· Others					
Complementary Measures[2]	Specific/local social and environmental gains	Enhance positive impacts and mitigate negative impacts (above) of Broader macroeconomic and sectoral policies			
· Market Based	· Reverse negative impacts of market failures, policy distortions and institutional constraints		(+M) (pollution tax reduces emissions)		
· Non-Market Based		(+H) (property rights reduce deforestation)	(+M) (fixes carbon)		
Investment Projects	Improve efficiency of investments	Investment decisions made more consistent with broader policy and institutional framework			
· Project 1 (Hydro Dam)	· Use of project Evaluation (cost Benefit analysis, Environmental Assessment, Multi-criteria Analysis, etc.)	(-H) (inundates forests)	(+M) (displaces fossil fuel use and reduces emissions)	(-M) (displaces people)	
· Project 2 (Re-afforest and relocate)		(+H) (replants forests)	(+M) (fixes carbon)	(+M) (relocates people)	
· Project N					

Source: Munasinghe 1993.

Notes

1 A few examples of typical policies and projects as well as key environmental and social issues are shown. Some illustrative but qualitative impact assessments are also indicated: thus + and - signify beneficial and harmful impacts, while H and M indicate high and moderate intensity. The AIM process helps to focus on the highest priority environmental issues and related social concerns.

2 Commonly used market-based measures include effluent charges, tradable emission permits, emission taxes or subsidies, bubbles and offsets (emission banking), stumpage fees, royalties, user fees, deposit-refund schemes , performance bonds, and taxes on products (such as fuel taxes). Non-market based measures comprise regulations and laws specifying environmental standard (such as ambient standards, emission standards, and technology standards) which permit or limit certain actions ("dos" and "don'ts").

Table A5.1. Techniques for Valuing Environmental Impacts.

	TYPE OF MARKET		
TYPE OF BEHAVIOUR	Conventional market	Implicit market	Constructed market
Based on actual behaviour	Effect on Production Effect on Health Defensive or Preventive Costs	Travel Cost Wage Differences Property Values Proxy Marketed Goods	Artificial market
Based on intended behaviour	Replacement Cost Shadow Project		Contingent Valuation

Source: Munasinghe (1993)

Effect on Production. An investment decision often has environmental impacts, which in turn affect the quantity, quality or production costs of a range of productive outputs that may be valued readily in economic terms.

Effect on Health. This approach is based on health impacts caused by pollution and environmental degradation. One practical measure related to the effect on production is the value of human output lost due to ill health or premature death. The loss of potential net earnings (called the human capital technique) is one proxy for foregone output, to which the costs of health care or prevention may be added.

Defensive or Preventive Costs. Often, costs may be incurred to mitigate the damage caused by an adverse environmental impact. For example, if the drinking water is polluted, extra purification may be needed. Then, such additional defensive or preventive expenditures (ex-post) could be taken as a minimum estimate of the benefits of mitigation.

Replacement Cost and Shadow Project If an environmental resource that has been impaired is likely to be replaced in the future by another asset that provides equivalent services, then the costs of replacement may be used as a proxy for the environmental damage -- assuming that the benefits from the original resource are at least as valuable as the replacement expenses. A shadow project is usually designed specifically to offset the environmental damage caused by another project – eg., if the original project was a dam that inundated forest land, then the shadow project might involve replanting an equivalent area of forest, elsewhere.

Travel Cost. This method seeks to determine the demand for a recreational site (e.g., number of visits per year to a park), as a function of variables like price, visitor income, and socio-economic characteristics. The price is usually the sum of entry fees to the site, costs of travel, and opportunity cost of time spent. The consumer surplus associated with the demand curve provides an estimate of the value of the recreational site in question.

Property Value. In areas where relatively competitive markets exist for land, it is possible to decompose real estate prices into components attributable to different characteristics like house and lot size, air and water quality. The marginal WTP for improved local environmental quality is reflected in the increased price of housing in cleaner neighborhoods. This method has limited application in developing countries, since it requires a competitive housing market, as well as sophisticated data and tools of statistical analysis.

Wage Differences As in the case of property values, the wage differential method attempts to relate changes in the wage rate to environmental conditions, after accounting for the effects of all factors other than environment (e.g., age, skill level, job responsibility, etc.) that might influence wages.

Proxy Marketed Goods. This method is useful when an environmental good or service has no readily determined market value, but a close substitute exists which does have a competitively determined price. In such a case, the market price of the substitute may be used as a proxy for the value of the environmental resource.

Artificial Market. Such markets are constructed for experimental purposes, to determine consumer WTP for a good or service. For example, a home water purification kit might be marketed at various price levels, or access to a game reserve may be offered on the basis of different admission fees, thereby facilitating the estimation of values.

Contingent Valuation. This method puts direct questions to individuals to determine how much they might be willing-to-pay (WTP) for an environmental resource, or how much compensation they would be willing-to-accept (WTA) if they were deprived of the same resource. The contingent valuation method (CVM) is more effective when the respondents are familiar with the environmental good or service (e.g., water quality) and have adequate information on which to base their preferences. Recent studies indicate that CVM, cautiously and rigorously applied, could provide rough estimates of value that would be helpful in economic decisionmaking, especially when other valuation methods were unavailable.

Summary of the IPCC Expert Meeting on Development, Equity and Sustainability held in Colombo, Sri Lanka, 27-29 April 1999.

Mohan Munasinghe and Rob Swart

A.1. Introduction and Overview

The meeting was opened on the evening of Tuesday, 27 April by the Honourable Batty Weerakoon, Minister of Science and Technology of Sri Lanka. In his keynote speech, the Minister stressed the importance of sustainable development issues (like growth, poverty and malnutrition) for developing country decisionmakers. Therefore, it was important for the TAR to relate climate change to these issues, in order to receive adequate attention.

On Monday, 28 April, Mohan Munasinghe introduced his background paper on Development, Sustainability and Equity, which was developed as one of the guidance papers on cross-cutting issues for the TAR. He argued that development, equity and sustainability are integral elements of sustainable development. Sustainable development has economic, social and environmental dimensions, which need to be given balanced treatment, while DES issues need to be analysed within this framework. TAR authors might consider the following broad and long term questions:

1. How will expected development patterns and scenarios affect climate change?
2. How will climate change impacts, adaptation and mitigation affect sustainable development prospects?
3. How could climate change responses be better integrated into sustainable development strategies?

TAR authors should make a special effort to systematically search well beyond the mainstream journals, for the small but growing volume of literature in economics, sociology and ecology which seeks to bridge interdisciplinary gaps – in as many different countries and languages as possible.

Munasinghe proposed that the many impacts of climate change and alternative strategies to address the issue might be evaluated broadly in terms of their long term effects on: (a) human welfare and equity (b) the durability and resilience of ecological, geophysical and socioeconomic systems (even in the face of sudden, non-linear system shocks); and (c) the stocks of different kinds of capital (e.g., manufactured, natural, human and socio-cultural assets). The TAR will need to identify specific economic, social and environmental indicators, at different levels of aggregation ranging from the global/macro to local/micro. It is important that the indicators be multi-dimensional in nature, practical, comprehensive in scope, and account for regional and scale differences. A wide variety are described already in the literature. Measuring economic, environmental (natural) and social capital raises various problems. Manufactured capital may be estimated using conventional neoclassical economic analysis. Natural capital needs to be quantified first in terms of key physical attributes. Then the physical damage could be valued using a variety of techniques based on environmental and resource economics. Human resource stocks are often measured in terms of the value of educational levels and earning potential. Social capital is the one which is most difficult to assess.

The paper stressed that equity issues (within and among nations, and across generations) deserve careful consideration. A useful starting point would be to assess whether climate change will worsen existing inequities, even though a climate strategy cannot be expected to address all equity-related problems. The TAR needs to assess the fairness of alternative outcomes with regard to climate change impacts, mitigation and adaptation, as well as the distribution of emissions rights across nations and over time.

While much of the work on climate change issues has focused on the global or regional level, its eventual impact and ultimate responses will be relevant mainly at the national and subnational levels. Thus, climate change strategy needs to be harmonised with national sustainable development policies. The TAR could help to clarify how greater priority might be placed on adjusting the development path to reduce GHG emissions, without undermining prospects for improving human welfare. Also, the TAR will be more useful as a practical guide for decisionmakers if it is able to assess the viewpoints of not only governments but also civil society, business, NGOs and other stakeholders.

If material growth is the main issue, while uncertainty is not a serious problem, and relevant data is available, then the focus is more likely to be on optimising economic output, subject to (secondary) constraints based on social and environmental sustainability. Alternatively, if sustainability is the primary objective, while conditions are chaotic, and data is rather weak, then the emphasis would be on paths which are economically, socially and environmentally durable or lasting, but not necessarily growth optimising. The TAR analysis could help to clarify the different viewpoints and explore the potential for greater convergence and complementarity of these approaches. When all important impacts of a specific climate change option may be valued in economic terms, the usual approach of comparing the corresponding costs and benefits will provide useful insights. Where certain critical impacts cannot be valued (i.e., reduced to a single monetary "numeraire"), other techniques such as multicriteria analysis could be helpful. High levels of uncertainty and risk might be dealt with through the use of modern decision analysis frameworks.

During the discussion there appeared to be broad agreement that the systematic assessment of DES issues within the TAR needed to be carried out within an organizing framework based on the economic, social and environmental dimensions of sustainable development.

Sustainability

In the first session that focused on sustainability issues, Gary Yohe presented a paper on Economic Sustainability, Indicators and Climate Change, which was co-authored with Richard Moss. It was argued that in the area of scientific assessment for sustainability, not only government decision makers but also individuals should be addressed, at the national, regional and global levels. On these different scales, different issues are at stake. The paper focused on two main issues: efficiency and substitutability. The authors argue that there does not need to be a conflict between (economic) efficiency and (social) equity, in the sense that equity goals can be pursued efficiently. It was acknowledged that there are limits to substitutability between different types of capital, while substitution does have transaction costs. The authors discussed three different economically-based approaches to select and quantify indicators of sustainability, notably the neo-classical model, non-declining natural capital approaches, and the safe minimum standards approach. They then proposed a template for assessing climate change response options in the TAR, focusing on case studies in the area of adaptation. In the discussion following the presentation, several points were debated, including: (a) the apparent discrepancy between the inclusion of equity in economic theory and the practical reality where little attention is paid to equity issues; and (b) the relevance of mainstream economic theory to practical questions relating to sustainability -- especially in poor countries where a large portion of the population does not participate in the formal economy. The issue of scale was again brought up, since impacts of sustainable development policies at the local or national scale can have negative effects on sustainability elsewhere, or at a higher level of scale.

The second speaker, Qazi Kholiquzzaman Ahmad presented a paper on Social Sustainability, Indicators and Climate Change, co-authored with Ahsan Uddin Ahmed. The paper proposed the "orderly progress of society" as a working definition of social sustainability, in the absence of adequate definitions in the literature. Physical impacts of climate change can lead to socio-economic impacts which can interfere with this orderly progress. Many socio-economic developments in the past have tended to increase vulnerability, while only few have decreased it. Response options would thus focus on decreasing the vulnerability of societies. This could be pursued not only through the reduction of the physical aspects of vulnerability, but also through the increase of social and economic development, and social justice. In the exchange of views after the presentation, it was suggested that the discussion about social sustainability is still too much grounded in the stocks and flows of economic assets, whereas the quality of life rather than quantitative aspects of development are more important from the social sustainability point of view. The discussion also addressed the inequitable distribution of impacts, and the options for attributing costs of adaptation and/or mitigation to different regions. For the assessment of climate change impacts, a complicating factor is that the impacts of climate change are usually just additional to effects of other changes -- i.e., there is vulnerability to stresses in general, rather than specifically to climate change.

Robert Costanza presented the final paper in the session on sustainability. He laid out a framework to assess the ecological sustainability of systems from the perspective of ecological economics. He stressed that there is no single answer to the questions, since different people hold different visions of how the world works and how we would like it to be. Consequently, appropriate tools for analysis and appropriate response options would also be different between different visions. Adequate indicators to describe (eco-) system health ought to include three main elements: vigor (e.g. productivity, output), organisation (e.g. structure, diversity), and resilience (e.g. recovery time after shocks). It is important not to fall into the reductionist trap, by maintaining a focus on the linkages between these indicators at all times, and recognising that preferences, goals, and values change continuously over time in an interrelated fashion. The author rephrased the three main goals of sustainable development (efficiency, fairness/equity, and ecological sustainability), noting that the use of a broad, structured set of indicators that goes beyond economic indicators has been pursued in several case studies (which however are generally outside the realm of climate change analysis).

In the round table discussion that concluded this session, Tariq Banuri pointed out that sustainability can be viewed from two vantage points that have to be taken into account in assessments: (a) some see the world as structured, and subject to effective management, e.g. to adapt to or mitigate climate change; (b) for others, the world is basically chaotic, and in order to cope with shocks such as those from climatic change, vulnerability should be decreased. Ramon Pichs-Madruga re-emphasised the key importance of addressing all economic, social and environmental elements of sustainable development in both policy development and scientific assessment, as well as in the qualitative and quantitative senses, by addressing the issues at the appropriate levels of scale. Zbigniew Kunzewics stressed the importance of being very concrete and specific when using indicators, illustrating this with examples from the area of water management. In the discussion, it was suggested that unfortunately, insufficient knowledge is available to adequately address all elements of sustainability, and all different perspectives in a balanced manner. But this should not be used as an excuse to neglect the analysis of these elements and perspectives in the TAR. This requirement may well force lead authors to venture well beyond their traditional areas of expertise and not hesitate to bring in contributors from other disciplines.

Development

John Robinson opened the session on Development with his presentation on How Climate Change, Adaptation and Mitigation will affect Sustainable Development Prospects. As the work on the Special Report on Emissions Scenarios SRES) suggests, future emissions of greenhouse gases do depend to a large extent on the development path, probably as much as on explicit climate policies. This makes the dividing line between having a climate policy and having no-climate policy very elusive, as well as the difference between climate mitigation and sustainable development scenarios. The SRES scenarios also show that different combinations of driving forces can lead to similar emissions of greenhouse gases. For any analysis of costs and impacts of scenarios, the choice of a reference baseline is all-important. It is argued that much of the literature on sustainable development deals with local issues, while the literature on climate change response is dominated by analysis at the global level. Reconciliation of these scales is crucial. Finally, the author emphasised that decreasing emissions can be achieved both by increasing resource use efficiency and by the development of less resource-intensive lifestyles. In the discussion, some elements of the SRES scenarios were clarified. As in the first session, it was suggested that in order to describe "development" adequately, a broad set of indicators is needed, including social indicators.

In his paper on "Development Patterns in the North and their Implications for Climate Change", Wolfgang Sachs placed the responsibility on the North -- to reduce greenhouse gas emissions in the perspective of a limited ecospace (determined by stabilisation of GHG concentrations), and to ensure a fair distribution of the mitigation burden. He referred to the so-called factor 10 approach that may be needed to increase resource productivity sufficiently in the next 50 years, to reduce emissions along with increasing income levels. Such resource productivity would have to be reached by a combination of increased efficiency increases in the use of resources, and dematerialisation of development ("sufficiency"). This dual strategy would be needed because the positive effects of technological productivity increases are often negated by increased demands (growth of volume). The discussant D.M. Gwary stressed that a dematerialisation strategy in the north may have negative repercussions on economic development in the south.

In her paper on "How Development Patterns in the South will Affect Climate Change", Leena Srivastava re-iterated that while the emissions of GHGs from developing countries must grow, their ability to contain these emissions is limited by several factors. In an effort to address their developmental needs, countries of the South are already implementing a number of policies and measures that are lowering their emissions growth path. However, a truly long-term solution to both reduced emissions from developing countries, as well as their participation in the global efforts to reduce adverse climatic impacts, would be to invest in raising the level of social and economic infrastructure in these countries. The discussant Luis Pinguelli Rosa observed that current development patterns in the south imitate those of the north -- the rich in both regions already have similar lifestyles, and the poor are expected to move in the same direction. Governments have relatively little control over the direction of consumption patterns and the markets that influence those decisions. Poor management capabilities and corruption hinder effective government policies. Low oil prices have even derailed moves towards increased reliance on renewable energy sources.

In the round table discussion ending this session, it was argued that, although GHG mitigation may not be required as yet in the south, it is quite possible to choose between different development pathways, and thereby reduce the growth of emissions as is happening already. Often decreased emissions of greenhouse gases can be regarded as ancillary benefits of national development choices. Here, technological leapfrogging could play a key role, but the knowledge on incentives and constraints for leapfrogging is still incomplete at best. Capacity building and education remain important strategies. From an impacts perspective, it is important for developing countries to reduce their vulnerability and increase their capacity to cope with climatic changes. Here it was argued that the synthesizing chapter on decisionmaking frameworks in the WGIII report may place too much reliance on the idea that climate change is a problem that can actively be managed, and that decision makers do make a conclusive difference. This perspective may be misleading and lead to the neglect of coping strategies to deal with the changes. It is important to report on a wide variety of ways of framing climate change and its response options in the TAR, including but not limited to those of neo-classical economics. This implies that authors would have to be more inclusive of the literature beyond their own disciplines. Eventually it was again concluded that while broadening the objectives of the TAR to include issues of development, sustainability and equity, the authors should remain within the IPCC climate change mandate.

Mohan Munasinghe pointed out the slow but steady progress by the IPCC on DES issues, over the years. In the First Assessment Report development, sustainability and equity issues were practically absent, but in the Second Assessment Report they were included to some extent (basically as separate elements). In the TAR, DES issues would be partly integrated with climate change, while eventually in the Fourth Assessment Report the integration would be complete.

Equity

Anil Aggarwal opened the session on equity with a paper "Addressing the Challenge of Climate Change: Equity, Sustainability and Economic-Effectiveness: How Poor Nations Can Help Save the World", prepared together with Sunita Narain. He discussed three "benchmarks": (a) ecological effectiveness -- "what actions are needed to prevent climate change?", (b) equity and global solidarity -- "how do we equitably share the proposed actions given the two basic facts that there is an enormous disparity in per capita emissions of different nations in the world and, as long as the world remains within a carbon-based energy economy, these emissions are closely related to economic growth and standards of living?"; and (c) economic effectiveness -- "how do we make sure that any action plan that is developed is cost-effective and does not disrupt either the global economy or any individual nation's economy?". In this context, Aggarwal suggested with respect to the Kyoto Protocol that the poor nations must insist: (a) on the principle of equitable entitlements, (b) that the problem of convergence should be accepted within the Kyoto Protocol, (c) that the Kyoto mechanisms must be pegged to a non-carbon energy transition, and (d) that no banking of emissions which are obtained through the Clean Development Mechanism from developing countries will be allowed. Much of the discussion focussed on basic approaches to define equitable atmospheric and emissions entitlements.

Steve Rayner in his paper on "Climate Change, Poverty, and Intragenerational Equity - the National Level" discussed 7 propositions: (a) climate change and poverty are linked by the issue of vulnerability, (b) the hardest equity issues arise because of qualitative differences in the nature of climate change and policy impacts on the poor and those who are better off, (c) poverty cannot be understood in terms of lack of goods or income, or even basic needs, but must rather be understood in terms of people's ability to participate in the social discourse that shapes their lives, (d) emerging multi-dimensional measures of poverty are much better than those based on income or needs, but may continue to underestimate socio-cultural factors, (e) eliminating poverty and developing societal resilience require building social diversity, (f) climate change and policy impacts on the poor do not conform very well to analytic dichotomies of national and international, or intragenerational and intergenerational, (g) in the final analysis climate protection and poverty elimination may be most effectively achieved through local-level actors and their global networks. The discussions focused on the need to help the truly poor in the south, with specific programs to reduce their vulnerability.

The last paper of the session "Climate Change, the Rights of Future Generations and Intragenerational Equity: an In-expert Exploration of a dark and Cloudy Path" was presented by Irving Mintzer. It was co-authored with David Michel. The author stressed that the impacts of climate change would be distributed unevenly over future generations in a yet unknown way. He also discussed the limitations of mainstream economics to deal with issues of intergenerational equity, noting the possibilities of different ways to select an appropriate discount rate. Giving these limitations, great care must be applied in using tools from mainstream economics on the problems considered. The author then looked into ways that international law defines intergenerational equity. He noted how Weiss' three basic principles: conservation of options, conservation of quality, and conservation of access can be used for the implementation of a system of "planetary rights". Finally, different models of operationalizing the concept of common, but differentiated responsibilities from the perspective of ethics were discussed -- utalitarian, realist (power relations), equitable commons, fiduciary trust, and earthrights.

A.2.Synthesis and Recommendations for the IPCC Third Assessment Report (TAR)

In the concluding session, rapporteurs Rob Swart, Neil Leary and Atiq Rahman presented their interpretation of the main issues discussed during the expert meeting. Together with information from a questionnaire that was distributed during the meeting and with additional feedback from the participants, the main findings were formulated in the form of 21 summary recommendations for lead authors of IPCC's Third Assessment Report. There was a strong consensus that the results of the meeting should be taken into account very seriously, especially by WGII and WGIII lead authors.

During the meeting, it was evident that the three issues of development, sustainability and equity are strongly overlapping and interdependent, and hence the recommendations do not necessarily follow the structure of the expert meeting program. Also, many of the main issues that were discussed were generic with respect to the different types of climate change response (coping with impacts, adaptation, mitigation). Hence, the recommendations do not distinguish between Working Group II and III.

Clearly, the substance of the assessment is the sole responsibility of the writing teams of the TAR. Nevertheless, it is hoped that the recommendations from this expert meeting could not only improve of the structure of the TAR by facilitating the more comprehensive and systematic treatment of an important crosscutting issue, but also strengthen the balanced analysis of development, sustainability and equity issues which are pertinent to climate policies. The TAR could take a major step forward (as compared to the Second Assessment Report), by following the recommendations below,

1. Elements of sustainability. The vocabulary, literature, and modes of discourse are disparate and isolated amongst the issues of development, sustainability and equity. However, there is broad agreement on the usefulness of distinguishing between three main elements: economic, social and environmental forms of capital; TAR Lead Authors are encouraged to (a) structure their assessment accordingly, (b) select associated concrete indicators to go beyond the conceptual level, and (c) analyze the crucial linkages among the three elements.

2. Equity issues. The fact that the gap between north and south in terms of per capita incomes and emissions is very large and is not decreasing, is a reason for very serious concern. Authors are particularly encouraged to include aspects of equity into their evaluation of climate change response options; the view that "while climate change cannot ensure equity, it should not worsen it", could be a point of departure. Equity issues can relate to income groups, nations and regions, generations and gender. The SAR addressed equity in a relatively theoretical, stand-alone chapter. In the TAR, equity would be one of the considerations in all chapters that consider impacts, and adaptation and mitigation options.

3. Options for fairness. After assessing distributional aspects (intra- and intergenerational) of consequences of future climate change, and of adaptation and mitigation options, lead authors can describe what the literature says about the fairness of this distribution; this includes as relevant factors the influence of a range of possible discount rates when assessing costs, and the equity implications of different options to distribute emissions quotas over regions and time.

4. Different decision makers. While decisionmakers other than governments (e.g. individuals, firms, families, NGOs) may not be the primary clients of IPCC, writing teams are encouraged to also take these actors into account in the assessment. Here, the applicability of scientific, technical and economic analysis for real-life decision making could be addressed, acknowledging the differences between decisionmakers in the real world, and analysts using theoretical models and other scientific methods.

5. Different views, different tools. It is advised that in the report, the existence of different views on alternative development pathways is acknowledged and presented, with the associated research tools and preferred policy options (which can be different for different views); this information would be presented as complementary rather than conflicting.

6. Different decision frameworks. Climate change is a relatively new problem, and lead authors are encouraged to recognise the full scope of available decision analytical frameworks for analysis, including emerging innovative ones; different tools for different questions may be appropriate and their advantages and limitations – notably in the context of DES – should be spelled out. An example discussed at the expert meeting was the difference in emphasis between the optimality approach (maximising economic efficiency) and the durability approach (minimising environmental and social risks). Are these approaches convergent or basically conflicting?

7. Different levels of spatial scales. A synthesis is needed to reconcile the mainly locally-nationally oriented literature on sustainable development and the climate change literature which is mainly focusing on the regional and global level. Eventual solutions to climate change have to be at the local level. Lead Authors are encouraged to take these different levels of scale and their interactions into account when drafting their chapters. This would capture (global, regional) top-down analyses and (local, national) bottom-up studies.

8. Different regions, different mitigation focus. From the perspective of stabilising concentrations of greenhouse gases, evaluation of long-term mitigation options in the industrialised countries would need to consider eventual deep emissions cuts. In addition, the assessment of mitigation options in the developing countries could focus on the possibilities and incentives for capturing early GHG mitigation opportunities in order to avoid future GHG emissions at the historic level of the industrialised countries (seeking to "tunnel" through the environmental Kuznetz curve that hypothetically depicts increasing emissions of GHGs at early levels of development and decreasing levels at high levels of income). However, the right of developing countries to develop economically cannot be compromised by climate change mitigation concerns. Since the two regions are closely tied together in various ways, the mutual impacts of such developments have to be carefully considered [WGIII].

9. Regional differences in indicators. In the assessment, lead authors should recognise regional differences in relevant indicators as much as possible, particularly with regard to social welfare indicators. It should be acknowledged that GNP is only weakly related to well-being; as far as the literature allows, indicators of poverty have to be multidimensional, going beyond income levels, access to goods and services, or basic needs.

10. Adequacy and specificity of indicators. It is recommended to pursue a set of indicators as comprehensive and concrete as the literature permits. Definitions of indicators have to be explicit and transparent. For example, reporting of costs should reflect as much as possible total social costs, but if this information is not available, this should be clearly stated.

11. Managing or coping. Authors are encouraged to acknowledge the view that the world can only be marginally managed at best, in addition to the more common view that the world can be effectively controlled to mitigate or adapt to climate change. In this way, what is known about increasing the ability to cope with changes (rather than trying to manage them), would be better reflected in the report. This particularly refers to the adaptive capacity of the most vulnerable groups [WGII].

12. Most vulnerable groups. TAR Lead Authors are encouraged to pay attention to the poorest and most vulnerable parts of the population in various regions when assessing the distributional aspects of the impacts of climate change, and adaptation and mitigation options to the extent possible. They should take into account that available global and regional analysis may provide little guidance on this.

13. Instabilities and non-linear changes. In addition to gradual changes, authors are advised to take into account the possibilities of changes affecting the stability of both socio-economic and biogeophysical systems, e.g., because of non-linear system behaviour.

14. Increasing overall resilience. Increasing countries' resilience to global change in general – e.g. increasing socio-economic development and social justice, and reducing physical vulnerability - can be recognised as a means of also increasing resilience with respect to climate change, especially with respect to the most vulnerable countries and groups [WGII].

15. Governance and institutions. Lead authors dealing with adaptation and mitigation options are encouraged to take into account governance issues at various levels of scales. Institutional effectiveness is crucial for addressing climate change at all scales.

16. Integrating climate change into development policies. Conversely, policies for national development, or for mitigating local problems (economic, social and environmental) can mitigate climate change and GHG emissions. New SRES scenarios suggest that differing development pathways can have at least as large an impact on greenhouse gas emissions as explicit greenhouse gas control policies. It may be assumed that human choice can influence these development pathways. Consequently, TAR writing teams could consider policy options that go beyond explicit climate policies in their assessment [WGIII].

17. Technological and social change. Any effective solution to the climate change problem in terms of mitigation is likely to include (technological) resource use efficiency, and social/behavioural/lifestyle changes, amongst other reasons because efficiency increases are often compensated for by increases in activity levels. Both types of change are interrelated, for example at the level of consumer demands. Effective solutions include both dematerialisation and decarbonisation options. Authors are encouraged to be comprehensive in their assessment of options in this respect [WGIII].

18. Incentives and constraints for technological change Lead authors are advised to assess the economic, social and environmental incentives and constraints for technological leap-frogging, both for north-south and south-south technology transfers and distribution, as well as for adaptation and mitigation. It is often forgotten that such technological advancement involves both hardware and software. This may require new perspectives on alternative development paradigms.

19. Long-term perspective for short-term actions. It is important to maintain a long-term perspective throughout the TAR, because of the very long time frames for: (a) manifestation of climate impacts, (b) achieving income convergence, and (c) the need for eventually needed deep GHG emissions cuts to achieve stale concentrations. This context should also be kept in mind when assessing shorter term response options.

20. Literature limitations. The assessment should be as comprehensive, rigorous and precise as the literature permits. Because (particularly quantitative) analyses in the mainstream literature tend to focus on just a subset of the full spectrum of economic, social and environmental aspects of response options, lead authors are encouraged to include literature in the assessment beyond those areas of expertise represented in the writing team -- for example by involving contributing authors from other disciplines. Integrating the information from a mainly scattered and disparate disciplinary literature is important, to make the TAR an effective interdisciplinary report. It is also important to note gaps in knowledge, e.g. in the form of research recommendations (e.g. non-monetised aspects of response options and impacts, quantification of social capital).

21. Climate change mandate of IPCC. “Development, Sustainability and Equity” issues are now widely accepted within the main context of the IPCC TAR, and the TAR objectives would be broadened as compared to the SAR. At the same time, the focus of the assessment necessarily has to remain within the climate change mandate of IPCC, avoiding a comprehensive assessment of (sustainable) development strategies. The IPCC may not be the best vehicle to deal comprehensively with development, sustainability and equity issues, but there is room to significantly improve our understanding in this area.

A.3. Public Symposium and Outreach

A public symposium was organised after the expert meeting. At the symposium, WG-III co-chairs Bert Metz and Ogunlade Davidson, and vice-chair Mohan Munasinghe gave presentations on climate change and its potential implications for Sri Lanka to a large and varied audience of representatives from the Sri Lanka government, industry, NGO community and academia.

Following the IPCC expert meeting and public symposium, Honourable Batty Weerakoon, the Sri Lankan Minister of Science and Technology, announced his intention to launch a new programme of climate change studies under the aegis of his Ministry.

Short Report of

IPCC Costing Issues Expert Meeting in Tokyo

R K Pachauri and T. Taniguchi
IPCC Vice-Chairs

Background and objectives of the Expert Meeting

Several cross cutting issues have been identified as relevant to the TAR. Four of these issues covering costing methodologies; uncertainty; decision analysis frameworks; and development equity and sustainability (DES) are being addressed through the preparation and discussion of a set of guidance papers. The purpose of these papers and their interpretation is to provide a consistent terminology and a conceptual framework that cuts across all three Working Group reports. The Bureau has assigned responsibility for coordination of work related to cross cutting issues to two IPCC Vice Chairs Dr R K Pachauri & Prof T Taniguchi.

The Expert Meeting held in Tokyo during June 29 to July 1 focussed on issues of costing, which is one of the central and perhaps one of the most important themes to be addressed in respect of climate change, both for mitigation and impact/adaptation. Costing also has linkages with other cross cutting issues, that is, uncertainty, DES and decision analysis frameworks.

Venue and participants

Approximately 70 participants attended the Expert Meeting, which was held at Hotel New Otani in Tokyo. The co-sponsors of the meeting included GISPRI, NEDO, MITI, the Environmental Agency of Japan and the Ministry of Foreign Affairs. Participants were drawn from different regions of the world and represented a wide range of expertise. A few participants from the Japanese Government were also included to provide useful policy inputs. The Expert Meeting was followed by an open symposium to create awareness and outreach on the activities of the IPCC.

Outline of the Meeting

The two and a half days meeting in five sessions was very intensive and comprehensively covered most of the important costing issues. It was unanimously regarded by the participants to be highly successful. The sessions in the meeting were devoted to: (1) Past IPCC discussions and cross-cutting aspects of cost assessment; (2) common theoretical issues related to impacts/adaptation and mitigation; (3) specific issues in mitigation, (4) specific issues in impacts/adaptation, and (4.5) integration of both these aspects; (5) wrap-up of the deliberations and practical steps forward including their policy relevance.

At the start, important points concerning cost assessment required in the SAR were identified by Dr. Halsnæs and Prof. Markandya. They were followed by a presentation from Dr Richard Moss on specific issues related to uncertainty. Aspects of decision-making framework were presented by Prof. Toth. Ms. Tani added to these the perspectives of policy-makers including the paper prepared by Ambassador Estrada who could not participate in the Meeting on account of sudden illness. The important items identified were: equity considerations, time discounting, timing of decisions and actions, non-market values and ancillary benefits, damage estimation, modeling methods, incorporating technological change, no-regrets options, and the use of policy instruments including carbon tax and emissions trading. Underlying uncertainties were categorized by a matrix: (level of agreement/consensus) × (amount of evidence).

Following these, some common issues mentioned above were discussed in depth in the next session. Much attention was focussed on the time dimension in costing decisions. Dr. Tol and Prof. Markandya presented aspects of these from the economic viewpoint. Numerical results were shown as very highly dependent on the value of the discounting rate. Concern for applicability of uniform discount rates over long periods were also raised. Non-market aspects and ancillary benefits were presented by Dr. Sokona. These aspects were commonly understood as an important but difficult issue for policy-makers. Issues arising from aggregation were presented by Prof. Yohe. Climate change was shown to enhance fluctuations rather than shifting mean value. In this regard, disaggregated assessment is very important as a practical approach.

Thirdly, issues specific to mitigation (WG III issues) were discussed. Dr. Sathaye presented the issues related to bottom-up measures, especially focusing on CDM project analysis including identification of several kinds of transactions costs. Dr. Tol explained the characteristics of bottom-up and top-down modeling approaches and their marriage with some types like hybrids, and new hybrid methodologies. Prof. Kashiwagi introduced his work as an example of a concrete bottom-up and sector specific approach focusing on exergy flow like heat cascading. He emphasized the large energy conservation potential of this approach. Dr. Halsnæs presented the specific issues for developing countries and economies in transition based on her concrete calculation of cost curves and social costs.

Fourthly, cost assessment issues related to impact/adaptation (WG II issue) were discussed. Theoretical issues were presented by Prof. Hanemann focusing on methodological weaknesses concerning ancillary assumptions, optimizing behavior, etc. Prof. Burton stressed the premature status of research for adaptation as a whole and difficulties of defining relevant costs. From a policy perspective, this area was viewed as requiring much more research. Dr. Shackleton presented the status of work of the energy modeling forum EMF 16 which intended to incorporate Kyoto commitments and other possible developments. Prof. Schneider stressed the importance of non-linear and irreversible events which are difficult to deal with in the framework of traditional economic and costing analysis. This is partly a matter of how to treat uncertainties, and broader analytical frameworks and new methodologies are needed to deal with them.

Both mitigation and impact/adaptation assessments were integrated by Prof. Yohe in assessing the application of simplified, parametric representation of their costs in decision analysis models. Matters related to technological change, costing of adaptation and underlying assumptions were discussed.

Finally, in the wrap-up session based on the in-depth discussions in the previous two days, Dr. Toth presented his views regarding costing issues within the framework of decision-making. His views are to be reflected in the revision of his cross-cutting issues guidance paper. The policy-relevant scientific, technical and socio-economic questions, which will be the main part of the Synthesis Report of the TAR, were also discussed in order to develop closer linkages with costing issues. Discussions by all participants and by the panel reviewed important issues identified in the previous days, with the intent that these issues should be further developed as useful inputs to the decision-making process.

It was decided that:

1. Much more work needs to be done to apply costing methodologies and principles to impacts and adaptation.
2. Research priorities would need to be defined in respect of climate change and its linkages with social factors, income distribution and health.
3. A glossary of terms and perhaps a simple primer should be produced on cross cutting issues, including costing issues and methodologies, and their applicability to both mitigation as well as impacts/adaptation.

Outputs

It was agreed by the Scientific Steering Committee, the proceedings of the meeting are to be published as a special issue of the Pacific and Asian Journal of Energy, in addition to the production and circulation of a book to assist drafting of the TAR based on the proceedings. The deadline for submission of papers by the authors and notes by the discussants was set as August 15, 1999.

Summary of Session 1:
Overview of Past IPCC Activities and Cross-cutting Aspects of Cost Assessment
[Chair: Prof. Yoichi Kaya]

Session 1 set forth the main objectives of the meeting. These objectives are to further evolve guidance to authors of the IPCC's Third Assessment Report (TAR) to facilitate (1) consistent use of cost concepts throughout the three volume report and (2) consistent assessment and reporting of uncertainties in cost estimates. In addition, the session included discussion of the need to present information in forms that are anticipated to be useful for policy decisions.

Cost assessment of climate change effects and responses to climate change, such as mitigation of greenhouse gas emissions and adaptation to climate change, provides a measure of their significance or importance for individual and social well being. The conceptual basis for cost measurement is individual utility, from which are derived monetary measures of the sacrifices individuals would be willing to make to secure benefits or avoid damages. These individual, monetized measures of sacrifices can be and are aggregated to provide a measure of the social cost of climate change and climate change responses.

It was noted many times during the session, and throughout the meeting, that monetized cost derived from individual utility is not the only metric in which to measure the importance of the effects of climate change and climate change responses. Other measures are available, are relevant to policy decisions, and should be reported in the IPCC's TAR. But monetized cost is one commonly and widely used measure and estimates of these costs will be evaluated and reported in the TAR.

Previous reports of the IPCC, have included assessment of the costs of climate change and climate change responses. The presentation by Kirsten Halsnæs provided an overview of this experience. A number of issues were identified as posing problems for cost assessment in past IPCC reports. These included equity assumptions implicit in different approaches to aggregating individual costs, competing approaches to discounting, reconciling cost estimates from highly aggregate (top-down) and disaggregate (bottom-up) approaches, establishing baselines against which to measure costs, technological change and its implications for future mitigation costs, estimating monetized costs for impacts on non-market goods and services, and transferring cost estimates from one setting to another (e.g. damage costs from developed countries to developing countries).

These issues will again pose challenges for cost assessment in the TAR. Anil Markandya presented the guidance paper intended to assist authors of the TAR with addressing these and other issues using a common framework. Definitions are offered in the paper for terms such as private, external, social and financial cost. A check list is provided as guidance for TAR authors to help assure that the assessment of cost estimates provides comprehensive information needed for the reader to understand and interpret the estimates.

Many uncertain factors such as future population and income growth, energy demand and supply, technological change, climate, and the sensitivity of natural and human systems to climate change, contribute to uncertainty about the costs of climate change and climate change responses. Richard Moss presented a guidance paper for assessing and reporting confidence levels for cost estimates. The guidance included common terminology to be used in the TAR and a series of steps that authors are encouraged to follow to provide an understanding of the factors that contribute to uncertain cost estimates and their implications for the likelihood of different cost levels. Key goals are to provide a transparent assessment of uncertainties and to avoid giving a false or exaggerated assessment of confidence levels for cost estimates.

Questions about the policy relevance of IPCC reports are raised in a paper submitted for the session by Ambassador Estrada-Oyuela. Although Ambassador Estrada-Oyuela was unable to attend the meeting, his paper provided a catalyst for discussions on this issue. The discussions made clear that, to be policy relevant, IPCC must strike a balance in reporting its findings. On the one hand, key findings must be stated clearly and simply so as to be understandable to an audience that is not technically trained in physical and social sciences. On the other hand, IPCC reports should not oversimplify complex problems nor exaggerate confidence in findings. To do so would endanger the credibility of the IPCC.

Summary of Session 2: Common Issues for Assessing Costs for Impact/Adaptation and Mitigation

[Chair: Dr. Bert Metz]

In the assessment of costs for impact, adaptation and mitigation, there are a few common issues, identified to be of theoretical, methodological and practical significance, pertinent to the preparation of the Third Assessment Report. This session is devoted to address some of the most pressing issues, including time dimensions, non-market aspects and aggregation problems, so as to gain a better understanding of these issues and suggest improvement in their treatment applicable to the Third Assessment Report.

Time dimensions are considered extremely important in deriving cost estimates associated with adaptation and mitigation due to the fact that time span in the context of climate change can be decades or even centuries. Two presentations were focused exclusively on this challenging subject by Richard Tol and Anil Markandya.

Richard Tol examined timing of greenhouse gas emission reductions in an optimal setting. The results indicate that, owing to a bonus for early reduction but lower cost for later action, there is not a priori preference for early or late emission reductions for any given level of stabilization of concentrations. Climate change mitigation will lead to induced technological changes, but the discounting of late emission reductions is likely to discourage early actions in view of the more limited effect on avoiding damages. Given the wide range of uncertainty in costs associated with emission reductions in the future, the determination of optimal timing of mitigation is not an easy task, but early actions can be taken to abate emissions, develop new technologies and build up stronger institutional frameworks.

In the presentation by Anil Markandya and the following discussions, the focus is on the rationale and problems of discounting in the assessment for climate change. Due to time preferences and the productivity of capitals, economic theory suggests that the rates of discount be positive. However, it is necessary to distinguish between private, market and social rates as they can differ substantially in an imperfect world. In general, the higher private/market rates are appropriate for investments while the lower social rates for impacts. It has been noted that discount rates can vary a great deal between different types of capitals, regions with different levels of economic development and different time horizons. In general, lower rates are applicable to public goods and services, higher rates to the developing world and declining rates to longer time horizons. With uncertainty, the rates tend to be higher.

As discount rate will heavily influence the results of cost estimates and have equity implications, care should be taken in its selection. It would be desirable to employ different rates in cost estimation. Also it is recommendable that sensitivity analysis be made to provide further information for decision making.

Non-market aspects are characteristic in environmental valuation. The presentation by Youba Sokona and subsequent discussions shed some light in cost measurement related to climate change. It is noted that human dimensions of climate change, i.e. individual and social preferences and behavior, are critical to evaluating anthropocentric costs. Methods for valuation of non-marketable goods and services have been developed in the literature, but they are far from mature. This is particularly true in their application to developing countries due to their diverse socio-economic environment, high dependency on natural resources, less developed market (up to 80% of the population inactive in the commercial sector), lack of data, and different institutional settings.

Because underlying values are not well understood, there is a need to model preferences and behavior in the valuation of non-market impacts of climate change. Certain non-market goods and services may be seen as irreplaceable. Monetary valuation in these cases may be therefore difficult and possibly inappropriate. Non-monetary measures can also be important cost indicators. Due to the existence of market failure and imperfection, it is advocated that the concept of social cost should be employed in the valuation exercise.

Aggregation constitutes an important challenge to estimation of climate change cost. Gary Yohe provided an illuminating illustration on the strengths and weaknesses of aggregation, which attracted a lively debate on the issue during the session. Aggregate measures can be useful to represent general trend and overall picture, but little indication is shown on regional and/or sectoral variations. It is also observed that there may exist differences between global aggregated impacts and the sum of regional impacts. In particular, aggregate models are unable to take into account the most disadvantaged sectors of the global population. A conclusion is drawn that aggregation is needed in the modeling exercise, but the analyst has to check what might get lost when aggregating. Disaggregation can provide insights into income distribution and allows some analysis of equity implications of certain policy options. Such analyses can generate useful information on possible efficiency-equity trade-offs.

The issue of aggregation and equity is also addressed at the session. Gary Yohe proved that analytical tools from the economic profession such as the Lorenz Curve and the Gini coefficient could contribute to the understanding of equity concerns. However, caution should be taken in defining the terms with regard to equity.

Summary of Session 3: Specific Issues in Mitigation

[Chair: Prof. Anil Markandya]

Session 3 of the Meeting addressed some mitigation-specific issues for cost assessment. Implementing the newly adopted Kyoto Protocol, the mitigation cost assessment has increased its importance, not only for short-term flexibility mechanisms but also for long-term strengthening commitments. In general, we have taken two major approaches as option-specific bottom-up analysis and macro-economic top-down analysis in order to assess the costs for mitigation.

For bottom-up and project-based cost assessment, Jayant Sathaye made a presentation on key aspects for clean development mechanism (CDM). As in many other bottom-up analyses, baseline establishment is needed for CDM projects. He specified that the baseline emissions should be re-estimated after monitoring and evaluating the energy use. Standardized approach for baseline setting can reduce transaction costs. Other processes like monitoring, evaluation, reporting, verification and certification, depending on the design of the scheme, need costs which may exceed the value of credits generated in the short term. These kinds of transaction costs influence the effective implementation of such project-based mechanisms. It was pointed out that taking the balance of accuracy and (shared) low transaction costs is necessary.

In general, bottom-up analyses are done by engineers and top-down analyses by economists. Richard Tol discussed the difference of these approaches and introduced alternatives like hybrid, new growth, and new hybrid approaches to transcend the gap. These approaches model the different aspects of the world; e.g., only bottom-up deals with the inefficiency of current economy; while the new growth and new hybrid approaches incorporate the endogeneous development of technology,… These approaches have common deficiencies in cost related issues. For example, distribution is often ignored; and the avoided damage is not well modeled as a linkage to the emission reduction costs. Technological change needs more data and instruments as well. It was discussed that it would not be appropriate to choose one approach as the best one, since approaches would complement each other and should be used in proper situations.

Takao Kashiwagi presented bottom-up type sector-wise analysis of cost effective energy efficiency measures, applicable in near future in Asia. He discussed about the list of economic potential options especially focusing on Japan. He emphasized that not only the essence of each promising option, but also the integration of energy system utilizing the heat cascading (exergy flow) can broaden the potential of options to reduce energy consumption. This indicates that for city planning, especially in the developing countries, it may be important to achieve more cost-effective energy saving and less resource type development pattern based on the concept of circular manufacturing society. However, the cost assessment of this type of inverse factory concept has not yet elaborated well.

The methodologies of cost assessment have not suited the situation of developing countries and countries with economy in transition. The SAR pointed out the existence of large potential of negative cost win-win type options, especially in those countries. Kirsten Halsnæs gave a presentation of cost assessment based on the UNEP case studies. She showed not only direct costs but also assessed the broader coverage of social and environmental impacts of mitigation options based on a methodological framework for the comparative assessment of direct and indirect costs and benefits. The latter associates with employment impacts, income gains/losses of different groups, environmental changes, and sustainability indicators. She showed the (direct) cost curves for GHG emission reductions defined in projection toward the year 2030 for some developing countries and countries with economy in transition. Financial and social costs assessment for some options in those countries showed that the social costs/benefits might be comparable with the magnitude of financial costs in some cases. However, benefits obtained by a technology may be dependent on the country, especially in terms of social costs. This kind of trial is premature at this moment and expected to be elaborated in the near future.

In summary, top-down versus bottom-up approach, in addition to some hybrid types, are useful if properly used. Especially for top-down and long-term models, the resulted numbers differ widely. While, the examples of bottom-up analyses are informative and may link directly to policy making. The results are very much dependent on the baseline setting. For CDM, the host government is interested in the reduction of direct costs, increase in ancillary benefits, and the relation to the economic growth. The bottom-up and some other hybrid-type analyses are used to identify these kinds of interests rather than the aggregated pure top-down analysis. Identification of (non-monetary) social costs is very important for policy-making. However, it has big uncertainty and arbitrariness at this moment, especially for adaptation. This problem links to the political question of how to support the vulnerable countries specified in the UNFCCC and the Kyoto Protocol.

Summary of Session 4:
Specific Issues in Impact/Adaptation
[Chair: Prof. Gary Yohe]

Session 4 of the meeting addressed a number of issues specific to the assessment of the costs of climate change impacts and adaptation to climate change. These issues will need to be explored in the Third Assessment Report to provide a comprehensive and transparent assessment of the costs of climate change impacts and adaptation. Each should be borne in mind to provide a careful assessment of the uncertainties that underlie published cost estimates and, where possible, construct appropriate confidence intervals for costs of climate change impacts and adaptation.

Michael Hanemann identified a number of problems that arise in economic modeling generally, but which particularly plague efforts to estimate the costs of climate change impacts. First is the problem of ancillary assumptions, or factors that are not central to the analysis but which are uncertain, must be specified to carry out the analysis, and which have the potential to significantly bias the results if miss-specified. Second, economic analyses commonly model behavior as optimizing. But, if agents do not optimize, or do not do so in precisely the way assumed by the model, the analysis will produce poor predictions of actual behavior and errors in cost estimates. Third, economic analyses are often highly aggregate. This can introduce errors in cost estimates if there are significant differences among agents and the differences are important for predicting behavior. It also hinders transparency of the analysis. Fourth, there has been little serious effort to validate the performance of economic models for predicting behavior and consequently model miss-specification goes undetected. Each of these problems is capable of imparting considerable uncertainty to cost estimates.

Ian Burton noted that far less progress has been made in the assessment of adaptation costs than for mitigation costs. One problem that hinders work in this area is the difficulty of establishing a baseline for adaptation activity. Adaptation to climate averages and variability is pervasive throughout human activity, but it is difficult to identify and evaluate existing adaptations. In addition, the benefits and costs of adaptive measures, and the objectives of agents, can be expected to vary substantially across agents, space and time. Consequently, it is difficult to model and predict adaptations to changes in climate and to estimate the associated costs. Given the limited literature on adaptation costs, the Third Assessment Report's main contributions in this area may be qualitative assessment of adaptation capacity and potential win-win strategies, as well as identification of methodological issues needing further research.

Robert Shackleton provided an overview of highly aggregate or top-down modeling approaches to the estimation of cost. These approaches generate economy wide cost estimates that insure consistency in costs across various economic sectors by taking into account broad market interactions. Applications of models that utilize a top-down approach to estimate mitigation costs yield widely ranging results. Differences arise due to differences in the flexibility of agents' modeled responses, treatment of expectations, and parameterization of the models. The assessment of cost estimates from these approaches should attempt to make transparent the factors contributing to differences in cost estimates, and compare these to the results of less aggregate bottom-up studies.

Steven Schneider argued that non-linear, surprise and irreversible effects of climate change significantly complicate the problem of estimating the costs of climate change, have been largely ignored, and could significantly widen confidence intervals for cost estimates if appropriately accounted for. To supplement information on monetized cost estimates, it is recommended that impacts using numerical values other than dollars be used and reported to provide alternative measures of the social significance of climate change impacts.

Summary of Session 4.5:
Integration of Cost Assessment
[Chair: Prof. Anil Markandya]

Session 4.5 tried to integrate the cost assessment of mitigation (session 3) and impact/ adaptation (session 4). Gary Yohe discussed this theme from the view point of simplified, parametric representations of costs in decision analysis models.

He argued the way to incorporate the price-induced technological change into the CES-type cost function. Another difficult issue specific to the climate change is cost/ benefit assessment of damage/adaptation. It depends not only on time, but also on some other factors like existence of foresightedness. It should be noted that the assessment heavily depends on the underlying assumptions of reporting. Theoretically, policy design (constraint), distortion, underlying theory, and uncertainty of information are key factors.

In conclusion, parametric representations of costs offer suggestions what to keep in mind to interpret the result of an assessment, i.e., what are hiding behind the simplification and choice of parameters. We can get useful information for decision making process about what is important and what is not through the careful assessment of the result.

It is not clear whether we will be able to have a general methodology incorporating, e.g., time-lag and other time dependent factors and market failure, for adaptation like terrible window approach. For the adaptive capacity, availability of information is important. This issue is multi-dimensional and it will be difficult to identify (the key parameters of) the system.

We must keep in mind that we are constrained by the fact that climate change does not have high priority in policy-making and we do not have enough scientific knowledge now.

Summary of Session 5:
Wrap-up: Integration and Synthesis—Recommendations for the TAR and Implications for Writing Teams
[Chair: Dr. Rajendra K. Pachauri]

The mission of the IPCC is to provide policy relevant but not policy-prescriptive information especially to policy-makers. In relation to this mission, linkage between cost assessment and decision-making is important. The wrap-up session discussions were on this theme reminding the "Policy-Relevant Scientific, Technical and Socio-Economic Questions (PRSTSEQ)" selected by the Panel, which the Synthesis Report of the TAR is going to answer.

In the beginning, Ferenc Toth gave a presentation on cost assessment and decision-making framework based on last two days presentations and discussions. For the relationship between adaptation and mitigation (PRSTSEQ 1), taking balance between them are necessary. Some iterative process may be needed to fill up the uncertainties. On one hand, we must keep the existence of some threshold in mind like emission corridor approach. Determining range and threshold is needed. On the other hand, there are some debates on the delayed action to optimize costs over time (PRSTSEQ 6). On this regard, we must seek the way to make a portfolio of mitigation options to choose now or in the near future. Kyoto Protocol gave us a strong signal of how strong the options are. Flexibility instruments may reduce costs once the target is fixed. However, relation between international flexibility mechanisms and domestic measures remains as unsolved (PRSTSEQ 9). Cost assessment may give us useful (but not crucial) insight to these questions.

Following the summaries of each session by session chairman, the discussions were made considering the six questions adopted at the Steering Committee meeting the night before for further works on this issue:

1. Are you comfortable with the information on costing issues provided in this meeting, and on the numbers, concepts and methodologies for costing?
2. Do you have a clear perception now on uncertainties and how to characterize them?
3. Are there any inconsistencies that need to be removed still on terminology and concepts employed?
4. What are the priority areas for research and further work to fill up the gaps and weakness remaining?
5. Do you have any suggestions on closer integration in the treatment of costing issues for mitigation and adaptation?
6. How can we ensure better interaction between the authors of WG II and WG III to build in consistency and full coverage of cross cutting issues?

Some comments were raised for uncertainties, suggesting the need of cross-referencing among three WGs for consistency (R. Moss and Y. Sokona). E-mail communications were appreciated for this purpose. It was specified that most WG II LAs are not economist (T. Jaszay). Five point scale level of confidence chart was appreciated in general. S. Schneider stressed that the problem is lack of knowledge/data for ecological studies and emphasized the difficulties in disaggregation, rather than the dependence on methods (e.g., bottom-up versus top-down).

Further research should be prioritized for (1) non-market aspects outside of climate change, (2) social impacts, and (3) baseline setting especially for adaptation (Q.K. Ahmad and Y. Sokona). Although much progress has been done recently (A. Markandya), highlighting difficulties in developing countries (e.g., lack of data) is important. Economies in transition have the different kinds of difficulties (applicability of economics) especially in setting energy prices right and establishing the market (T. Jaszay).

Linkage and balance between adaptation and mitigation were stressed (N. Mongia). Intergenerational equity was mentioned by P. Ghosh as an issue to be taken into account. Equity consideration can be partially incorporated in the cost assessment (A. Markandya), Ghosh mentioned the limit of cost/benefit analysis for the issue of climate change and asked for research to clarify alternative norm beyond methodological difference followed by R.K. Pachauri. Misusage of cost assessment, due to partial analysis was mentioned by B. Metz as well. He pointed out the need of facilitative approach.

From the policy-maker's point of view, M. Tani appreciated the diversity of opinions as important to keep credibility of IPCC. She claimed that as the policy discussions are messy, clear information from diverse viewpoints representing diversity in geography and disciplines makes important input for policy-makers to build a consensus. Y. Wake questioned the utility function of the policy-makers.

Wrapping up the session, R.K. Pachauri summarized the remaining high-lighted issues: (1) simple monetary measures are not important; (2) social benefit considering equity based on individual utility is important; (3) cost is a measure of prioritization; (4) discounting over time and space should be carefully assessed; (5) efficiency and equity sometimes trade off; (6) integration of top-down and bottom-up methodology gives new insights; (7) research priority for the imbalance of adaptation and mitigation; (8) policy-makers' concern is what we can do? and what we cannot do?

In general, the participants appraised the expert meeting as a useful meeting for them to clarify the concept and difficulties of cost assessment and drafting the TAR and assessment reports that would follow.

T. Taniguchi, as the principal organizer of the meeting, concluded the meeting by mentioning that the policy-making process is shifting from bureaucratic to public concerned. The message from IPCC was communicable to the public, as it is credible and easily understandable. Costing issue is not limited to the domain of economists. It needs to have new domains and disciplines. Synthesization in a publicly communicable way is now an evolutionary process.

The result of the Expert Meeting was expected to be reflected in the drafting of zero-order and the other versions of TAR. The final version of the cross cutting issue guidance papers was expected to be released by the end of August. The proceedings of the Meeting will be on the special issue of Pacific and Asian Journal of Energy.

SECOND REGIONAL EXPERT MEETING ON "DEVELOPMENT, EQUITY AND SUSTAINABILITY", HAVANA, 23-25 FEBRUARY 2000 SUMMARY

By Ramon Pichs, Neil Leary and Rob Swart

I. Introduction and Framework

The Second IPCC Expert Meeting on DES was held in the Hotel Copacabana, Havana, Cuba, on 23-25 February 2000.

Taking as reference the results of the First Expert Meeting on DES, Colombo, 27-29 April 1999; this meeting further explored and developed ideas on DES, along the lines already identified at the Lead Author meetings of the Working Groups (WG) II and III, with the ultimate goal of:

- incorporating climate change strategies smoothly into the sustainable development agenda;
- assessing and rectifying any shortcomings in the treatment of DES issues in the first drafts of WG II and WG III Reports (Third Assessment Report, TAR);
- encouraging the participation of experts from Latin America and the Caribbean in this debate. The meeting was conceived with a regional (Latin American and Caribbean) focus.

The participants included 30 invited experts on climate change: 17 from Latin America and the Caribbean; 6 from North America; 4 from Asia; 2 from Europe and one representative of the UNDP Office in New York. Ten Cuban experts also attended the meeting.

Dr. Rosa Elena Simeon, Minister of Science, Technology and Environment of the Republic of Cuba opened the meeting on the evening of Wednesday, 23 February 2000. In her speech, the Minister emphasised the requirement of climate change response strategies, integrating development, equity and sustainability issues, at the global, regional and local levels. She also stressed the efforts of Cuba in dealing with the climate change related challenges. Dr. Osvaldo Martinez, Director of the Centre for World Economy Studies (CIEM) and President of the Commission for Economic Affairs of the Cuban Parliament referred to the socio-economic gap between the North and the South in the context of globalisation; and pointed out the importance of properly dealing with DES concerns in designing responsible environmental strategies. Dr. Tomihiro Taniguchi and Bert Metz addressed the meeting on behalf of the IPCC Bureau, highlighting the relevance of the DES as one of the cross-cutting issues of the IPCC TAR.

During the two sessions (A & B) and the Round Table of Thursday 24 February, eighteen speakers expressed their views with respect to the international debate on DES issues and climate change response strategies, with particular reference to the Latin American and the Caribbean context.

Session A, chaired by Mohan Munasinghe, Sri Lanka and Ramon Pichs, Cuba, focused on Sustainable Development and Climate Change. This session included two introductory presentations, with particular reference to the framework for incorporating DES into the TAR (by Mohan Munasinghe, Sri Lanka; and John Robinson, Canada); and three main topics: Socio-economic and Emission Scenarios for Latin America and the Caribbean (by Emilio Lebre La Rovere, Brazil; and Mario Nuñez, Argentina); Climate Change Impacts and Adaptation / Implications for Sustainable Development (by Max Campos, Costa Rica; and Americo Saldivar, Mexico); and Climate Change Mitigation / Implications for Sustainable Development (by Humberto Rodriguez, Colombia; and Carlos Suarez, Argentina)

Session B, dealing with equity and climate change was chaired by Ronaldo Seroa Da Mota, Brazil, and included two basic topics: Equity and Climate Change Response Strategies (by Juan Llanes, Cuba; Luis Pingueli, Brazil; Raul Estrada-Oyuela, Argentina; and Tom Heller; USA); and Equity and Climate Change / Lessons for Latin America and the Caribbean (by Hector Sejenovich, Argentina; and Omar Masera, Mexico).

This working day was closed with a **Round Table,** chaired by Ramon Pichs, Cuba. In this round table, four panellists (Eduardo Sanhueza, Chile; Carlos Rios, Colombia; Leonard Nurse, Barbados; and Angel de la Vega, Mexico) explored the opportunities and barriers for incorporating climate change response strategies into the sustainable development agenda.

The programme for Friday 25 February was organised in two sessions (C & D), with ten basic presentations oriented to assess and rectify shortcomings in the treatment of DES issues in the first drafts of WG II and WG III TAR.

Session C was chaired by Bert Metz, The Netherlands, and included eight speakers. Neil Leary, USA; Saleemul Huq, Bangladesh; Luis Mata, Venezuela; and Stewart Cohen, Canada particularly referred to DES in the WG II TAR; while Luis Pingueli, Brazil; John Robinson, Canada; Carlos Gay, Mexico; and Rob Swart, The Netherlands, based their presentations on DES in the WG III TAR.

Session D, chaired by Tomihiro Taniguchi, Japan, was devoted to the Rapporteurs (Neil Leary, TSU-WGII; and Rob Swart, TSU-WG III) Summary and the general discussion on next steps.

A **public symposium** was organised after the meeting, chaired by Dr. Gisela Alonso, President of the Agency of Environment of Cuba; with the attendance of around 80 participants from Cuban institutions dealing with DES issues. WG III co-chair Bert Metz based his presentation on the current developments on climate change at the international level; Raul Estrada Oyuela, Argentina referred to the Latin American and the Caribbean context; and Luis Paz presented the Cuban experience on climate change adaptation and mitigation.

II. Summary of Lessons for and from Latin America and the Caribbean

During the sessions dealing with the Latin American and the Caribbean perspective on DES issues, in the context of climate change response strategies, some basic ideas were presented and discussed. The summary of the discussion presented here reflects views and ideas expressed by participants in the meeting and is not a summary of IPCC views or findings on sustainable development and equity issues as they relate to climate change.

Basic ideas expressed by the participants in the sessions on Latin America and the Caribbean:

- The increasing recognition of the interconnectedness of social, economic and environmental conditions and issues. The three standard dimensions of sustainable development do not map simply or unidimensionally onto three dimensions of DES.

- Future GHG emissions are the product of complex dynamic systems, determined by driving forces such as population growth, socio-economic development and technological change. Scenario building can provide a powerful tool and a framework to discuss impacts of climate change, adaptation and mitigation strategies, as well as sustainable development issues. Further research -particularly regional studies- is needed to improve the representation of the narrative scenario components by modelling approaches.

- Climate change response strategies, based on sustainable development considerations, would be an important component of policies designed to face the challenges of globalisation and the structural changes brought by neoliberal reforms in Latin America and the Caribbean. Environmental education and community participation are crucial for the implementation of climate change policies within an agenda for sustainable development.

- The Latin American and the Caribbean contribution to the climate change mitigation strategies can be analysed by examining the low regional coefficient of specific CO_2 emissions per energy unit. However, the privatisation of the energy systems in several Latin American and the Caribbean countries has accelerated during the 90´s, and this process, under the particular conditions of some Latin American and the Caribbean countries, has tended to increase GHG emissions, with negative impacts for climate change mitigation. Experience in other regions has demonstrated that under different conditions privatisation can lead to lower emissions.

- In addition to national policy measures, new international procedures are required to transfer economic resources to developing countries, in general, and to Latin America and the Caribbean, in particular, taking into account the relatively low contribution to climate change from the region compared to industrialised countries, and to enhance the region's future contribution to more efficient solutions for climate change mitigation. International systems of compensatory taxes could be explored as sources of funds to support sustainable development objectives in the developing countries, in synergy with the climate change response strategies.

- An integral approach, based on long-term socio-economic sustainable development, instead of short-term oriented free market forces, would be crucial for additional contributions of Latin America and the Caribbean to climate change mitigation.

- The unequal income distribution in the world and within the region is a key element for identifying the levels of responsibility of different countries and social groups, in the debate and negotiations on climate change. Equity problems have been analysed mainly among nations, but some equity questions must be analysed from the regional point of view and also from the sub-national point of view.

- Adequate inclusion of equity criteria in the TAR, with special reference to intragenerational equity, is a condition *"sine qua non"* for the credibility of the Report and its acceptance by the developing countries. The literature on the model of "contraction and convergence" must be properly considered in the TAR.

- The burden of emission reduction compares with other international imposed burdens as the foreign debt of the developing countries, although they are not fully comparable. Based on equity considerations, for almost all developing countries a global QELROS[34] framework is unacceptable. It appears more promising to explore alternative policy frameworks for the developing countries, such as benchmarking of sectoral technologies or efficiencies. Those policy frameworks should consider the specific DES priorities of the developing countries.

- Future regional research must consider the development of indicators for measuring and registering the contribution of the various socio-economic sectors to climate change in the national accounts. Special attention must be paid to the socio-economic and cultural effects of climate change mitigation policies.

    - Climate change adaptation and mitigation strategies require a long-term approach due to the long-term perspective of climate change as a global environmental problem. The

[34] Quantified Emission Limitation and Reduction Objectives

analysis of mitigation/ adaptation response options needs an alternative decision-making framework that fully integrates sustainability, equity and development concerns. In this regard, it is essential:

- to consider how these options contribute to: productivity (efficiency), stability, policy reliability, resilience, adaptability, equity, and self-reliance;
- to derive indicators for each of the attributes and options;
- to integrate the different indicators in a multicriteria decision making framework .

- Adequately designed and implemented mitigation options in the forest sector may present environmental and socio-economic benefits. Mitigation/ adaptation options in this sector must address equity concerns related to differences among countries, options and social groups; capacity building; technology and development; effective community participation; and consistency with regional/ national sustainable development priorities.

- With regard to technology policies to achieve the goals of the CC Convention, it is important to take into account the increasing technological gap between the North and the South. Technology can not be seen as a goal in itself. Analysing climate change response options both technological and social aspects have to be considered. Current modelling approaches are not very well equipped to deal with social issues, particularly not at the regional level.

- It is required, in the region, further research on the opportunities and challenges derived from the flexibility mechanisms of the Kyoto Protocol (CDM, in particular) for sustainable development. Market price distortions over real values is the root of some statements about lower emission reduction costs in developing countries. Therefore, to fully understand the implications and opportunities of the CDM for Latin America and the Caribbean, especially in terms of full social cost, possible projects would have to be evaluated taking into account all elements of development, sustainability and equity for the Latin American and the Caribbean nations.

III. Summary of Discussions on WG II-TAR

The general framework applied by WG II for the assessment of vulnerability to climate change is one that can readily integrate sustainable development and equity issues. Vulnerability to climate change is defined as the degree to which a system is susceptible to damage or adverse effects from climate change. It is a function of system exposure to climatic variation, the sensitivity of the system to climate stimuli, and the adaptive capacity of the system to adjust to climatic stimuli. The future development path will shape each of the three determinants of vulnerability.

The location of future development is a determining factor of future exposure of human populations and resources to climate variation. The rate and character of development are determining factors of non-climate pressures acting on systems such as population growth, land and other resource use, and air and water pollution. These pressures can fundamentally alter the sensitivity of systems to climate stimuli. The rate and character of development will also determine adaptive capacity by shaping the amount and distribution of access to resources, information, technology and skills that can aid adaptation.

The first draft of the WG II report already makes effective use of this framework for linking sustainable development and equity issues to climate change vulnerability. Most draft chapters identify non-climate pressures acting on systems and review evidence of potential effects of non-sustainable development on natural and human systems and the potential consequences for the vulnerability of systems to climate change. There is also consideration of the implications for adaptive capacity of development that either exacerbates or closes gaps in access to resources, technology and information between developing and developed countries, or across different segments of the population. The draft report includes limited assessment of the pathways by which climate change impacts may alter future development prospects and differences in the impacts by region and by social-economic group. Finally, the draft report considers the potential for adaptation to climate change to promote or conflict with sustainable development and equity objectives.

In the next draft of the WG II report, further effort is needed in three areas. First, the links between development paths and climate change exposure, sensitivity, and adaptive capacity need to be elaborated and made explicit. Second, the potential impacts of climate change on development are only touched upon in a few chapters and need to be explored further. And third, the potential for adaptation response strategies to jointly promote reduced vulnerability to climate change, sustainable development, and equity needs to be evaluated consistently across chapters.

How far the next draft can go on these issues will be limited by the information available in the literature. A number of participants in the discussions urged that the report give explicit coverage of research needs to fill in the existing gaps in the literature. Comments highlighted the need for research at regional scales to better understand the exposures, sensitivities, adaptive capacities, and vulnerabilities at these scales and to better link these issues to sustainable development and equity issues. Research also needs to look at how different segments of the population may be differentially affected.

The discussion pointed to a need for assessment of linkages between adaptation and mitigation responses. The draft reports of WG II and WG III both indicate that the performance, costs and benefits of adaptation and mitigation options are strongly dependent on the future development path. Care is needed to assure that consistent scenarios of future development are used to consider and compare adaptation and mitigation performance, costs and benefits. Attention needs to be given to the possible existence of and nature of trade-offs and synergies between adaptation and mitigation responses. The assessment should take care to note that the benefits of adaptation tend to be local and private, while the benefits of mitigation tend to be global and public, and to consider what implications these differences have for climate policy decisions.

IV. Summary of Discussions on WG III-TAR

<u>Adequacy of Treatment of DES Issues in IPCC WG III - TAR</u>

- Of the chapters of the first draft of the IPCC-WG3 TAR, only chapters 1 and 7 pay significant attention to DES issues, the others pay either lip service to DES, or discuss only elements in a way that is disconnected with the rest of the chapters.
- The phrasing of the linkage between sustainable development and climate change is very important: saying that the development path is more important than climate policies suggests that climate policies would be unimportant; rather the synergy has to be emphasised: climate policies are more effective, easier to implement, and possibly cheaper in a policy environment aiming at sustainable development.
- If DES criteria are taken into account in addition to direct costs, they can effect the ranking of technological options and policies and measures.
- Authors have difficulty in addressing DES issues. They should make extra effort in identifying such literature, should consider non-published/non-peer reviewed literature also, and otherwise identify gaps in knowledge and formulate research recommendations.
- The concept of mitigative capacity can help linking the current climate change issues in the report to DES issues; this is especially relevant for describing sectoral and regional differences.
- Considering alternative development pathways is important. It is not only important how the cake is cut, also how it is cooked.

<u>Linkages Working Groups II and III</u>

- While the SAR focus was on costs-benefits (to help deciding IF action is needed), the TAR seems to move towards mitigation-adaptation in a DES framework (to help deciding WHAT action is needed); important issues to be discussed between WG2 and WG3 include trade-offs, synergies and co-benefits.
- WG2 emphasises strengthening adaptive capacity; WG3 mitigative capacity; it should be discussed how these could be combined.
- While earlier IPCC reports used emissions profiles and emissions scenarios, the TAR tends to shift towards the use of alternative development pathways that affect both mitigation and adaptation.
- Sequestration options for mitigation depend on climate impacts, can affect vulnerability to impacts of climate change and adaptation options.

V. FUTURE WORK AFTER THE EXPERT MEETING

- Concrete suggestions for improvements of the current WG2 and WG3 drafts from a DES perspective should be provided by participants to Ramon Pichs by mid March
- Speakers are requested to submit their papers in electronic format to Ramon Pichs by mid March
- Ramon Pichs, Neil Leary and Rob Swart will develop a draft proceedings by the end of March, consisting of a summary, the submitted papers, and the comments received
- This draft will be circulated to WG2 and WG3 Lead Authors to allow them to take into account the suggestions in their second order drafts
- The draft will also be circulated to all participants of the Havana meeting for comments and suggestions for research directions, due by April 30
- Ramon Pichs, Neil Leary and Rob Swart will work on the preparation of the final proceedings in time for the last Lead Author meetings of WG2 and WG3
- WG2 and WG3 will explore the possibilities of organising a meeting with a selected number of CLAs from both working groups (especially WG2 chapters 1, 18 and 19 and WG3 chapters 1, 2 and 10) in order to discuss the issues identified at the meeting (end of March)