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INTERGOVERNMENTAL PANEL ON climate change

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IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics

Lima, Peru
23-25 June 2011

Meeting Report

Edited by:
Christopher B. Field, Vicente Barros,
Ottmar Edenhofer, Ramón Pichs-Madruga, Youba Sokona,
Michael D. Mastrandrea, Katharine J. Mach, Christoph von Stechow

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Working Group II (WG II) – Impacts, Adaptation and Vulnerability

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IPCC WGII/WGIII Expert Meeting on Economic Analysis, Costing Methods, and Ethics

23-25 June 2011
Lima, Peru

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Preface

Economic analyses are widely applied in research related to climate change. Primary examples are valuation of climate-related impacts, including monetary valuation and use of alternative metrics; consideration of costs, benefits, co-benefits, risks, behavioral dimensions, and uncertainties in the context of adaptation and mitigation options; and economic implications of policy design and instrument choice. There is also a growing body of literature on the ethics of climate change, including on the ethical dimensions of economic analyses. Literature incorporating ethical, behavioral, and economic analyses will be assessed across the chapters of the Working Group II and III (WGII and WG III) contributions to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), and costing and economic analysis are a cross cutting theme identified during the AR5 scoping process. While economic analyses encompass enormous diversity in context, shared fundamentals suggest that common criteria can be applied in the assessment of the resulting literature. To support ongoing AR5 assessment efforts, WGII and WGIII of the IPCC held a joint Expert Meeting on Economic Analysis, Costing Methods, and Ethics in Lima, Peru, from 23 to 25 June 2011. The meeting assembled a diverse set of experts, including WGII and WGIII AR5 authors and review editors, to discuss these topics and the results of existing research.

This meeting report summarizes the content and perspectives presented and discussed during the meeting. It provides summaries of breakout group discussions of key topics and synthetic themes, as well as extended abstracts for keynote presentations at the meeting.

We thank Minister Augusto Arzubiaga and the Ministry of Foreign Affairs of Peru for flawless and gracious hosting of the meeting. The event could not have succeeded without the extensive efforts of Dr. Eduardo Calvo, Pilar Castro Barreda, and Daniel Vidal Aranda. We are also deeply grateful to the members of the Scientific Steering Group, who contributed invaluable expertise and extensive time in developing the meeting's expert content and agenda, and to the meeting participants for their many productive exchanges. Finally, we thank the members of Scientific Steering Group and meeting participants who contributed to the summaries contained in this report.

We are convinced that the presentations and exchanges at the meeting, described in this report, provide important input for the authors of the AR5 and the broader research community. They have stimulated collaboration across WGII and WGIII of the IPCC on this set of cross-cutting topics.

Christopher Field
Co-Chair, WGII

Vicente Barros
Co-Chair, WGII

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Table of Contents

Executive Summary

The Working Group II and III (WGII and WGIII) contributions to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) will assess a broad range of literature employing economic analyses of the costs and benefits of climate change impacts and of adaptation and mitigation response options, and of literature considering associated risks, uncertainties, and behavioral and ethical dimensions of such analyses. To support ongoing AR5 assessment efforts and promote coordination across AR5 author teams, WGII and WGIII of the IPCC held a joint Expert Meeting on Economic Analysis, Costing Methods, and Ethics in Lima, Peru, from 23 to 25 June 2011 to summarize the body of knowledge and highlight key issues related to this important set of topics.

The meeting consisted of three primary activities. First, through thirteen keynote presentations, invited experts provided a synthesis of the state of knowledge on the overarching topics of valuation, decisionmaking under uncertainty, and distributional ethics and equity, identifying both what is known and what key issues and uncertainties remain to be studied. Plenary discussions allowed an opportunity for meeting participants to build on these presentations and draw out additional points. Second, in six Breakout Groups, participants discussed and addressed questions related to cross-cutting themes: (i) valuation of climate impacts and co-benefits, (ii) evaluation of adaptation and mitigation options under uncertainty, (iii) risk assessment and risk perception, (iv) behavioral challenges in linking adaptation and mitigation, (v) considerations of both equity and efficiency, and (vi) ethical dimensions of adaptation and mitigation policies. Finally, the meeting concluded with synthesis presentations and Breakout Groups. The synthesis presentations summarized the perspectives presented during the meeting for the overarching topics listed above, emphasizing the state of knowledge and important open questions. The Synthesis Breakout Groups focused on three of the key issues highlighted during the meeting: (i) social welfare functions, (ii) co-benefits, and (iii) the evaluation of adaptation and mitigation options in the context of different world views.

This meeting report contains short reports written by the Chair and Rapporteur of each Breakout Group and the Chairs of each Synthesis Breakout Group. Additionally, it includes abstracts of all keynote presentations, along with other meeting documentation. Short summaries of the discussions from the Breakout Groups follow, with further details provided in the subsequent sections of this meeting report.

Summaries of Breakout Group Discussions:

Breakout Group I.1: Incorporating non-monetary metrics and co-benefits into valuation of climate impacts *(Chair: Muyeye Chambwera, Rapporteur: Michael Hanemann)*

This Breakout Group report summarizes discussions related to valuation of climate impacts. Participants discussed economic and ethical considerations for valuation methods, including relevant monetary and non-monetary metrics, appropriate aggregation or disaggregation across scales and metrics, and the possible purposes of valuation efforts. They also considered the importance of making explicit the assumptions and associated ethical judgments of research approaches incorporating monetization and/or aggregation of climate impacts.

Breakout Group I.2: Incorporating climate change uncertainty in evaluations of adaptation and mitigation options
(Chair: John Quiggin, Rapporteur: Stéphane Hallegatte)

Analyses of the impacts of climate change can be marked by pervasive uncertainty. This Breakout Group report summarizes participant discussions of how estimates of uncertainty can inform decisionmaking. The group considered methods for incorporating climate change uncertainty in evaluations of adaptation and mitigation policy options, and it focused on risk assessment

approaches for informing decisionmaking under uncertainty, in particular Robust Decision Making approaches. Participants discussed a variety of considerations related to investigating wide ranges of scenarios, including those at the tails of distributions of possible outcomes.

Breakout Group I.3: Linking risk assessment and risk perception with risk management strategies for mitigation and adaptation
(Chair: Elke Weber, Rapporteur: Daigee Shaw)

Risk assessments by experts and perceptions of risk by the public can differ significantly. This Breakout Group report summarizes participant discussions related to approaches for managing risks from climate change through mitigation and adaptation, informed by these differences. The group in particular discussed differences in the perceptions of benefits and costs related to mitigation and adaptation, and the roles of the public and private sectors in developing risk management strategies for mitigation and adaptation.

Breakout Group II.1: Behavioral challenges in linking adaptation and mitigation
(Chair: Howard Kunreuther, Rapporteur: Elke Weber)

Behavioral biases and heuristics affect actions that individuals and firms undertake in response to incentives for adapting to a changing climate. This Breakout Group report summarizes participant discussions related to the characteristics of strategies for linking adaptation and mitigation that can be effective in addressing challenges such as habitual behavior and cognitive myopia. The group also considered aspects of framing and communication that can address these challenges.

Breakout Group II.2: Balancing equity and efficiency considerations
(Chair: Reyer Gerlagh, Rapporteur: Purnamita Dasgupta)

This Breakout Group report summarizes discussions related to treatment of the distribution of impacts and costs and to possible approaches for characterizing distributional differences. The group discussed tradeoffs in reporting aggregate and disaggregated information, as well as alternative categorizations by which to present distributional aspects.

Breakout Group II.3: Ethical dimensions of adaptation and mitigation policies
(Chair: John Broome, Rapporteur: Dale Jamieson)

Participant discussions of ethical issues related to policy design and implementation, building on the presentations and exchanges during the meeting, are summarized in this Breakout Group report. The group discussed the relationship of development with adaptation and mitigation policies, considerations related to focusing on efficiency versus accounting for distributional aspects, and roles for ethical analysis in research on climate change science and policy (e.g., in helping to make value judgments explicit).

Synthesis Breakout Group S.1: Social welfare functions
(*Chairs: John Broome, Dale Jamieson, and Geoff Heal*)

This Synthesis Breakout Group report summarizes participant discussions regarding social welfare functions and associated aggregation issues—in particular the capabilities approach and the Human Development Index (HDI). The discussion focused on options for making the capabilities approach operational and the suitability of the HDI in this context.

Synthesis Breakout Group S.2: Evaluating the co-benefits of mitigation options
(*Chairs: Michael Hanemann and Kirk Smith*)

This Synthesis Breakout Group report summarizes discussions focusing on co-benefits of mitigation actions. The group discussed categories of co-benefits relevant for different sectors and the opportunities for coordination across Working Groups II and III on the assessment of both the mitigation potential and the co-benefits of specific types of mitigation options.

Synthesis Breakout Group S.3: Decision analysis in the context of different world views
(*Chairs: Stéphane Hallegatte and Howard Kunreuther*)

This Synthesis Breakout Group report summarizes discussions regarding the evaluation of mitigation and adaptation options in the context of different world views and levels of acceptable risk. The group discussed different approaches for informing decisionmaking both by formal scientific knowledge and by individual beliefs and preferences. It also highlighted the importance of considering and communicating the assumptions related to world views and values underlying different decision analyses, particularly in the context of assessing literature across Working Groups II and III.

Overall, the Breakout Group and Synthesis Breakout Group summaries contained in this report characterize key topics and cross-cutting themes related to economic and ethical dimensions of research on climate change impacts, adaptation, and mitigation that were presented and discussed at the meeting. The WGII and WGIII Co-Chairs believe that these summaries, as well as the material provided in the report annexes, will provide useful input to the author teams of the AR5, as well as to the broader research community.

Breakout Group Reports

Breakout Group I.1: Incorporating non-monetary metrics and co-benefits into valuation of climate impacts

Chair: Muyeye Chambwera (International Institute for Environment and Development, Zimbabwe)
Rapporteur: W. Michael Hanemann (University of California, Berkeley, USA)

The summary that follows, written by the Chair and Rapporteur, characterizes the main points of the discussion that took place during Breakout Group I.1 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Discussions in the Breakout Group were stimulated by a series of questions focused on cross-cutting themes, developed by the Scientific Steering Group for the meeting.

Although economic valuation is an important, tractable, and tangible approach to valuing (and costing) climate change, monetization of some aspects of current and projected impacts (e.g., those that affect the lives and livelihoods of vulnerable populations or that affect ecosystem goods and services) is difficult and fraught with uncertainty. In such cases, the challenge is determining how to effectively incorporate non-monetary metrics into valuations of impacts, including taking into consideration that stakeholders often assign different values to impacts, co-benefits, and adaptation measures. The discussion in this Breakout Group focused on the following points.

Within the group, there were divergent views about the role of cost-benefit analysis (CBA) and monetary valuation in general, whether based on willingness to pay (WTP) or willingness to accept (WTA), in the assessment of climate impacts. The concerns arose for both technical and ethical reasons. Many of these issues are well known and have often been raised in the past. Yet conventional economic measures continue to be widely employed.

The group discussed the fact that not all impacts can be monetized; the question therefore is what can be monetized and what cannot. The set that can be monetized extends beyond purely market impacts; non-market valuation can be applied to certain use and non-use values associated with non-market items. In the context of economic valuation, the measure of value—WTP or WTA—reflects an implicit judgment regarding the assignment of property rights, and in some cases WTA will be the more appropriate measure. Moreover, ethical issues arise that call into question the notion of comparing and aggregating economic value across regions with great differences in income or material circumstances without some adjustment to correct for those differences. The adjustment could involve some form of extrapolation, for example an adjustment to measure how an average Indian household would value an item if it had the same income as an average European household. Another approach involves the use of utility weights derived from one or more numerically calibrated social welfare functions embodying certain axioms of equity.

The group discussed that the heterogeneity of climate impacts within and between regions, and within and between socio-economic groups, calls for a significant degree of spatial, sectoral, and socio-economic disaggregation in the characterization of impacts. To be sure, the degree of disaggregation may vary because of the differential availability of data, and endless disaggregation leading to too many metrics can cause confusion and reduce transparency. Rather, the goal is to attain a sufficient degree of disaggregation—analogous to the notion of a "sufficient statistic"—so that there can be a meaningful, useful, and transparent characterization of the impacts of climate change. Careful thought also needs to be devoted to weights when aggregating across multiple metrics: using equal weights by default is not necessarily the best approach. In addition, impacts assessment requires a counterfactual: what would be happening without climate change? There may be no easy answer, but without some answer one cannot characterize the impact of climate change. In this

context, the use of one or more scenarios may be very helpful. Whatever metrics and methods are employed, transparency about the methodology, assumptions, and data is important to allow replication.

There was recognition in the group that various assessment efforts have employed non-monetary metrics relevant to the scope of the Fifth Assessment Report (AR5), including the Global Burden of Disease (GBD) Assessment (described in the plenary presentation by Kirk Smith), the Millennium Ecosystem Assessment, and the Global Biodiversity Report, which AR5 author teams may consider in their assessments. In addition, the DALY metric used by the GBD, for example, while not immune to criticism, including some ethical criticisms, satisfies certain ethical axioms, is consistent, and is coherent. Consequently, one can present a transparent explanation of the ethical rationale for the use of this metric, its pros, and its cons. AR5 author teams could potentially use such an approach as a basis for the evaluation of metrics of other types of impacts such as ecosystem impacts.

The group also noted that the economic concept of value is inherently anthropocentric: it reflects the preferences, attitudes, and circumstances of human beings. There is scope for judgment as to which is the set of humans whose preferences should be represented in an economic measure of value; that itself is an ethical judgment on the part of the researcher, which is important to make explicit and to justify. Moreover, economic value is defined at the level of an individual decisionmaker. The method by which *aggregate* value is characterized for a group (e.g., a national measure of value) requires an ethical judgment on the part of the researcher which is also important to make explicit and to justify. A common approach in the general economic literature is to assume a single "representative" consumer, for whom an aggregate measure of value is constructed. But because climate change has such widespread but heterogeneous effects, the assumption of a single representative consumer is unlikely to be appropriate in this context.

Further, the group noted that because the economic concept of value is inherently anthropocentric, it is unacceptable to those who reject the anthropocentric standard of value and adopt, for example, the notion of an intrinsic value for nature. An approach that accounts for this view is to employ multiple metrics when characterizing climate impacts, including both anthropocentric and non-anthropocentric metrics, with the latter used to characterize impacts on nature from an intrinsic value perspective.

Finally, the group discussed the purpose for which measures of climate impact are being developed, with three categories noted. One purpose is to provide some guidance for determining the scale of mitigation policy. A second is to inform the allocation of burdens related to mitigation (e.g., emissions targets, financing burdens) among countries, which could be based partly on the distribution of impacts among countries. A third is to provide some guidance for adaptation strategies, where consideration of impacts could lead to a prioritization of specific adaptation programs. These latter two applications highlight the importance of sensitive accounting for heterogeneity of impacts among different regions and sensitive treatment of inter-personal comparisons of well-being when developing measures of impacts.

Breakout Group I.2: Incorporating climate change uncertainty in evaluations of adaptation and mitigation options

Chair: John Quiggin (University of Queensland, Australia)
Rapporteur: Stéphane Hallegatte (Centre International de Recherche sur l'Environnement et le Développement, France)

The summary that follows, written by the Chair and Rapporteur, characterizes the main points of the discussion that took place during Breakout Group I.2 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Discussions in the Breakout Group were stimulated by a series of questions focused on cross-cutting themes, developed by the Scientific Steering Group for the meeting.

The role of uncertainty in decisionmaking can be approached from multiple perspectives, and this Breakout Group (BOG) discussed several of these aspects.

First, it is important to assess uncertainty in the climate change domain, such as the possible outcomes of a strategy or policy. For instance, with a specific set of assumptions about agriculture and climate policy, what are the possible futures for US agriculture and how uncertain are these futures (with or without probability estimates)? This assessment depends – among other things – on which model and methodology are used, and on which assumptions are made about climate change itself. The uncertainty about future impacts varies depending on the considered systems (e.g., ecosystems, economic sectors, communities). Characterizing the "most likely" outcome is insufficient; it is also important to evaluate the range of possible outcomes and, if possible, their relative likelihoods.

Second, it is important to communicate uncertainty. For example, what are options for reporting different estimates of the projected impacts of climate change on US agriculture, and the uncertainty in these estimates? What are approaches for assessing and synthesizing analyses of policy options in an IPCC chapter, while providing information on relevant uncertainties? Are probabilities the best way to communicate uncertainty in this context, and is there a potential for over-confidence in such probabilities?

Third, it is important to provide information on how uncertainty estimates can inform decisionmaking. For example, how can information on the possible outcomes of a policy inform the decision on whether to implement it? What approaches are appropriate when there is disagreement among experts or when there is no clear information about possible outcomes? This category of questions was the main focus of the discussions in this BOG.

Using uncertainty information to inform decisionmaking

The group discussed several categories of approaches for risk assessment in the context of decisionmaking under uncertainty. A traditional method for risk assessment is based on the concept of risk defined as the probability of an outcome multiplied by its consequences. From this information, various methods (expected utility maximization, option value approaches, etc.) can be used. These approaches all face the same problem: it is often difficult to estimate the probabilities of different outcomes, especially for issues like climate change for which the probability density function of some outcomes can be unknown.

Alternative approaches avoid the use of probabilities. An example is the Robust Decision Making (RDM) approach. The RDM approach searches for policy options that provide an acceptable outcome in as many scenarios as possible (i.e., "robust" solutions), without trying to reach an optimum. Starting from one policy option, the approach entails evaluating the consequences of this policy option under various scenarios (a state-contingent analysis of what will happen), defining what

constitutes an unacceptable outcome, and then adjusting the policy option in order to reduce the number of scenarios in which an unacceptable outcome is reached. A crucial step is the building of the scenario set, which needs to be broad in order to include as many possible futures as possible. In the standard RDM approach, scenarios are built through a combination of stakeholder involvement and modeling.

Generally, there are "residual" scenarios under which an unacceptable outcome is reached, and a decision is needed on whether this residual possibility is acceptable (e.g., based on the perceived plausibility of these scenarios). If this residual possibility is deemed acceptable, the policy is also considered acceptable for implementation.

One issue with approaches that do not use probabilities is that, often, partial information on outcome probabilities is available. More generally, an important criterion for any decisionmaking method could be stated as, "is all the available information used?"

Another approach is to work backward. Instead of starting from probabilities and assessing whether an option is desirable, it is possible to assess the probability (or range of probabilities) of a negative outcome for which an option is desirable. For some options, this probability range may be quite large, essentially addressing the problem of uncertainty about the probability of the negative outcome. An extreme case is the so-called "no-regret option" that is desirable regardless of the probability of the negative outcome.

There are many available methodologies for risk assessment to inform decisionmaking. There is clearly no "best" decisionmaking method; the right choice depends on how much information is available and on the context of the decision.

The special role of worst-case scenarios

The group also noted that in most decisionmaking frameworks, and especially for RDM approaches, one important input is the "worst case scenario"; in probabilistic approaches, an equivalent is the tail of the distribution. This input is critical and particularly difficult to provide, as there is no one approach for defining the worst-case scenario. For example, while global climate models have a relatively narrow range of climate sensitivity, much larger values are considered "non-impossible," and there is no agreed "maximum" that can be used as a "worst-case" to inform the selection of a target for atmospheric greenhouse gas concentrations. The selection of a "worst-case" goes beyond what scientific research can provide, but scientific research can provide information about outcomes "in the tails," and thus about possible worst-case scenarios.

Iterative approach

The group discussed that a "learn and act approach" can be a fragile strategy in the context of potential climate "surprises" (e.g., abrupt climate changes). Regardless, delaying decisions is often impossible. For instance, many infrastructure investments will be made in the coming years in developing countries, and the question is "how to do it" not "whether to do it." Therefore, the learn-and-act option can be difficult to apply in practice. "Act and learn and act" (i.e., early action with learning and iterative adjustment) can be a more robust solution, but one that can be more costly. One approach in this context is to minimize the potential for regret (another way to define a robust decisionmaking approach).

Other dimensions

The group also discussed other important dimensions of this issue, including approaches for identifying priority areas for research aimed at reducing uncertainties and types of uncertainty that have received less attention in climate research. This latter category includes "value" uncertainty

(i.e., uncertainty regarding how components of human and natural systems are valued) and the connection with ethics in this context. In the philosophy literature, this is referred to as "moral uncertainty."

Conclusion

Analysis of the risks posed by climate change and policy options to address those risks requires information on a wide range of future scenarios, including those at the tails of the distribution of possible outcomes. The group acknowledged the difficulty associated with investigating these extreme cases, but agreed that such research is critical for policy analysis.

Breakout Group I.3: Linking risk assessment and risk perception with risk management strategies for mitigation and adaptation

Chair: Elke U. Weber (Columbia University, USA)
Rapporteur: Daigee Shaw (Chung-Hua Institution for Economic Research, China)

The summary that follows, written by the Chair and Rapporteur, characterizes the main points of the discussion that took place during Breakout Group I.3 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Discussions in the Breakout Group were stimulated by a series of questions focused on cross-cutting themes, developed by the Scientific Steering Group for the meeting.

Risk assessment evaluates the chances of a specific set of events occurring and/or their potential consequences with descriptions of uncertainty with respect to these estimates. Risk perception is concerned with the psychological and emotional factors that affect behavior. This Breakout Group was asked to focus on the roles of the public and private sectors in developing risk management strategies for mitigation and adaptation, taking into consideration how experts assess risks and how laypersons perceive risks. The discussion focused on three questions.

What are the advantages and disadvantages of different types of risk assessments for developing mitigation and adaptation strategies?

There are many different types of risk assessments (RA), which can be categorized in different ways, including the distinction of whether the RA assesses the probability of key events (typically with adverse consequences) or whether it attempts to combine some assessment of the probabilities with some measure of the (dis)utility of consequences (e.g., risk as variance, as in finance). Some of these assessments are observation-based, others are model-based. Another distinction can be made between assessing risk levels and assessing or inferring acceptable levels of risk. One problem with acceptable levels of risk is the inconsistency in levels of acceptable risk between different risk domains within a given country, such as across different government agencies. Yet another distinction can be made between assessments of objective risks (typically involving probabilities of key events) versus assessments of subjective perceptions of risk (typically influenced by more than likelihood of occurrence, including affective responses to event occurrences and other psychological risk dimensions). Subjective risk assessments also tend to be culture-specific, influenced by social values and predominant social structures.

The group noted that a comprehensive table of existing types of RA methodologies and metrics, listing their characteristics as well as advantages and disadvantages for developing mitigation and adaptation strategies would be useful. All RAs have a need for data monitoring to provide information for the assessment of probabilities and consequences of climate variables and climate change's impact variables. These data are typically not available for developing countries (DCs), and few RA studies have been performed there, suggesting the need for RA studies in DCs.

How is the public likely to perceive the benefits and costs of alternative mitigation and adaptation strategies for avoiding, preparing for, and coping with the impacts of climate change?

The group discussed that the assessment of risks that lead to adaptation strategies can occur very naturally, when climate risks that require protective action present themselves. RAs related to mitigation strategies are harder to motivate, because—at least in developed countries—such risk assessments tend to be model-based, focusing on the severity of projected adverse climate impacts. People react far less to pallid statistical RAs than they do to personal experience (eyewitness testimony) of adverse events.

The group also noted that the benefits and costs of alternative climate change mitigation and adaptation strategies are also perceived very differently by the public. The costs of mitigation strategies are generally perceived to be greater than their benefits, but the costs of adaptation strategies are generally perceived to be smaller than their benefits. One reason for this asymmetry is that the benefits of mitigation strategies are shared by the global public, and the costs are personal/local. For adaptation actions, on the other hand, both benefits and costs of adaptation strategies are more likely to be personal/local. While for both adaptation and mitigation, costs are incurred upfront, benefits come later and typically in small installments over a long period of time. This pattern can be more extreme for mitigation than adaptation responses; for adaptation, benefits of action typically become apparent faster and up-front costs can be lower.

Based on the previous questions posed, what are the characteristics of effective risk management strategies for encouraging mitigation and adaptation measures for reducing the impacts of climate change in the short and long-term?

The group discussed that because of the differences in their perception of benefits and costs mentioned above, both governments and the public can be more willing to take actions to adapt to climate change than to mitigate. Senior governments (national and state governments) can be more reluctant to manage climate change risks through mitigation and adaptation strategies than local governments, because costs are usually borne by senior governments and benefits are uncertain and come later. The public's perception of benefits and costs mentioned above is an important factor too. Pressure from the public can make government officials weigh economic growth more than environmental protection in order to be elected or reelected. The commonly observed approach of "not in my term of office" leads to a short-term focus and prevents politicians from taking immediately costly actions that create long-term benefits.

It is commonly found in developed and developing countries that relocating communities away from highly vulnerable areas such as flood plains, coastal areas, and mountain slopes, as well as stopping risky activities that have negative spillover effects, can be very difficult even when complementary mechanisms are used to motivate people, such as economic incentives and free new housing and public facilities. Compulsory regulations are often required, but the unpopularity of such measures makes governments reluctant to pass such regulations.

The group discussed potential solutions drawn from the literature to address public and government reluctance to embrace climate risk management strategies related to adaptation and especially mitigation, such as reducing the perceived or actual up-front costs. Reframing adaptation or mitigation action as risk insurance is another potential approach, including increasing the availability of climate risk insurance in DCs.

The group raised the point that, in general, public response to climate risk management options is far from rational. For example, even a simple adaptation strategy such as disclosing risk information through publishing local risk maps is not very popular because it will bring negative impacts on the property values in the risky areas. Thus, government agencies are usually reluctant to publish risk maps. Of course, governments may not have the necessary information to create risk maps (especially in DCs), or may not know how to communicate climate change risks effectively even though they do have the information, suggesting benefits from developing the capacity of risk assessment and risk communication in DCs.

The group noted that high initial costs—especially in developing countries—are often a barrier keeping people from taking personally beneficial adaptation and mitigation actions (such as using energy-saving lighting and adding insulation to existing houses), suggesting that integrating existing risk management activities in different government agencies at every level of government into a more unified risk management framework could be beneficial. In this context, it could also be beneficial to consider climate change risk management with other risks that are managed in a unified framework.

Climate risk management initiatives that have co-benefits that address other local governmental goals can increase the attractiveness of such mitigation or adaptation actions. An independent climate change risk management agency could benefit from incorporating various stakeholders into the risk management and decisionmaking process in order to create private-public cooperation among stakeholders, rather than employing a top-down approach.

Breakout Group II.1: Behavioral challenges in linking adaptation and mitigation

Chair: Howard Kunreuther (University of Pennsylvania, USA)
Rapporteur: Elke U. Weber (Columbia University, USA)

The summary that follows, written by the Chair and Rapporteur, characterizes the main points of the discussion that took place during Breakout Group II.1 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Discussions in the Breakout Group were stimulated by a series of questions focused on cross-cutting themes, developed by the Scientific Steering Group for the meeting.

Behavioral heuristics and biases affect actions that individuals and firms undertake in response to incentives for adapting to a changing climate. Tendencies to maintain the status quo, focus on short-term benefits and costs, and misperceive risks are normally not considered when characterizing economically rational choices of individuals based on neoclassical models. As a result, the prescribed policy options do not maximize social welfare. Mitigation and adaptation policies will benefit from considering the biases that may occur when making choices with respect to climate change and thus will better reflect the way people actually behave. This Breakout Group was charged with discussing the characteristics of strategies for linking adaptation and mitigation that can be effective in addressing behavioral challenges. The discussion focused on three questions.

What impact do behavioral heuristics and biases have on the evaluation and ranking of specific mitigation and adaptation measures with respect to climate change?

The behavioral obstacles to appropriate responses to climate change discussed by the group included: (a) the habitual nature of much of human behavior, making interventions that change the incentives for different actions (e.g., via prices or taxes) relatively ineffective, because the actions taken are not the result of rational deliberation; (b) human cognitive myopia, arising from insufficient attention and processing capacity (bounded rationality), which leads to an often excessive focus on the here and now and on oneself and those close to oneself (versus people distant in space and time, including future generations), which in turn leads to such behavioral phenomena as excessive discounting of future cost and benefits, as well as to loss aversion and a status quo bias; and (c) human needs and goals similarly focus more on the here and now (e.g., physical safety, food and shelter, immediate survival, employment), so that more abstract goals (e.g., sustainable development, long-term stabilization of greenhouse gas concentrations) get less allocation of either attention or resources.

With respect to obstacle (a), the group discussed that adaptation and mitigation responses to climate change pose similar challenges and both involve behavior change, that is the unlearning of old habits and/or the establishment of new habits. Habits that may have been based on sound reasoning or cost-benefit analysis when they were originated (e.g., the QWERTY keyboard that was designed to minimize the entanglement of keys on manual typewriters), often are no longer optimal behavior in new contexts (e.g., when typing on computer keyboards), but people and institutions will resist change, because change requires effort and may require additional investment (e.g. the cost of a newly designed keyboard). Because the young do not have firmly established existing habits that need to be "unlearned," environmentally responsible behavioral patterns are far easier to establish in the young. Analogies to this might exist for the use and acceptance of new, green technology. For example, despite a large and expensive social marketing campaign by Walmart, compact fluorescent bulbs in the US still capture only a small market share, because people exhibit a strong status-quo bias in favor of conventional incandescent light bulbs. Uptake of compact fluorescent bulbs is far larger in India, where the government has been promoting their use since 2009, perhaps in part because many previously rural consumers have less of a history with incandescent bulbs.

Crises can also be learning opportunities. They often impose short-term constraints on existing

behavior, forcing change in the short-term that with sufficient practice carries over into the future where these constraints may no longer exist. New habits can become established. Examples raised by the group of such crises that lead to long-term behavioral change come from Juneau, Alaska, where severed power lines required the community to subsist on a fraction of their previous energy budget for an extended period of time, but where energy savings of up to 30% persisted after all power lines were repaired. Similar examples have been reported in Brazil with respect to energy use, and from Australia with respect to water use after a drought, i.e., the effect appears to generalize across cultures. A related example on a smaller scale comes from Washington DC, where use of the subway (Metro) has risen significantly when gas prices increase, but has not decreased as much when gas prices go down again.

With respect to obstacle (b), the group noted that it can be useful to compare the costs and benefits of adaptation responses to climate risk in terms of repeated and extended exposure to such risks. The benefits (which are small over any given period) accumulate over time and may dwarf the more immediate up-front costs.

With respect to obstacle (c), the group discussed that one approach is to develop and emphasize the co-benefits of adaptation- or mitigation-relevant decisions at the individual level, and/or to help people achieve their more immediate goals by other means. People, for example, drive Sport Utility Vehicles, even though gas is expensive, to satisfy other goals (e.g., status, the need for off-road travel) and because of lack of knowledge about negative externalities.

People are often reluctant to focus on climate risks, because of other, seemingly more pressing concerns. This also can be addressed, at least in part, with a more integrated approach to risk management that ties climate risks and climate change risk management goals to other risks and goals. Incentives, including co-benefits, will differ for individuals, firms, and politicians, but the general point about the importance of considering co-benefits in an integrated decision and risk management frameworks holds at all levels.

More generally, the group also discussed the example of transportation decisions made by individuals and households for mitigation, where there have been successes but also failures or problems. Public transportation, for example, tends to be taken up by people who used to walk, not those who used to drive, since the latter are unwilling to give up the comfort, safety, and status associated with driving. Policy actions can make public transportation more attractive either directly or indirectly. Dedicated bus lanes that allow reliable and fast travel during rush hours can do so, helping people achieve efficiency and punctuality goals. Regulations that restrict car use (e.g., to even or odd days) have also been employed, but can be problematic because they can be circumvented (e.g., by obtaining additional license plates for cars).

Based on our understanding of behavior, how can one frame climate change and develop alternative strategies so as to link cost-effective adaptation measures with mitigation strategies?

The group agreed that even though many challenges are common to adaptation and mitigation responses, there are also many important differences between them. Thus, there are arguments both for and against the linking of adaptation measures and mitigation strategies. On the one hand, there is evidence accumulating that, on a local level, adaptation planning helps to inform people and governments about climate change risks, which in turn drives home the costs of climate change and thus creates or increases willingness to commit to mitigation strategies. On the other hand, linking the two types of actions can be difficult, as beneficiaries are harder to identify for mitigation than for adaptation actions. There are obvious tragedy-of-commons issues with mitigation, and it is easier to overcome free-rider issues at the local rather than global level.

One step can be to use multiple interventions or policy instruments in parallel. It is also important to know that it matters how information about choice or action alternatives and their consequences are

presented to decision makers (framing) and who the messenger is (trust issues). The group noted that there is a body of behavioral science literature related to these issues, reviewed in part in the plenary presentation by Elke Weber.

While behavioral-science based tools for persuasion that influence and shape decisions are sometimes depicted as "manipulation," it was the sense of the group that there is no value-neutral way to present any kind of information, as there is an implicit shaping of choice in any communication. In addition to these indirect forms of persuasion, more direct forms of social pressure, using social norms and moral persuasion exist (e.g., appeals to do the right thing, or do what people approve of). Social norms regarding energy use (or even more generally regarding contributions to public goods) clearly differ in different regions of the world, and can be shaped in different ways.

Group deliberations on these topics can be summarized by the following hypotheses about action: (a) economic incentives are necessary but not sufficient; (b) co-benefits across multiple sources of risk or management strategies can be utilized; and (c) myopia means that long-term adaptation and mitigation are difficult, and iterative actions that promote economic opportunities can be beneficial.

Given that there is a tendency for individuals to be myopic, are there ways to develop long-term contracts with short-term incentives for encouraging the adoption of cost-effective adaptation and complementary mitigation strategies?

One response discussed by the group to the myopia of individuals focusing excessively on the short-term costs of adaptation or mitigation strategies lies in both public and private mediation, as well as public-private partnerships, noting that examples were given in the plenary presentation by Howard Kunreuther. Insurance companies are one example of public-private partnerships, with building codes encouraging protective action (e.g., against fire or earthquakes) and the insurance industry then providing lower premiums when adaptive action is taken. Another example is governments providing backstops to large losses through reinsurance to allow insurance companies to take on adaptation or mitigation steps. To encourage mitigation efforts like greater investments in energy efficiency, energy companies (public or private utilities) can play an intermediary role, paying for the investments up front and collecting the benefits down the road. Similarly, appliance manufacturers could turn from providers of goods into providers of services (e.g., selling refrigeration rather than refrigerators), reaping the financial benefits from leasing rather than selling the equipment.

Solutions can benefit from adjustment for different contexts and different needs in different regions of the world, taking into consideration especially differences between developed and developing countries. One example of this is the effectiveness of as well as limitations of relying on regulation in developed versus developing countries. Whereas regulation in the domain of building codes clearly works to reduce vulnerability to earthquakes (e.g., comparing the impacts of recent major earthquakes in Chile and New Zealand versus Haiti), they are often not enforced (e.g., as in the case of seismic codes for buildings). The group indicated that it may not be feasible to advocate regulatory changes in building codes in countries where they are not currently in place and where corruption could make such codes ineffective, suggesting a need for creative alternative solutions.

Breakout Group II.2: Balancing equity and efficiency considerations

Chair: Reyer Gerlagh (Tilburg University, Netherlands)
Rapporteur: Purnamita Dasgupta (Institute of Economic Growth, Delhi, India)

The summary that follows, written by the Chair and Rapporteur, characterizes the main points of the discussion that took place during Breakout Group II.2 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Discussions in the Breakout Group were stimulated by a series of questions focused on cross-cutting themes, developed by the Scientific Steering Group for the meeting.

Climate change potentially involves a large-scale redistribution of human welfare across space and time. Some regions will in the future acquire a climate more favorable to agriculture, while other regions may see decreasing agricultural yields, with corresponding shifts in the location of agricultural production and other important economic activities. Furthermore, responsibilities and costs for mitigation and adaptation are unequally distributed through space. This Breakout Group (BOG) discussed the scholarly literature about characterizing and treating the distribution of impacts in economic analyses of climate change, and the effects of different approaches on the conclusions that are typically reached.

Description of discussions in the BOG

The group was unanimous in its appreciation of the importance of the topic. The discussion was initiated around four broad concerns:

- How do we present impacts/consequences of climate change in a manner that captures distributional concerns?
- Can costs be disaggregated?
- If costs can be disaggregated, then by what approach?
- Loss aversion: should a loss count the same as a gain?

The group discussed the fact that aggregate information is often more easily available and lends itself more readily to analysis. In terms of operationalization, separation of efficiency and equity may be constrained. Trade-offs are always faced, and therefore need to be reported clearly. There are trade-offs in terms of the amount of information that can be practically reported. However, without disaggregated information, it is difficult to address issues of equity adequately. Therefore it is important to qualify aggregate information with distributional aspects.

It can be desirable to present measures to capture equity aspects alongside those of efficiency. These may either take the form of summary or aggregative indicators, or may map the distributional aspects through a set of indicators where summary information is lacking.

In presenting impacts and consequences of climate change, the group noted that issues of boundaries for defining distributional aspects arise. These may call for distinction at different levels such as by sector (e.g., agriculture, health, water); by national, regional, or international divisions; or by subnational distinctions (e.g., rural versus urban, income distribution), since costs and benefits accrue differentially across alternative categorizations. Distinguishing between adaptation and mitigation costs in the discussion of distributional aspects can be useful, since the underlying approaches to each differ.

The group felt that some uniformity of language could be desirable for taking forward the discussion on distributional issues in the context of the Fifth Assessment Report (AR5). Without making specific suggestions for standardized language or format, the group suggested that attention be given to whether costs and benefits are evenly or unequally spread, and what the main boundaries are over

which inequalities arise. For example, it can be relevant to know whether costs/gains correlate systematically with some groups, and to assess possible issues of asymmetric valuation related to loss aversion.

The group noted that reporting measures that capture disaggregation are desirable, and suggested that AR5 author teams consider developing lists of units/categories/measures most relevant to their respective chapters. Characterizing distributional aspects can include consideration of quantitative indicators such as Gini coefficient or diversity indices, simpler representations/groupings such as quintiles or inclusiveness indicators, and/or more qualitative and indicative comparisons such as major losers and gainers.

Breakout Group II.3: Ethical dimensions of adaptation and mitigation policies

Chair: John Broome (University of Oxford, United Kingdom)
Rapporteur: Dale Jamieson (New York University, USA)

The summary that follows, written by the Chair and Rapporteur, characterizes the main points of the discussion that took place during Breakout Group II.3 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Discussions in the Breakout Group were stimulated by a series of questions focused on cross-cutting themes, developed by the Scientific Steering Group for the meeting.

There are many ethical issues associated with adaptation and mitigation policies. This Breakout Group (BOG) focused on what the scholarly literature says about ethical issues related to policy design and implementation. Questions to be addressed in this BOG included:

- What are the criteria for fairness in distributing the burdens of mitigation and adaptation?
- What does the literature suggest should be the appropriate way of combining concern for economic efficiency with issues of justice? Should policy on climate change be directed only at achieving efficiency by correcting the externality, or should it also accept a distributional aim?
- What impact do issues of justice and other ethical dimensions have on the evaluation of the costs and benefits of proposed adaptation and mitigation policies?
- Are there specific adaptation and mitigation policies that one would not consider implementing due to considerations of fairness and other ethical issues?
- How can changes in population be taken into account in valuations of climate impacts?

A first theme of the discussion was on the boundaries of the questions above, and whether the focus should be on development rather than adaptation and mitigation to climate change. The group discussed whether adaptation funding is charity and therefore subject to conditionality, or whether it is a matter of justice and therefore can be spent at the discretion of the beneficiaries. The group also discussed whether existing inequities should be taken as given, or whether adaptation/mitigation spending should be used to try to rectify them. The group noted that such responses can be an inefficient way of reducing pre-existing inequalities and that adaptation/mitigation spending benefits from taking non-climate change factors as fixed points that are part of the background.

A second theme of the discussion was focusing on efficiency versus taking distribution into account in a policy context. The group discussed whether it was ever possible to avoid distributive matters, considering some precedents including spending on the Millennium Development Goals. The group noted that the question can be approached from a different angle. Climate change is an externality, so addressing the problem will result in a benefit to distribute. Such a perspective reframes the problem from one of cost allocation to one of benefit allocation, since in principle it is possible to address the problem without anyone sacrificing. The difference between climate change and a typical problem analyzed by cost-benefit analysis is the question of distribution among generations. People in the future will gain most of the benefits from people in the present internalizing externalities. One way people in the present can claim a share of the benefit is by controlling externalities with borrowed money or by compensating themselves in other ways. It was pointed out that building up debt also does damage along the way. Questions were also raised about what the baseline is for intergenerational justice, about grandfathering, and the importance of stability of expectations. This led to discussion about the need for an ethics of transition and about some paradoxes of low discount rates.

Several other topics were discussed by the group in less detail. The first of these was procedural justice, with the group noting that much of the discourse about ethics and justice tends to focus on outcomes and neglect questions about the procedures by which outcomes are arrived at. Another

was the scale at which ethical concepts are applied. The group discussed ethics as it applies at scales from individuals to firms to governments, and there was agreement that it was important to disaggregate ethical concerns.

The group also considered whether there were specific adaptation/mitigation measures that ethics ruled out, agreeing that it was obvious that there were, an example being forced sterilization. Finally, the group discussed population and consumption, agreeing that changes in population and consumption must be taken into account as part of the ethics of mitigation/adaptation. Population matters to climate change in a number of ways, including the fact that there are ethical questions about the goals and implementation of population policy.

The BOG discussion ended with a sense that one of the most important roles for ethical analysis is to make value commitments explicit, not only in economics, but also in the physical science of climate change. The concept of global warming potential was mentioned specifically in this regard. The group also agreed that concepts such as historical responsibility, efficiency, capacity, are important to this discussion. Finally, the group observed that ethical responsibilities to animals and non-human nature are often neglected in discussion of climate change.

Synthesis Breakout Group Reports

Synthesis Breakout Group S.1: Social welfare functions

Chairs: John Broome (University of Oxford, United Kingdom), Dale Jamieson (New York University, USA), Geoff Heal (Columbia Business School, USA)

The summary that follows, written by the Chairs, characterizes the main points of the discussion that took place during Synthesis Breakout Group S.1 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Each Synthesis Breakout Group was asked to consider a key topic emerging from the plenary presentations and meeting discussions, as well as any corresponding suggestions for author teams across the contributions of Working Groups II and III to the Fifth Assessment Report.

This Synthesis Breakout Group (BOG) was asked to consider social welfare functions and in particular the capabilities approach to social welfare. Time did not permit consideration of social welfare functions in general; most of the time was devoted to discussion of the capabilities approach and the Human Development Index (HDI).

A social welfare function specifies how good a state of affairs is for a society, on the basis of how good it is for individuals, or perhaps on the basis of some other property of individuals such as their capabilities. That is to say, it aggregates properties of individuals to determine the goodness of a state of affairs. The Synthesis BOG aimed to discuss, first, alternative views about what property of individuals should be aggregated in a social welfare function, and, second, about the form of the aggregation function.

The group started with a discussion of the capabilities approach. According to this approach (developed by Amartya Sen), the property of individuals that should be aggregated is their capabilities. A person's capabilities consist of what she can achieve, or what she is free to achieve. Capabilities do not necessarily encompass all aspects of a person's welfare, but according to the capabilities approach, they are what a society should care about, or what it should value. An individual is free to make of her capabilities what she chooses, and that is no concern of society. The approach is not concerned with the welfare of the people but with their capabilities.

The group considered options for making the capabilities approach operational and, in particular, how a person's capabilities can be measured in practice. In this context, the group discussed the HDI, which has been adopted by UNDP and is intended to measure the state of capabilities in a country. It is a very simple index made up of three components: income per capita, life expectancy, and the average number of years of education received. In recent versions of the HDI, each component is adjusted to take account of societal inequality. For instance, if education is unequally distributed, the figure for average education is adjusted downwards. This is achieved by basing the index on the logarithms of the three components, rather than on a linear function of the components. The index is the unweighted sum of the three logarithms. This means, in effect, that the weights given to the three components are arbitrary.

The group noted that practical details of the index have been altered over time, so that comparisons across time are unreliable, and that the index is calculated by different means in different countries, according to what data are available. This makes it difficult to make international aggregations or international comparisons. The group also recognized that many people in societies – for example many indigenous people – are not well enough connected to the market economy to fall within the scope of the HDI.

The issue of aggregation across individuals, which a social welfare function is supposed to achieve, is suppressed in the HDI, since the HDI is calculated on the basis of aggregate national data. The group noted that there are other questions about aggregation, however. One is aggregation across time (e.g., whether it would be appropriate to discount the HDI). Another is the weighting of the three components. The HDI is very widely accepted, and constitutes a well-recognized standard. This gives the weights that are used some sort of support on grounds of convention, even though they are arbitrary. It was the sense of the group that there has been no real attempt to justify the weights that are used, or to find other justifiable weights, and that this is a shortcoming in the index.

The group then considered how one might set about justifying weights. A subjectivist approach, standard in economics, would base the weights on people's preferences among the three components of the index: income, longevity, and education. But it was pointed out that in reality, many people do not have the opportunity to choose between these components, so their preferences cannot be expressed. Thus, an objectivist approach to the justification of the weights may be needed, but it is unclear how an objectivist justification might be developed.

The group also considered the HDI in relation to conventional cost-benefit analysis (CBA), which is founded on monetary values. The group discussed that CBA can make use of distributionally weighted rather than unweighted monetary values, and it was pointed out that the HDI could be used to determine weights. But it was noted that since the weights contained in the HDI have not been justified, this does not seem a promising direction for determining distributional weights.

Synthesis Breakout Group S.2: Evaluating the co-benefits of mitigation options

Chairs: Kirk R. Smith (University of California, Berkeley, USA), W. Michael Hanemann (University of California, Berkeley, USA)

The summary that follows, written by the Chairs, characterizes the main points of the discussion that took place during Synthesis Breakout Group S.2 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Each Synthesis Breakout Group was asked to consider a key topic emerging from the plenary presentations and meeting discussions, as well as any corresponding suggestions for author teams across the contributions of Working Groups II and III to the Fifth Assessment Report.

This Synthesis Breakout Group (BOG) was asked to discuss co-benefits, in the context of actions that are taken to mitigate climate change that have significant benefits of other types for society. Although there is no mitigation action that does not have at least some influence on other sectors, co-benefits activities are those in which there is sufficient impact to be considered an intervention in their own right for those sectors. Thus, evaluation of side-effects or life-cycle impacts of mitigation options, which are important to understand in themselves, are not per se co-benefits analyses. The dividing line between a side-effect and a co-benefit is not easily defined, but is informed by whether the action might be considered alone as an intervention in that sector without its climate mitigation potential. This implies than when a climate mitigation action has a negative impact on another sector, it is not a co-benefit of a different sort. It is an untended consequence or negative side-effect.

The group discussed the fact that there are a number of sectors for which actions with co-benefits are potentially important. This includes mitigation actions that have benefits for protecting human health, biodiversity, energy security, income, gender equity, and so on. The group agreed that a reasonable starting point for a listing of major benefit categories would be those used in the Millennium Development Goals, which serve as an international consensus of what is important for society to achieve in the next decades. To these, the group added energy security in recognition of the distinctive issues associated with the supply of oil and natural gas, major sources of carbon emissions. In summary, this list encompasses improvements in

- Poverty reduction
- Hunger reduction
- Education
- Gender equity
- Health
- Environmental sustainability, including ecosystem protection
- Global partnership
- Energy security

The group agreed that comprehensive assessment of mitigation actions with co-benefits involves author teams across Working Groups II and III, as this includes evaluation of both the non-climate and climate benefits of mitigation actions. Thus, collaboration between the Working Groups can minimize gaps, overlaps, and inconsistencies. This issue was discussed in the Synthesis BOG with the general feeling that the assessment of the co-benefits of mitigation actions could occur in the appropriate chapters of Working Group II, with the mitigation potential of those actions assessed in Working Group III.

To do this effectively, however, the group recognized that it would be beneficial for there to be a mechanism through which Working Group II and III author teams discuss the co-benefits actions included in each Working Group assessment. In addition, there are framing issues when conducting such analyses that might be considered through such a mechanism. The group did not, however,

propose specific elements of such a mechanism. Finally, the group suggested that, perhaps as part of the Synthesis Report, the full co-benefits assessment might be combined in one location, bringing information from the contributions of both Working Groups II and III.

Synthesis Breakout Group S.3: Decision analysis in the context of different world views

Chairs: Stéphane Hallegatte (Centre International de Recherche sur l'Environnement et le Développement, France), Howard Kunreuther (University of Pennsylvania, USA)

The summary that follows, written by the Chairs, characterizes the main points of the discussion that took place during Synthesis Breakout Group S.3 at the IPCC Expert Meeting on Economic Analysis, Costing Methods, and Ethics. Each Synthesis Breakout Group was asked to consider a key topic emerging from the plenary presentations and meeting discussions, as well as any corresponding suggestions for author teams across the contributions of Working Groups II and III to the Fifth Assessment Report.

This Synthesis Breakout Group was asked to consider approaches for evaluating mitigation and adaptation options in the context of different cultures and actors with different world views, which can lead to different levels of acceptable risks.

As a starting point, the group noted that there is an important difference between mitigation and adaptation. Mitigation is a global issue; there will be a single trajectory of greenhouse gas emissions for the world. International policy negotiations have aimed for a strategy that considers the many different world views and takes into account different levels of acceptable risk. Adaptation, on the other hand, is at least partly a local issue, and actors in different locations can make decisions about their own level of acceptable risk, as a function of both their own considerations as well as their world views. Adaptation also has a global component, however, especially in the context of international support. Defining what risks are acceptable is likely to play a role in determining which adaptation projects are eligible for international support.

To account for differences in world views in decisionmaking, the first question to ask is: Who are the stakeholders and decisionmakers—for whom and by whom are decisions being made? The group also felt that an interesting distinction can be made between "top-down" decisionmaking and "bottom-up" decisionmaking.

In a bottom-up approach, the community-based adaptation literature focuses on participatory approaches to finding solutions for adaptation and other environmental problems. Even though it uses scientific information and expert knowledge, this approach gives a heavy weight to stakeholder beliefs, preferences, and choices. It is often criticized for not being "scientific enough," or relying on choices made by stakeholders who do not have all the information. It may lead to marginal-change solutions, or be viewed as inapplicable when problems are too complicated or the number of stakeholders too large.

On the other hand, the cost-benefit analysis (CBA) approach is carried out in a top-down manner, often by experts. Even though it can take into account local context and stakeholders' world views, this approach gives a heavy weight to scientific information and analytical calculation. It is often criticized for not considering behavioral or organizational changes and for recommending strategies that are inapplicable or inconsistent with local needs.

The group discussed comparing bottom-up and top-down approaches and questions raised about the differences between individual decisions and collective decisions. At the individual level, people use more than probability and consequences to make risk-related decisions; they rely on emotion, perception, and ethical aspects. For instance, they treat risk differently depending on whether risks are perceived to be voluntary or involuntary. Different actors may treat risks very differently depending on their culture, knowledge, training, etc.

When collective decisions are required, the question arises as to whether a decisionmaker should take these other aspects into account, or whether they should consider them as biases of individual

behavior that should be ignored. More generally, the question is how to infer social welfare functions (that can be used for collective decisions) from individual behaviors (that can be observed).

This discussion led to questions about how to communicate about risk and to inform decisionmaking, beyond providing estimates of probability and consequences. For example, does science have a role in providing information about the emotional impacts of climate change on individuals? It was the sense of the group that in general, IPCC assessments produce formal scientific knowledge that informs top-down decisionmaking approaches. It is unclear what the role of IPCC assessments are in informing more bottom-up approaches that rely more on local, informal knowledge and people's preferences and beliefs.

The group recognized that any decision analysis benefits from being extremely clear about the assumptions of the analysis, including those related to world views, values, and beliefs; risk perception; and types of data and information considered. In addition, in the same way that decisionmaking can benefit from taking uncertainties into account (e.g., multiple possible futures), it can also benefit from accounting for multiple world views.

The group noted that some have proposed methodologies to include uncertainty in formal decisionmaking (e.g., CBA with uncertainty, option value theory, robust decisionmaking). Similarly, decisionmaking approaches could be proposed that are able to include the multiplicity of world views and help reach a consensus on one acceptable course of action. It is unclear, however, whether this is possible when very different world views have to be accommodated (especially for an issue with large-scale ethical issues like climate change).

In the construction of scenarios, the Robust Decision Making approach requires each actor to recognize that he or she might be misguided and that others may have a more appropriate outlook on how to approach the problem. It proposes to use many scenarios, representing the beliefs of all actors, and look for solutions that work for all actors. The group discussed whether it might be possible to take a similar approach for world views: asking all actors to recognize that other world views are legitimate and that the solution needs to be acceptable for other world views.

In conclusion, the group agreed that many decisionmaking methods exist and that no method can be ranked "best." Various options are available to inform decisionmaking by both formal scientific knowledge and by individual beliefs and preferences. Designing a decisionmaking method able to encompass very different world views is still an open research question. The group placed great importance on reporting the world views, values, and other assumptions that are used in different analyses, suggesting that author teams across the contributions of Working Groups II and III to the Fifth Assessment Report (AR5) could also include such information when reporting results of relevant analyses as part of their assessment. Finally, the group suggested that it would be useful to incorporate research on people's beliefs and preferences and on methods to use this information in the AR5.

Annex 1: Meeting Proposal

ipcc

INTERGOVERNMENTAL PANEL ON climate change

THIRTY-FIRST SESSION OF THE IPCC
Bali, 26-29 October 2009

IPCC-XXXI/Doc.10
(12.X.2009)
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SCOPING OF THE IPCC 5TH ASSESSMENT REPORT

Expert Meetings and Workshops

(Submitted by the IPCC Secretariat)

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WMO UNEP

Proposal for an IPCC Expert Meeting on
Economic Analysis, Costing Methods and Ethics

(Submitted by the Co-chairs of Working Group III and II for the
31st Session of the IPCC Plenary, Bali, Indonesia, October 26-29th, 2009)

1. Background

As laid out in part D of the output document from the scoping meeting in Venice, Italy (13-17 July 2009) and in part C of the scoping document provided to the current Plenary Session (IPCC-XXXI/Doc. 4), a number of Cross-Cutting Methods (CCM) and Cross-Cutting Themes (CCT) have been identified. One of the CCMs concerns the economic analyses that play a major role in WG III as well as in WG II.

At the Venice meeting, the need to clarify a number of cost concepts and their underlying rationale emerged. In particular, this includes problems with representing climate impacts in monetary and non-monetary terms, and with aggregating benefits and costs and the implications for cost-benefit-analysis (CBA) and other methods. Furthermore, the ethical dimensions of estimating costs of mitigation, adaptation and residual damages need to be assessed.

2. Aim of the Meeting

The aim of the meeting is to congregate a diverse set of views and to make suggestions for how assessment frameworks can be created. In particular, the meeting will address:

- Identifying and comparing metrics
  - Multidimensional metrics for evaluating damages; key dimensions of characterising damages.
  - Metrics of mitigation costs: balanced growth equivalents, net present value and beyond
  - Economic implications of global warming potentials
- Measuring risk and valuing information
- Technical change: opportunities, incentives and past evidence
- Adaptation as an economic process
- Integrated assessment -- state of the art
- Behavioral dimensions of consumer and firm choice vis-a-vis energy conservation and carbon reduction
- Reconciliation of negative cost opportunities with observed behaviour
- Intragenerational justice and costs: comparing actors, households, regions; willingness to pay, willingness to accept, equity weighting and beyond
- Intergenerational justice and costs: discounting, overlapping generation models and beyond
- Economic and ethical implications of decision making under uncertainty
- Social cost-benefit analysis
  - The social costs of carbon in the context of multiple discount rates, heterogenous households and social cost-benefit-analysis
- Optimal carbon prices in second-best settings (multiple market failures)

3. Scientific Steering Group

A Scientific Steering Group (SSG) for the planning and execution of the Workshop will be established, taking into account the need for balanced scientific expertise, as well as geographical and developed/developing country representation. WGs III and II will jointly lead the SSG selection process and the meeting planning. WG III will take the operational lead for the meeting.

4. Participation and Output

The meeting is expected to have around 70 participants. It will be comprised of scientific experts in the topic areas identified, including lead authors from WG II and III responsible for the economic and valuation sections of the various chapters in the respective working group contributions to the AR5.

The meeting outcome will be an agreed guidance paper for the authors to feed directly into the respective working group contributions.

5. Timing, Duration and Location

The meeting is scheduled for Spring 2011 and shall last for two days. The location is still to be determined.

6. Trust Fund

30 journeys (across all WGs) from the budget line 'AR5 cross cutting meetings and SYR'.

Annex 2: Agenda

AGENDA
for the IPCC WGII/WGIII Expert Meeting
on Economic Analysis, Costing Methods, and Ethics
Lima, Peru, 23-25 June 2011

THURSDAY, 23 JUNE 2011

8:00 Registration
8:45 Welcome and Introduction

- Welcome Address (Local Host)
- Introduction/Background (WGII & III Co-Chairs)

9:15 FRAMING PLENARY: Cross-cutting issues in economic analysis, costing methods, and ethics (Chair: Ottmar Edenhofer)

Presentations F-1 & F-2: *The intersection of economics and ethics in climate change decisionmaking*
9:15-9:35 F-1: *Economics perspective* (Charles Kolstad)
9:35-9:55 F-2: *Ethics perspective* (John Broome)
9:55-10:15 Discussion

10:15 – 10:45 Coffee Break

10:45 PLENARY SESSION I: Valuation (Chair: Purnamita Dasgupta)

10:45-11:15 Keynote I-1: *Monetary valuation of climate impacts* (Michael Hanemann)
11:15-11:35 Keynote I-2: *Alternative metrics I: Human health* (Kirk Smith)
11:35-11:55 Keynote I-3: *Alternative metrics II: Quantifying tradeoffs in other sectors* (Robert Scholes)
11:55-12:30 Discussion

12:30 Lunch

14:00 PLENARY SESSION II: Decisionmaking under uncertainty (Chair: Ronaldo Seroa da Motta)

14:00-14:20 Keynote II-1: *Implications of climate change risk on developing iterative long-term adaptation and mitigation* (Gary Yohe)
14:20-14:40 Keynote II-2: *Benefit-cost tradeoffs in and risk management approaches to making choices under uncertainty* (Ray Kopp)
14:40-15:00 Discussion

15:00 Introduction to Breakout Groups (BOGs) (WGII & III Co-Chairs)

15:05 – 15:30 Coffee Break

15:30 BREAKOUT GROUP SESSION I

BOG I.1: *Incorporating non-monetary metrics and co-benefits into valuation of climate impacts*
(Chair: Muyeye Chambwera, Rapporteur: Michael Hanemann)
BOG I.2: *Incorporating climate change uncertainty in evaluations of adaptation and mitigation options*
(Chair: John Quiggin, Rapporteur: Stéphane Hallegatte)
BOG I.3: *Linking risk assessment and risk perception with risk management strategies for mitigation and adaptation*
(Chair: Elke Weber, Rapporteur: Daigee Shaw)

17:30 BOG Reports and Plenary Discussion (Chair: Youba Sokona)

FRIDAY, 24 JUNE 2011

8:30 Co-Chair Summary of Day 1 and Introduction to Day 2

8:45 PLENARY SESSION II (Continued): Decisionmaking under uncertainty

8:45-9:05 Keynote II-3: *Dealing with behavioral dimensions in climate change decisionmaking under uncertainty* (Elke Weber)
9:05-9:25 Keynote II-4: *The role of public and private sectors in developing adaptation and mitigation strategies for dealing with climate change* (Howard Kunreuther)
9:25-9:50 Discussion

9:50 PLENARY SESSION III: Distributional ethics and equity (Chair: Edgar Gutierrez-Espeleta)

9:50-10:10 Keynote III-1: *Ethical dimensions of cost-benefit analysis of global environmental problems* (Geoff Heal)
10:10-10:30 Keynote III-2: *Distributional impacts of climate policies (and possible complementary policies)* (Stéphane Hallegatte)

10:30 – 11:00 Coffee Break

11:00 PLENARY SESSION III: Distributional ethics and equity

11:00-11:20 Keynote III-3: Positive dimensions of responsibility for past actions (Dale Jamieson)
11:20-11:40 Keynote III-4: Approaches for allocating future emissions abatement (Jiahua Pan)
11:40-12:20 Discussion

12:20 Introduction to Breakout Groups (BOGs) (WGII & III Co-Chairs)

12:30 Lunch

14:00 BREAKOUT GROUP SESSION II

BOG II.1: *Behavioral challenges in linking adaptation and mitigation*
(Chair: Howard Kunreuther, Rapporteur: Elke Weber)
BOG II.2: *Balancing equity and efficiency considerations*
(Chair: Reyer Gerlagh, Rapporteur: Purnamita Dasgupta)
BOG II.3: *Ethical dimensions of adaptation and mitigation policies*
(Chair: John Broome, Rapporteur: Dale Jamieson)

15:30-16:00 Coffee available

17:00 BOG Reports and Plenary Discussion (Chair: Jean-Pascal van Ypersele)

18:00 Reception offsite

SATURDAY, 25 JUNE 2011

9:00 SYNTHESIS PLENARY

Presentations SP-1 to SP-4: *Themes of the meeting and suggestions for the AR5*
9:00-9:15 SP-1: Working Group II CLA perspective (Purnamita Dasgupta)
9:15-9:30 SP-2: Working Group III CLA perspective (Charles Kolstad)
9:30-9:40 SP-3: Working Group II Co-Chair perspective (Chris Field)
9:40-9:50 SP-4: Working Group III Co-Chair perspective (Ottmar Edenhofer)

9:50-10:30 Discussion

10:30-11:00 Coffee Break

11:00 Synthesis BOGs

13:00 Lunch

14:00 FINAL PLENARY (Synthesis BOG reports, final discussion, closing remarks)

16:00 Adjourn

Annex 3: Proposal for Keynote Presentations

KEYNOTE PRESENTATIONS
for the IPCC WGII/WGIII Expert Meeting on Economic Analysis, Costing Methods, and Ethics
Lima, Peru, 23-25 June 2011

FRAMING PLENARY: Cross-cutting issues in economic analysis, costing methods, and ethics

Chair for Session: Ottmar Edenhofer

Framing Presentations F-1 & F-2: *The intersection of economics and ethics in climate change decisionmaking* (20 minutes each)
- From economics and ethics perspectives, these presentations will introduce cross-cutting issues, questions, and themes in decisionmaking related to climate change.
- Presenter for economics perspective (F-1): Charles Kolstad
- Presenter for ethics perspective (F-2): John Broome

PLENARY SESSION I: Valuation

Chair for Session: Purnamita Dasgupta

Keynote Presentation I-1: *Monetary valuation of climate impacts* (30 minutes)
- This presentation will synthesize what is known about quantification of climate impacts in monetary terms. It will consider methods for valuation of co-benefits and other external effects, as well as methods for accounting for adaptation in impacts valuation.
- Presenter: Michael Hanemann

Keynote Presentation I-2: *Alternative metrics I: Human health* (20 minutes)
- This presentation will synthesize what is known about quantification of climate impacts in non-monetary terms in the health sector. It will consider metrics used to quantify health impacts such as DALYs and QALYs.
- Presenter: Kirk Smith

Keynote Presentation I-3: *Alternative metrics II: Quantifying tradeoffs in other sectors* (20 minutes)
- This presentation will synthesize what is known about quantification of climate impacts in non-monetary terms for decisionmaking in other sectors and contexts. For example, it will consider metrics used to quantify measures of societal and ecological wellbeing such as income distribution, poverty, and biodiversity.
- Presenter: Robert Scholes

PLENARY SESSION II: Decisionmaking under uncertainty

Chair for Session: Ronaldo Seroa da Motta

Keynote Presentation II-1: *Implications of climate change risk on developing iterative long-term adaptation and mitigation* (20 minutes)
- This presentation will examine experts' estimates of the likelihood of different degrees of climate change and their potential consequences over the next 50 to 100 years. It also will address the challenges of providing longer term (more than 100 year) estimates of the impacts of climate change. It will consider, given these uncertainties, what adaptation and mitigation strategies can be considered.
- Presenter: Gary Yohe

Keynote Presentation II-2: *Benefit-cost tradeoffs in and risk management approaches to making choices under uncertainty* (20 minutes)
- This presentation will examine the challenges in developing strategies for dealing with climate change when there is considerable uncertainty with respect to benefits and costs due to climate change, and it will briefly review existing approaches (e.g., cost-benefit analysis, cost-effectiveness analysis, distributionally weighted cost-benefit analysis). Specific attention will be given to ways that benefits and costs can be addressed, especially when they are evaluated in different dimensions (e.g., health vs. income; ecosystem vs. equity) and/or they are incommensurable.
- Presenter: Ray Kopp

Keynote Presentation II-3: *Dealing with behavioral dimensions in climate change decisionmaking under uncertainty* (20 minutes)
- Individuals and organizations exhibit biases and heuristics, such as myopia and misperceptions of risk, and can use thresholds in making decisions under uncertainty. This presentation will examine alternative adaptation and mitigation strategies (e.g., long term enforceable contracts) for dealing with these decision processes and simplified choice models.
- Presenter: Elke Weber

Keynote Presentation II-4: *The role of public and private sectors in developing adaptation and mitigation strategies for dealing with climate change* (20 minutes)
- This presentation will consider the following questions related to the role of public and private sectors in developing adaptation and mitigation strategies, with particular attention to differences among developed and developing country contexts. Given the uncertainties and negative externalities associated with climate change, what roles can the private and public sectors play in developing strategies for addressing the problem? How does one deal with heterogeneity of preferences and values between different interested parties in evaluating these strategies?
- Presenter: Howard Kunreuther

PLENARY SESSION III: Distributional ethics and equity

This session involves a broad and complex set of issues spanning economics, ethics, philosophy, and politics. Each presenter should approach the topic from a positive perspective and should avoid prescriptive findings, for instance on how much fairness should be included in any climate agreement. Each presenter should focus on what the literature says about the state of knowledge for these issues, not on personal perspectives on what should be done.

Chair for Session: Edgar Gutierrez-Espeleta

Keynote Presentation III-1: *Ethical dimensions of cost-benefit analysis of global environmental problems* (20 minutes)

- Economists have long recognized the limitations of cost-benefit analysis for making normative decisions on public policy (although those limitations are often ignored). Non-economists often have an even larger set of concerns about the use of cost-benefit analysis. This presentation should critically discuss the literature on the strengths and weaknesses of cost-benefit analysis for climate issues. Of particular concern is aggregation across countries with dramatically different incomes as well as intergenerational issues. The issue of the value of a statistical life in these contexts is also important.
- Presenter: Geoff Heal

Keynote Presentation III-2: *Distributional impacts of climate policies (and possible complementary policies)* (20 minutes)

- This presentation will consider distributional impacts of climate policies (and complementary policies including those related to technological change), and it will review the ways in which distributional impacts creating winners and losers have to be taken into account for a comprehensive assessment of environmental policy.
- Presenter: Stéphane Hallegatte

Keynote Presentation III-3: *Positive dimensions of responsibility for past actions* (20 minutes)

- A number of commentators have suggested that past emissions from the developed countries should imply that those countries have a greater burden for future abatement of greenhouse gas emissions. Others have suggested that large populations in the developing world will increasingly contribute to emissions and therefore share responsibility for reversing emissions growth. Strictly from a positive perspective, this presentation will consider the literature on the ethical dimensions of burden sharing for future emissions abatement and cost of adaptation.
- Presenter: Dale Jamieson

Keynote Presentation III-4: *Approaches for allocating future emissions abatement* (20 minutes)

- A number of approaches or proposals have been put forward for allocation of future abatement of greenhouse gas emissions. This presentation will review a broad range of proposed allocation approaches, with an emphasis on developing country perspectives.
- Presenter: Jiahua Pan

CHARGE TO PRESENTERS

- 20 minutes will be allocated for each presentation, unless otherwise indicated. The set of presentations in each Plenary Session will be followed by a question-and-answer period for the Plenary Session's presenters.

-Plenary presenters are asked to provide comprehensive syntheses of the body of knowledge related to the assigned topic. Talks should not be descriptions of the presenter's own research. Presenters should attempt to synthesize the current state of understanding on the topic, delineating as clearly as possible what is known and where key uncertainties and/or debates remain. Where relevant, presenters should synthesize and provide an overview of research methods commonly used. Presenters may want to seek input from colleagues for their presentations in order to represent fully the spectrum of views and discussions.

Annex 4: Proposal for Breakout Group Discussions

BREAKOUT GROUP DESCRIPTIONS
for the IPCC WGII/WGIII Expert Meeting on Economic Analysis, Costing Methods, and Ethics
Lima, Peru, 23-25 June 2011

Breakout Group Session I (Thursday, 23 June, 15:30-17:30):

BOG I.1: Incorporating non-monetary metrics and co-benefits into valuation of climate impacts

Chair: Muyeye Chambwera

Rapporteur: Michael Hanemann

Although economic valuation is an important, tractable, and tangible approach to valuing (and costing) climate change, monetization of some aspects of current and projected impacts (e.g., which affect the lives and livelihoods of vulnerable populations or that affect ecosystem goods and services) is difficult and fraught with uncertainty. When that is the case, the challenge is how to effectively incorporate non-monetary metrics into valuations of impacts, including taking into consideration that stakeholders often assign different values to impacts, co-benefits, and adaptation measures. This Breakout Group (BOG) will discuss the methods and practical aspects of valuing climate change impacts, including incorporation of co-benefits and adaptation. The session will discuss how the complexities associated with and the different approaches to valuation could be addressed consistently across the AR5.

Questions to be addressed in this BOG include:

- What are the main non-monetary metrics used to value impacts?
- How can monetary and non-monetary approaches be harmonized, ensuring that all values are appropriately reflected? How should different stakeholder perspectives on value and metrics be incorporated into valuations, and how can these be communicated consistently? How can multiple valuation metrics be aggregated to produce a summary statistic?
- What are the boundaries for assessing impacts and incorporating co-benefits, and how should double-counting be avoided? To what extent do adaptation and mitigation reduce the cost of climate change impacts at various temporal and spatial scales? What are approaches for incorporating the uncertainties in projecting the rate, extent, and efficacy of adaptation/mitigation, as well as the costs of adaptation/mitigation, inaction, and residual damages?

BOG I.2: Incorporating climate change uncertainty in evaluations of adaptation and mitigation options

Chair: John Quiggin

Rapporteur: Stephane Hallegatte

Assessments of the impacts of climate change are marked by pervasive uncertainty. This BOG will discuss the methods and practical aspects of incorporating climate change uncertainty in evaluations of adaptation and mitigation options, such as uncertainty about technological progress, uncertainty about future emissions of GHGs, uncertainty about the resultant response of the climate system to additional forcing, model uncertainty in projections of changes in climate conditions (e.g., temperature and precipitation), uncertainty about the downscaling of those changes to a fine spatial scale, uncertainty about the direct and indirect local impacts of those changes and valuation of those impacts, uncertainty about the extent, efficacy, timing, and costs of policies and measures to avoid and prepare for impacts, and deep uncertainty.

Questions to be addressed in this BOG include:

- How should uncertainty be characterized generally and for the purpose of formal analysis? Under what circumstances and how should it be characterized in terms of ambiguity?
- How should uncertainty be formally evaluated? How should risks be propagated through analyses?
- Should analyses of impacts assume risk neutrality? If not, what form/degree of risk aversion should be considered? From whose perspective? How can risk aversion be applied to the consideration of multivariate (as opposed to univariate) outcomes?
- How should deep uncertainty be evaluated, such as uncertainty regarding abrupt change or events with limited basis for assigning probabilities?
- Should analyses assume ambiguity neutrality? If not, how should ambiguity aversion be incorporated?
- What are the challenges in separating uncertainty due to climate change given the presence of natural phenomena that are independent of climate change (e.g., hurricane cycles)?

BOG I.3: Linking risk assessment and risk perception with risk management strategies for mitigation and adaptation

Chair: Elke Weber

Rapporteur: Daigee Shaw

Risk assessment evaluates the chances of a specific set of events occurring and/or their potential consequences with descriptions of uncertainty with respect to these estimates. *Risk perception* is concerned with the psychological and emotional factors that affect behavior. This BOG will focus on the roles of the public and private sectors in developing *risk management strategies* for mitigation and adaptation, taking into consideration how the experts assess risks and laypersons perceive risks.

Questions to be addressed in this BOG include:

- What are the advantages and disadvantages of different types of risk assessments for developing mitigation and adaptation strategies?
- How is the public likely to perceive the benefits and costs of alternative mitigation and adaptation strategies for avoiding, preparing for, and coping with the impacts of climate change?
- Based on our understanding of the previous questions posed, what are the characteristics of effective risk management strategies for encouraging mitigation and adaptation measures for reducing the impacts of climate change in the short and long-term?

Breakout Group Session II (Friday, 24 June, 14:00-17:00):

BOG II.1: Behavioral challenges in linking adaptation and mitigation

Chair: Howard Kunreuther

Rapporteur: Elke Weber

Behavioral biases and heuristics affect actions that individuals and firms undertake in response to incentives for adapting to a changing climate. The tendency to maintain the status quo, focus on short-term benefits and costs, and misperceive risks are normally not considered when characterizing economically rational choices of individuals based on neoclassical models, such that the prescribed policy options do not maximize social welfare. Mitigation and adaptation policies will benefit from reflecting the way people actually behave by considering the errors that may occur when making choices with respect to climate change. This BOG will discuss the characteristics of strategies for linking adaptation and mitigation that can be effective in addressing behavioral challenges.

Questions to be addressed in this BOG include:

- What impact do behavioral biases and heuristics have on the evaluation and ranking of specific emissions and adaptation measures with respect to climate change?
- Based on our understanding of behavior, how can one frame climate change and develop alternative strategies so as to link cost-effective adaptation measures with mitigation strategies?
- Given that there is a tendency for individuals to be myopic, are there ways to develop long-term contracts with short term incentives for encouraging the adoption of cost-effective adaptation and complementary mitigation strategies?

BOG II.2: Balancing equity and efficiency considerations

Chair: Reyer Gerlagh

Rapporteur: Purnamita Dasgupta

Climate change potentially involves a large-scale redistribution of human welfare across space and time. Some regions that currently have unfavorable climates will in future acquire a more favorable climate, and vice versa, with corresponding shifts in the location of agricultural production and other important economic activities. Furthermore, responsibilities and costs for mitigation and adaptation are unequally distributed through space. This BOG will discuss what the scholarly literature says about characterizing and treating the distribution of impacts in economic analyses of climate change, and the effects of different approaches on the conclusions reached.

Questions to be addressed in this BOG include:

- When assessing impacts, how can distributional concerns be properly reflected and how can those distributional issues associated with socioeconomic characteristics of individuals and groups be incorporated?
- In addressing distributional issues, to what extent and in what ways can physical/monetary costs and impacts be disaggregated, and at what scales?
- If costs and impacts are disaggregated, how can they appropriately be aggregated across groups? For example, using some form of welfare weights? What forms of aggregation (social welfare functions) might be considered, or should the analysis terminate with a disaggregated characterization of outcomes?
- To what extent should loss-aversion (divergences between assessment of losses versus gains relative to an expectation or a reference point) be taken into account when assessing impacts? What role do reference points and expectations play in the process and how should they be incorporated into the analysis?

BOG II.3: Ethical dimensions of adaptation and mitigation policies

Chair: John Broome

Rapporteur: Dale Jamieson

There are multiple ethical issues associated with adaptation and mitigation policies. This BOG will build on the presentations and discussions during the other sessions of the Expert Meeting with a primary focus on ethical issues related to policy design and implementation, but with issues related to valuation welcomed. The BOG will discuss what the scholarly literature says about these topics, not simply opinions that have been voiced.

Questions to be addressed in this BOG include:

- What are the criteria for fairness in distributing the burdens of mitigation and adaptation?

- What does the literature suggest should be the appropriate way of combining concern for economic efficiency with issues of justice? Should policy on climate change be directed only at achieving efficiency by correcting the externality, or should it also accept a distributional aim?
- What impact do issues of justice and other ethical dimensions have on the evaluation of the costs and benefits of proposed adaptation and mitigation policies?
- Are there specific adaptation and mitigation policies that one would **not** consider implementing due to considerations of fairness and other ethical issues?
- How can changes in population be taken into account in valuations of climate impacts?

Annex 5: Keynote Abstracts

FRAMING PLENARY: Cross-cutting issues in economic analysis, costing methods, and ethics

Keynotes F-1 & F-2: The intersection of economics and ethics in climate change decisionmaking
Economics perspective (F-1): *Charles D. Kolstad*
Ethics perspective (F-2): *John Broome*

PLENARY SESSION I: Valuation

Keynote I-1: Monetary valuation of climate impacts
W. Michael Hanemann
Keynote I-2: Alternative metrics I: Human health
Kirk R. Smith, Jamesine Rogers, and Manish Desai*
Keynote I-3: Alternative metrics II: Quantifying tradeoffs in other sectors
Robert J. Scholes

PLENARY SESSION II: Decisionmaking under uncertainty

Keynote II-1: Implications of climate change risk on developing iterative long-term adaptation and mitigation
Gary Yohe and Ted Parson*
Keynote II-2: Benefit-cost tradeoffs in and risk management approaches to making choices under uncertainty
Ray Kopp
Keynote II-3: Dealing with behavioral dimensions in climate change decisionmaking under uncertainty
Elke U. Weber
Keynote II-4: The role of public and private sectors in developing adaptation and mitigation strategies for dealing with climate change
Howard Kunreuther

PLENARY SESSION III: Distributional ethics and equity

Keynote III-1: Ethical dimensions of cost-benefit analysis of global environmental problems
Geoff Heal
Keynote III-2: Distributional impacts of climate policies (and possible complementary policies)
Stéphane Hallegatte
Keynote III-3: Positive dimensions of responsibility for past actions
Dale Jamieson
Keynote III-4: Approaches for allocating future emissions abatement
Jiahua Pan

** Speaker*

Keynote F-1: The intersection of economics and ethics in climate change decisionmaking: economics perspective.

Charles D. Kolstad

Professor, University of California, Santa Barbara, USA; *University Fellow, Resources for Future, USA*; *Research Associate, National Bureau of Economic Research, USA*

This paper focuses on the identification of important issues in the economics of climate, both settled knowledge (i.e., where there is consensus in the literature) and unresolved questions.

For this presentation, the literature has been divided into broad categories of mitigation costs, damage from climate change, discounting and cost-benefit comparisons, induced technical change, regulation, adaptation as an economic process, risk/uncertainty, and incidence. As part of this, we will touch on behavioral dimensions of consumer and producer behavior, particularly as applied to energy conservation and voluntary actions. We will also address the social cost of carbon and the pricing of carbon. In the context of mitigation, we will address the question of negative cost opportunities suggested by engineering analysis. In the context of induced technical change, we will address what we understand about price induced innovation and what regulatory levers are available to spur innovation. In the context of dynamics, we will address the issue of the adequacy of global warming potentials, as defined in the United Nations Framework Convention on Climate Change (UNFCCC).

Keynote F-2: The intersection of economics and ethics in climate change decisionmaking: ethics perspective.

John Broome

University of Oxford, UK

One part of the task for Working Groups II and III is to identify what options are available for adapting to climate change and for mitigating it. Another part is to assess these options. We are expected to make judgments about their merits, or at least to offer a methodology for making these judgments. We need to find a basis for judging which policies are better than which, which policies should be adopted and which not. At the most general level, we need to judge how far the international community should go in responding to climate change, and how rapidly. We also need to find principles for distributing the burdens of adaptation and mitigation around the world.

All these are ethical questions. Ethics (or moral philosophy) is the discipline that deals at the most general level with good and bad, right and wrong. The most basic principles that should guide us in answering these questions are ethical ones. They are the subject matter of moral philosophy. However, climate change is an immensely complex subject, involving long periods of time and the entire population of the world, so the detailed application of ethical principles to climate change goes far beyond the methods of ethics. It requires technical and quantitative methods that can be supplied by economics, decision theory, and other quantitative and technical disciplines. Ethics supplies the foundational principles and other disciplines their working out.

Like all disciplines, and no doubt to a greater extent than most, moral philosophy contains disagreement. It will be the responsibility of the moral philosophers in the Working Groups to represent the extent of the disagreement. But probably a more important part of our role will be a critical one. Ethical presumptions are implicitly or explicitly embedded in many of the existing methods of evaluation. They will need to be brought into the open and assessed.

Two very broad ethical principles are embedded in much of economics. One is preferencism, the view that values should be based on people's preferences, and policies should be aimed at satisfying preferences. The other is utilitarianism, the view that value is given by people's well-being, and that policies should be aimed at promoting well-being. These principles are not entirely consistent with each other; they can be consistent only in so far as people's well-being is increased by satisfying people's preferences. Preferencism and utilitarianism lead to different methods and conclusions within economics. For example, they support very different approaches to cost-benefit analysis. To take two more specific examples, they lead to different conclusions about the discount rate and about the value of human life. An important part of the work for moral philosophers in the Working Groups will be in clarifying and mediating between the approaches that are founded on these differing ethical principles.

Besides the discount rate and the value of life, work going on within moral philosophy has direct implications for several other specific issues that are raised by climate change. Perhaps most importantly, philosophers are as much engaged as economists and others in working out the right way to cope with uncertainty. At the extreme, the uncertainty of climate change raises the question of how to judge the risk of total catastrophe; this is particularly a topic for ethics. Another example is the theory of fairness within philosophy, which has direct implications for judging the fair way to distribute the burden of responding to climate change among different nations, and ultimately among individual people. The value of equality is another topic within moral philosophy, and is an issue directly raised by climate change. Philosophers are also working on the value of changing population. Population growth is a major cause of climate change, and climate change is likely in

turn to influence the progress of population. Our assessments have to take account of population, and ethics is concerned with how.

Keynote I-1: Monetary valuation of climate impacts.

W. Michael Hanemann

Department of Agricultural and Resource Economics and Goldman School of Public Policy, University of California, Berkeley, USA; Department of Economics, Arizona State University, USA

One must distinguish between how the monetary valuation of climate impacts has largely been done in practice in existing integrated assessment models (IAMs) and how, in principle, it ought to be done. Economic valuation raises some difficult and controversial issues, especially for non-market impacts, which may be a substantial portion of climate impacts. However, many of these issues are moot in the context of existing IAMs because of the crudeness of the way in which they represent the impact of climate change on human well-being.

Starting with the conceptual foundations, in economics the monetary value of an item is the amount of money that a decisionmaker would be willing to exchange for the item, whether measured in terms of the minimum monetary amount the decisionmaker would be willing to accept (WTA) to forego the item or the maximum monetary amount the decisionmaker would be willing to pay (WTP) to obtain the item. Monetary valuation is thus an act of translation, identifying the amount of one item (money) that is equivalent to another item. To the extent that multiple items are being assessed, the computation of WTP/WTA is also a means of aggregation: it provides an implicit weighting of the items being considered based on the marginal rates of substitution among them. In the climate context, the items being valued can be market and/or non-market impacts. The former include a direct change in income, a change in the price of a market commodity or input, a change in the availability (other than price) of a market commodity or input, and a change in the quality of a market commodity or input. The latter include the loss of well-being due to changes in non-market items (human health and mortality, amenity from quality of life or quality of the environment, impacts on ecosystems, etc.).

An implication is that economic value is defined with reference to a decisionmaker and that it is inherently subjective and reflects the decisionmaker's particular situation and her preferences. To formulate an estimate of, say, national WTP to avoid climate impacts therefore requires either the fiction of a representative household for the entire nation or the calculation and aggregation of WTPs for separate groups within the nation. Because of the broad—indeed global—range of climate change, interpersonal aggregation of welfare is an inescapable issue in the valuation of climate impacts.

Besides aggregation over individuals, aggregation of impacts is also a key factor in economic valuation. The projected changes in climate (e.g., temperature and precipitation) are temporally and spatially heterogeneous—the latter has become increasingly evident with the growth in the practice of spatial downscaling. In addition, the physical impacts often involve thresholds and tipping points, leading to a significant non-linearity in the physical damage function with increasing marginal damage at larger changes. Given the non-linearity of the damage function, spatial or temporal aggregation of the change in climate (e.g., using the increase in global average temperature versus the increase in temperature at various specific locations) tends to understate the overall damage: the degree of understatement being larger the greater the convexity of the damage function and the larger the spatial/temporal variance in climate change. Excessive aggregation is a distinctive feature of the existing IAMs.

In addition, some of the existing IAMs—notably DICE and FUND—have certain features that may lead to understatement of the physical (and economic) damages from climate change, including the use of a quadratic functional form (which implies symmetry) where there are first benefits and then harms from increasing temperature, the assumption of no impacts on certain impacts of the economy

in developed countries where more recent analysis tends to dispute this, and (in the case of DICE) a likely overstatement of the amenity benefits of climate change in the US. In some cases, there is not adequate allowance for the valuation of the loss of utility (as opposed to the loss of income) associated with market impacts of climate change. Moreover, while there is an allowance (in DICE) for universal risk aversion associated with catastrophic impacts of climate change, there is no allowance for risk aversion regarding the local effects of climate change on the part of the local populations affected. Moreover, the existing IAMs model damages from climate change as pure reductions in consumption, treating damages and income as perfect substitutes. This makes for a constant marginal rate of substitution between market and non-market impacts, and between income and damages. A varying marginal rate of substitution could lead to a larger monetary valuation of damages in later periods.

Some concerns have been expressed that the damage functions in these IAMs do not increase sufficiently with large increases in global temperature. There are also grounds for concern that these damage functions are too low for more moderate temperature increases.

Keynote I-2: Alternative metrics I: Human health.

Kirk R. Smith, Jamesine Rogers, and Manish Desai

School of Public Health, University of California, Berkeley, USA

There are two general ways that have been proposed to combine mortality and morbidity into a common metric for evaluation and comparison across populations: economic valuation (money) and lost healthy life years. The first is extremely difficult to apply across populations at different levels of development without creating unacceptable differences, i.e., a death in Germany counting more than one in the Gambia. There are several types of lost life year metrics, e.g., QALYs, HALYs, etc., but only one has a systematically developed and updated global database, the DALY, which is elaborated in the Global Burden of Disease (GBD) database maintained by the WHO and used in the Comparative Risk Assessment (CRA) literature and databases. The GBD is the only **C4** database in the health field.

- **Combined**: includes mortality, illness, and injury in a systematic way using incidence-based lost healthy-life years in a transparent, highly developed, and peer-reviewed framework
- **Complete**: all conditions, including difficult-to-assess mental and parasitic conditions and a large range of disease sequelae (the different ways a particular disease can manifest itself over time—sometimes to rare but severe outcomes) and all parts of the world, even those not covered by government health statistics based on filling gaps with models, epidemiological assessments, and triangulation using demographic databases and other inputs
- **Consistent**: hundreds of clinicians and health scientists worked to map different diagnostic procedures, medical and health record keeping methods, etc. around the world into the International Classification of Death (ICD) system and an associated disease and injury framework for non-fatal conditions
- **Coherent**: The output is a set of tables by age, sex, and region for death, years lost to premature death, years lost to illness, and total lost years, that reflect the distribution of the ill-health burden globally. These add by row and column, as appropriate for parsing out a finite burden, and thus are comparable to C4 databases for other important parameters of interest to society—e.g., energy production/use, financial flows, trade flows, demographic stats, etc.

The two principles for creating the GBD are (i) like is like, i.e., the only difference between a death or illness will be according to age and sex, universal human experiences. There will be no difference by country, social class, income, race, etc. The death of Bill Gates in the Mayo Clinic would count the same as the death of the 55-year old male beggar in the streets of Kolkata and (ii) everyone has the capability of living to the longest observed life expectancy in the world. The fact that some do not is a reflection of their burden of ill-health, not of genetics or other uncontrollable factors.

When created, the GBD represented a radical departure and improvement compared to previous databases in the field. The particular lost life metric it uses, the DALY, may not be the one everyone would choose, but as it is the only one embedded in a global C4 database, there is really no point in arguing if one is hoping to do comparisons across diseases, regions, ages, risk factors, etc. in a consistent way. The databases also provide deaths, prevalence, and incidence. In addition to annual updates, there are also GBD projections to 2030, which are handy for analyses of alternative interventions/scenarios. It is divided globally in several ways, including by both WHO and World Bank regions and by national income categories. The finest regional division is by 14 regions, in which one is entirely dominated by China (another by India). There are also now summary national estimates for 2004, but without much detail for each country.

The CRA follows from GBD to estimate what proportion of the burden is attributable to important risk factors. It too is a major advance in the field, being the only set of risk assessments with a "C," i.e., done in a consistent way across risk factors using common methods, populations, background disease rates, and rules of evidence. Thus one can compare the impacts of, say, household air pollution with that of high blood pressure or poor water and sanitation with some confidence that the comparison is meaningful. It is extremely valuable for policy.

To illustrate the distinction between the two databases, the GBD tells how much lung cancer there is in a particular place, but the CRA tells us what proportion of it could be reduced if we eliminated smoking, air pollution, or occupational hazards, for example. Unlike the GBD, however, the CRA is not coherent, i.e., there is no natural envelope within which the rows and columns add. Thus, there is overlap in results, i.e., you cannot directly add the burdens from different risk factors. Conversely, for illustration, if smoking was eliminated first, there would be fewer lung cancers to eliminate by dealing with air pollution, and vice versa. That attributable risks do not add is a fundamental distinction and one often lost on people unfamiliar with health analyses, such as those in the media. (How can you save the same person twice is a common question.)

Note, however, that the GBD and CRA are now undergoing a major revision and all data, assumptions, models, etc. are being revisited with many more diseases, sequaele, age groups, disability weighs, etc. This time, there will be 21 regions. This is a huge effort, with many hundreds of people involved worldwide. There are more than 1000 systematic reviews and consequent statistical meta-analyses being undertaken just in the GBD effort. It will be published later this year.

The first CRA, published in 2004, included climate change as a risk factor. This time, however, climate change is being done outside the official CRA process, but attempting to use parallel methods. It is being organized by WHO in Geneva and is expected to be published in 2012.

Responsibility Metrics

Annual emissions of GHGs in CO_2-equivalent are commonly used to apportion responsibility for climate change across nations, economic sectors, etc. Such a metric, however, does not reflect well the actual impact on the climate given the differential influence of different climate-active pollutants on radiative forcing over time. In addition, as the current status of a nation's income and other characteristics is not due to its activities in one year, neither is its impact on the climate, which is better indicated by the remaining portion of its historical emissions that affect the climate today. Previous efforts at establishing historical responsibility, sometimes called "natural debt," have focused just on CO_2. Here, we will present a more comprehensive version of the natural debt metric that incorporates all three major GHGs, CO_2, methane, and N_2O. The result is a substantially different view of the relationships among countries in terms of responsibility.

The main GBD website is at http://www.who.int/healthinfo/global_burden_disease/en/index.html

- The latest database divided by world regions defined in several ways (WHO regions, World Bank regions, income groups etc.) is at http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/index.html
- Summary country estimates for WHO member states without much detail are at http://www.who.int/healthinfo/global_burden_disease/estimates_country/en/index.html
- Projections to 2030 are at http://www.who.int/healthinfo/global_burden_disease/projections/en/index.html
- Best single modern book covering the GBD and CRA ideas, methods, and results, but without full detail and sophistication/complexity: Global Burden of Disease and Risk Factors, (Lopez, Mathers, Ezzati, Jamison, Murray) Oxford University and World Bank Presses, 2006. 475 pp. Fully downloadable at http://www.dcp2.org/pubs/GBD

- The full set of background materials, databases, and pubs of the Comparative Risk Assessment (for the year 2000) covering 26 major risk factors, environmental and other: Includes several chapters on methods.
  http://www.who.int/healthinfo/global_burden_disease/cra/en/index.html
- For assessment of the cost-effectiveness of interventions across a broad range of disease and risk factors, see Disease Control Priorities in Developing Countries at
  http://www.dcp2.org/pubs/DCP

Keynote I-3: Alternative metrics II: Quantifying tradeoffs in other sectors.

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A tradeoff is the marginal change in the ability to satisfy one need when the system is adjusted to increase the yield of another need. In a world that is increasingly approaching its limits—whether in terms of resources, space, or the capacity to absorb wastes—promoting one activity almost always means a loss of opportunity to conduct other activities, though not always. In some cases the underlying resources are independent of one another, or can be shared without detriment to either. A plot of the yield ("ecosystem service") in relation to one objective against that of another objective has an upper envelop—a "frontier curve"—corresponding to the technically most-efficient joint yield for various combinations of the two. Conceptually, this type of analysis can be extended to the interactive tradeoffs between any number of factors, though it is hard to visualize for more than three orthogonal factors.

If it were possible to convert the yields with regard to each service into some shared metric of social utility (a "value"), then it would be possible to reveal unambiguously which combination has the greatest social value. The difficulties in quantifying such values are many: Value to whom? How should future values be rated relative to present ones? How should risk and uncertainty be factored in? Are the full costs and benefits accounted for? For factors where well-functioning markets exist, accessible to everyone and without externalities, prices should be a good proxy for the value placed on the goods or service being traded. A socially-optimum, self-regulating equilibrium should automatically be reached. This may indeed sometimes be the case. More often, the basic assumptions are not met—the market is seriously imperfect or even non-existent—for one or more of the goods or services. In this case, regulations are frequently put in place to prevent the domination of the service for which a private value exists from dominating the services with a social but hidden value. The level at which these regulations are set are sometimes determined by "shadow prices" estimated through a variety of techniques (CBD, 2007), acting as a proxy for the markets. While the estimation of common value in monetary terms is a widely-applied approach, it suffers from a number of technical and ethical problems: for instance, the assignment of a price to human life or the existence of a species. There are non-monetary metrics of value which may be more suitable for tradeoffs within a domain where the services are commensurate—for instance, disability-adjusted life-years for health-related tradeoffs, or global warming potential for climate tradeoffs—but they still suffer from the problem of non-generality across domains.

Multi-criterion decision analysis (MCDA; see for instance Triantaphyllou, 2000) is a group of techniques that try to circumvent both the issue of the impossibility of strict optimization of competing nonexchangeable outcomes, and the difficulty of quantifying them in shared units. The simple MCDA techniques (e.g., weighted or unweighted compound indices) risk trivialization of the problem, and the sophisticated ones are opaque to non-experts. Although MCDA makes the presumed tradeoff explicit, it generally renders it either effectively invisible or untestable. It can transfer decisionmaking power away from a broadly-based set of stakeholders and into the domain of a small number of experts. Perhaps the best use of MCDA techniques is to eliminate unacceptable outcomes rather than to select the single optimal one: in other words, emphasizing long-term robustness rather than short-term efficiency.

It may not be necessary to either convert outcomes to common units or use arbitrary weightings in order to delimit an acceptable ("safe") set of trajectories (Scholes, 2009). All that is necessary is to have a shared driver value and knowledge of the form of the respective outcome response curves. You then look for abrupt changes (maxima or minima in the second-order derivative) in the ratio of

the outcomes, and use these to bound the problem. Stated formally this sounds complex—but illustrated graphically it is intuitive (Figure 1).

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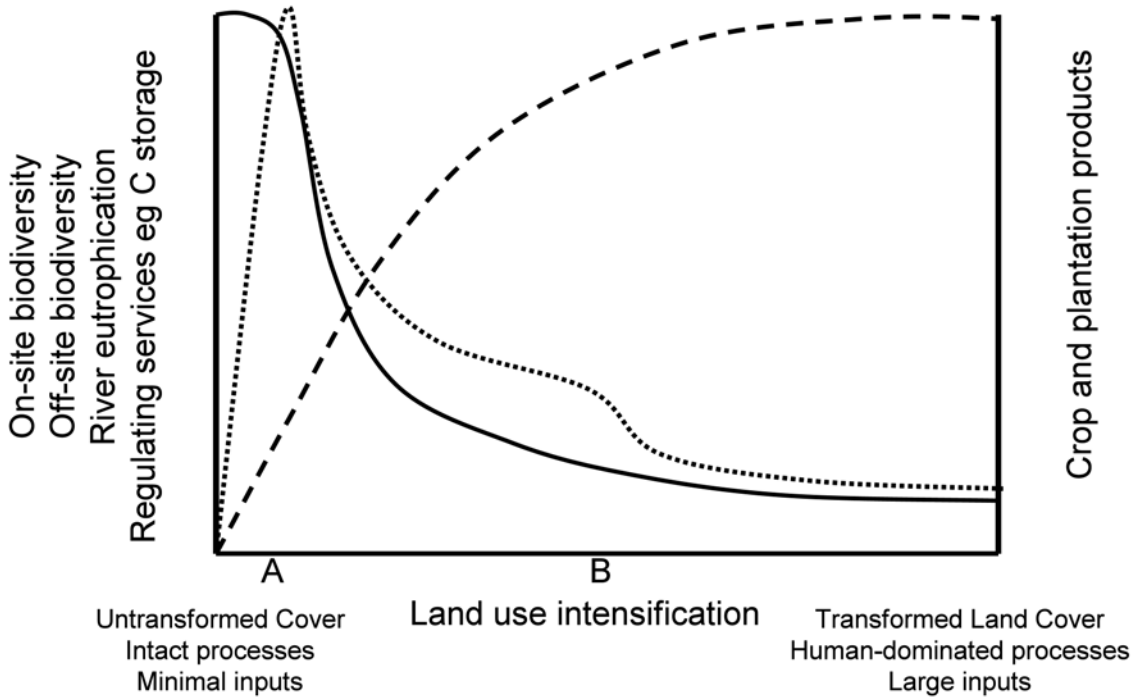

Figure 1: Conceptual sketch of the shape of the yield functions for two clusters of ecosystem services (a declining group, solid line, and an increasing group, dashed line), along a gradient of land-use intensification. The ratio of the latter to the former is represented by the dotted line. The range of desirable outcomes probably falls between the inflection points A and B. The concave shape of the declining cluster beyond A suggests that a partitioning of the landscape into protected areas (<A) and moderately intensively-used areas (~B) will maximize the joint outcome.

Keynote II-1: Implications of climate change risk on developing iterative long-term adaptation and mitigation.

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The Intergovernmental Panel on Climate Change recognized the need for iterative decisionmaking in the Summary for Policymakers of the Synthesis Report of the Fourth Assessment Report when it concluded that "Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity and attitudes to risk" (IPCC, 2007; pg 22).

Given the enormous uncertainties that cloud our understanding of the climate system and what will drive it into the future, responding to the associated risks must be a problem of sequential, or iterative, decisionmaking. Parson and Karwat (2011) argue that this means that decisions by policymakers, investors, and others will probably (and must for rational decisionmakers) be made and revised repeatedly over time in response to new knowledge, accumulated experience, and/or changing conditions. Future decisions will depend on current decisions, to be sure, but they will also respond to new scientific knowledge about climate change and derivative impacts and risks. They will, as well, respond to new technologies and other factors that influence our capacity to respond. Indeed, performance (measured somehow), costs (calibrated in whatever metrics are appropriate), and associated risks (co-benefits or ancillary damages) will all play a role. Finally, and perhaps most importantly, future decisions will respond to changes in societal goals—some related to climate change, but some not—that may or may not be anticipated.

Given this complex environment, iterative decisionmaking is required both for mitigation decisions to limit anthropogenic emissions of greenhouse gases and other drivers of climate change and for adaptation decisions to ameliorate the risks associated with climate changes that cannot be avoided. The time horizon over which sequential decisionmaking continues may range from several years to several decades to several centuries—either until human societies have transitioned to a state in which they impose no further net climate forcing, or until, for whatever reason, global climate change has ceased to be a matter of concern. Irreversibilities will certainly play a role, as well; and so, too, will the ability to monitor and respond in a timely fashion.

In this presentation, we offer some insights into some of the complexities involved in contemplating iterative risk management approaches to climate change from an economic perspective; and so we highlight some of the challenges for both new research and ongoing assessments. We begin with an analogy and then highlight a few of the economics questions that are embedded in the design of any iterative response strategy. Bringing the abstraction into the realm of climate change, we report on some recent work that dissects the sources of uncertainty about our climate futures over the next century. This allows us to suggest a carbon budget structure for contemplating iterative mitigation strategies at a national level; and it allows us to contemplate what drivers of global climate change might be most important in informing adaptation decisions that can iterate repeatedly and those that might perhaps allow only one once it turns out that a decision with long-term consequences has been taken.

First the analogy—imagine driving a strange new car down a dangerous mountain road that swerves right and left with a cliff on the one side (which may vary) and a vertical natural barrier on the other. Weather conditions are unknown, but the mountain passes may take you from places where the temperature is above freezing to places where it is not (and back). You will want to steer carefully and be as informed as possible as you "iterate" your way down the mountain. What are the questions

that you would like to have answered before you start, or at least early in your trip? We think that they include:

- What are the steering controls, how do they work, how well do they work, and *where are the handles*?
- What are the speed controls, how do they work, how well do they work, *and where are the handles*?
- What are the consequences of deviating off one side of the road or the other (cliff versus barrier)?
- How are the likelihoods of those deviations correlated with speed, and how do they vary with conditions?
- Are those conditions observable, how, and how well?
- How are the consequences and the conditions correlated with distance down the mountain?

It strikes us that these questions translate directly into analogous questions about mitigation and adaptation. Where are the controls? How well do they work? How are they affected by the speed of climate change? What are the consequences of various actions and how do they depend on circumstances? What are the likelihoods of those circumstances? What can we observed to infer those likelihoods and consequences? How are they correlated with how far and how fast we have moved along a path to a different climate?

The economics of response to external stress, be it anticipated or observed, tells us that there are economic consequences associated with the answers to these questions. They include the following characterization of a fundamental economic tradeoff. Iterate too infrequently and you will:

- extend the period of mistaken trajectories;
- expand the damage caused by those errors;
- create the need to exaggerate the subsequent adjustment; and
- …….

But, iterate too frequently and you will:

- make it more likely that you will be responding (incorrectly) to noise;
- create uncertainty in the policy environment;
- diminish the credibility of any adjustment and thus its efficacy; and
- …….

Of course, the nature of these costs highlights how important it is to address not only how frequently you adjust, but also what signal you attend to, and how it is possible either to increase a signal-to-noise ratio and/or construct response algorithms that reduce dependence on the noise. We have not yet begun to frame this tradeoff well in the climate arena for either adaptation or mitigation, but we can begin to infer some very salient characteristics of the climate system.

It has become clear to many observers that the sources of uncertainty are not confined to our evolving understanding of how the climate system works. Within that sphere, many conclusions about uncertainty are now widely accepted even though many of the details of specific sources of risk are still sketchy. However, uncertainty about future climate change post mid-century is, from our perspective in 2011, expected to be eclipsed in magnitude by uncertainty about how our socio-political-economic systems will work as they evolve in ways that are nearly impossible to envision (see Hawkins and Sutton, 2009, 2011). That is to say, decisions over the next two or three decades affecting this larger context may influence the climate of 2050 and beyond in ways that are at least as significant as the implications of even the major current scientific uncertainties, like climate sensitivity and long-term ice-sheet stability. There are, of course, nuances of correlation here that cannot be ignored. Should we choose to do nothing over the next few decades, then the upper tails of our current emissions scenarios will become more likely, and that will make the upper tails of the vulnerability distributions become more likely. Coming to grips with this realization and these

nuances is yet another challenge for those who try to design iterative policy responses that will surely require increasing attention not only by Working Groups II and III, but also Working Group I. The basic climate science assessed by Working Group I must be transmitted to Working Group II and Working Group III in a form that is appropriate for the risk management framework which is needed to grapple fully with this dynamic socioeconomic context.

For mitigation, this means that near term decisions will be critical and that it will be perhaps most important to monitor socio-economic developments: development pathways (including demographic trends, urbanization trends, economic and social integration, and the like), international participation (formally or by unilateral action without UNFCCC participation), energy sector developments (for non-climate related reasons), and the efficacy of mitigation policies in achieving their goals. The Limiting Panel of the America's Climate Choices initiative conducted by the National Academy of Sciences [NRC (2010)] chose to describe domestic policy in terms of a carbon budget through 2050 based on the US share of the burden to increase the likelihood of achieving a long-term 2 degree (C) temperature limit. This notion is consistent with the new science highlighted in NRC (2011a, 2011b) linking long-term temperature equilibrium to cumulative global carbon budgets; and it indicated roughly a 40-year iteration period. Such a design would allow "when" flexibility along the intervening 40 years and suggests a mid-century adjustment based on changing science on climate sensitivity *as well as the socio-economic factors listed above*.

For adaptation, this means that it is important to understand the degree to which responses can adjust to changing conditions. In some cases, adjustment can be quick and nearly costless (as in green adaptation to increased risk from coastal storms driven by climate along rural coastal zones, for example). In others, where adaptation involves significant investment at some point in time (as in constructing a physical barrier to protect an urban area against increased risk from coastal storms driven by climate along rural coastal zones, for example), it means taking risk into account and contemplating the sensitivity of the timing decision to alternative futures that depend on changing science on climate sensitivity *as well as the socio-economic factors listed above*.

In conclusion, this is not rocket science, but it is really hard given our current knowledge base. We do not have a clear understanding of what to monitor as we contemplate iterative decisions. We do not have a handle on the multiple metrics of risk that will be of interest to decision-makers. Nor do we have internally consistent indictors of risk for localities (to motivate adaptation and provide a basis for evaluating how well it is working) that can be aggregated to national or international levels (and thereby inform mitigation decisions and downstream adjustments).

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Keynote II-2: Benefit-cost tradeoffs in and risk management approaches to making choices under uncertainty.

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The presentation will discuss cost-benefit analysis (CBA) within the larger context of welfare economics thereby allowing for a more complete treatment of efficiency and equity issues and will draw heavily upon two survey papers, Kopp, et al. (1997), and Pizer and Kopp (2005). Simple summation of Hicksian surplus (the foundation for most CBA) will be augmented with discussions of social welfare functions.

CBA is a formal procedure by which one organizes information for the purposes of decisionmaking. Thus, the usefulness of CBA depends on information enabling the estimation of benefits and costs. If such information is poor (uncertainty prevails with respect to probability distributions or where one is completely ignorant with respect to probability distributions) the usefulness of CBA is diminished. However, in cases of poor information, CBA is no more degraded than other formal or informal decisionmaking process. The presentation will assume that precise probability distributions may not be known, but that we are not in a world of ignorance.

Introduction to cost-benefit analysis

CBA and cost-effectiveness analysis (CEA) are economic techniques that produce information intended to improve the quality of public policies. In this context, quality refers to a measure of the social well-being that a policy conveys to society. Policies that reduce well-being are a priori inferior to those that improve well-being, and policies that improve well-being a great deal are superior to those which improve it only marginally. Conceptually, then, CBA could be used to rank policies on the basis of their improvements or reductions in well-being. CEA is a particular form of CBA and will not be addressed in this presentation as an independent tool of analysis.[1]

Social well-being is defined as an indicator of social quality—in the abstract, the summation of all the things that members of a society see as contributing to the quality of their lives, individually and collectively—without enumerating what those factors might be. However, to develop empirical measures of well-being in CBA, a concrete definition of well-being is needed. To avoid confusing the abstract notion of well-being with its operational counterpart, I hereafter term the latter social welfare. Unlike the components of well-being which are left vague and open to interpretation, the components of social welfare included in CBA must be clearly delineated and therefore will give rise to disagreements about what is included and what is excluded.

Constructing the measure of social welfare used in CBA can in principle be broken into two steps. In the first step, one attempts to develop measures of well-being for people in a society. In the second step, one aggregates the measures of individual welfare to form a measure of aggregate social welfare. The individual measures are subject to two critical concerns: the appropriateness of the single measure chosen as a valid measure of an individual's well-being and the problems that one faces when attempting to quantify the components of the measure. The appropriateness of the aggregate measure depends on both the appropriateness of the individual measures and their aggregation.

[1] CEA does *not* imply choosing the policy with the smallest dollar price tag (although many people believe that it does). Strictly speaking, CEA chooses the policy that achieves the specified goal with the smallest loss in social well-being. The smallest welfare loss might not be associated with the smallest dollar cost.

Individual measures of well-being are premised on a fundamental economic assumption: that the satisfaction of individual preferences gives rise to individual well-being. Economists take this assumption as a matter of faith, and it underlies most if not all of economic theory. Others (many others) reject the assumption outright. At its base, the assumption is that individuals know what is good for them (what will enhance their well-being), their preferences for actions and outcomes reflect this knowledge, and they act in a manner consistent with these preferences in a desire to increase their well-being. The validity of the "preference satisfaction" assumption has been debated since Bentham and will continue to be debated. There is nothing we can add to the debate but to note simply the crucial importance of the assumption to the intellectual foundation of CBA. If we accept the preference satisfaction assumption, we can look to people's actions as guides to their well-being.

To economists, the term value has a specific meaning that we hereafter refer to in this paper as economic value. The most important, but often overlooked, features of economic value are that it is a theoretical construct and that monetary measures of it are inferred by analysts from the actions that people make in accordance with their preferences. Economic value cannot be independent of an action, in particular, a type of action that requires a person to make a choice whereby something is given up and something gained.

A crucial step in CBA is the aggregation of measures of individual welfare to form a measure of social welfare. In the most common applications of CBA, the aggregation of individual welfare treats all individuals anonymously. That is, no person's welfare is weighted more heavily in the aggregation than another's. The changes in all individuals' welfare are simply totaled. If a policy increases the welfare of rich people and decreases the welfare of poor people, but the rich people's gain outweighs the poor people's loss, the anonymous-aggregation rule would label this change an improvement in aggregate social welfare. That example forms the basis for the criticism that CBA neglects important distributional considerations.

However, nothing in the theory of welfare economics dictates an anonymous-aggregation rule. In theory, different segments of society or even individuals can be given different weights in the aggregation. The reasons one rarely sees CBA studies that use such preferential weighting will be discussed in a later section.

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Keynote II-3: Dealing with behavioral dimensions in climate change decisionmaking under uncertainty.

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I present two implications that behavioral economics and behavioral decision theory have for the IPCC tasks of quantifying climate change risks and of evaluating the costs and benefits of climate change risk management options: (i) reexamination of assumptions about goals/objectives made by current valuation methods, (ii) reexamination of assumptions about how people process information about risks and risk management options.

Widely used economic valuation methods (e.g., cost-benefit analysis, expected or discounted utility) provide guidance about efficient choice options if and only if their assumptions about goals and objectives hold. These assumptions need to be examined, both from a descriptive and a prescriptive perspective. I will describe different categories of goals that have been shown to motivate human behavior, of which economic well-being and health and safety concerns are only a subset. Adaptation and mitigation responses that may offer similar climate change risk reduction at similar expected present value costs may be perceived and evaluated differently by the public and other actors in part because they score differently on other (psychological) goals (e.g., the need to feel effective or to feel in control), not currently considered in economic analyses.

The second important assumption I will examine, implicitly made by the (climate change) policy community, is that people (e.g., consumers, farmers, corporate actors) evaluate risks and risk management options in rational ways. Psychology and decision neuroscience have documented numerous deviations from economic rationality, showing that people deal with uncertainty and long time horizons in myopic ways (Weber and Johnson, 2009). A more accurate appreciation of people's response to uncertainty and long time delays is crucial to understand the challenges involved in giving mitigation and adaptation responses to climate change risk the societal attention that rational analysis suggests they deserve. I will review several relevant research literatures:

- People use several qualitatively different decision processes (Weber and Lindemann, 2007). These include analytic processes ("by the head"), where choice options are evaluated as a function of their consequences, and different costs and benefits and their probabilities are combined in some calculation-based fashion, but also affective processes ("by the heart"), where positive associations with choice options dictate acceptance and negative associations (e.g., fear) dictate rejection or decision avoidance. Climate change risks do not elicit fear, hence neither mitigation nor adaptation seem necessary (Weber, 2006). Yet another class of decision processes ("by the book") are rule-based, where recognition of a decision as one of a kind triggers the conscious or automatic activation of a response. Rule-based decisions span the range from the activation of learned behavior (e.g., turning off lights when leaving a room) to the application of deontological moral codes of conduct (e.g., assuming stewardship of planet earth, or feeling that people ought to fix a problem they caused such as anthropogenic climate change).
- Even when making decisions using calculation-based processes, people do so in ways that deviate from rational-economic models. These deviations can be seen as adaptive (heuristic) responses to finite cognitive capacity, i.e., cognitive constraints as a bound on possible rationality (Simon, 1957). One way in which people simplify their judgment and choice tasks is by encoding information locally, relative to reference points, rather than in an absolute or global fashion (see prospect theory, Kahneman and Tversky, 1979). Local encoding (cognitive "myopia") opens the door to framing effects, where people select differently from among objectively same choice alternatives when the alternatives are

presented in different ways (often using different reference points). I will provide a brief tutorial of the behavioral phenomena most relevant in a climate change risk management context, including loss aversion, hyperbolic discounting, the systematic over- or under-weighting of small probability events, and the single action bias. I will also suggest that finite capacity considerations apply not only to cognitive capacity, but also to emotional capacity ("finite pool of worry").

I will illustrate these different decision modes and resulting judgment and choice patterns that deviate from rational-economic assumptions using the example of decisions people must make about energy use and energy efficient products and technology, showing that consideration of the broader set of processes used by consumers to make such decisions can help explain why energy-efficiency solutions to mitigate CO_2 emissions that have large positive expected values are so strongly underadopted (Creyts et al., 2010). I will end by outlining the implications of a behaviorally more accurate model of human motivation and cognition for the communication of climate change forecasts and the design, communication, and implementation of climate change risk management strategies (Weber, 2012; Weber and Stern, 2011).

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Keynote II-4: The role of public and private sectors in developing adaptation and mitigation strategies for dealing with climate change

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This presentation will consider the following questions related to the role of public and private sectors in designing adaptation and mitigation strategies:

1. Given the uncertainties and negative externalities associated with climate change, what roles can the private and public sectors play in developing adaptation and mitigation strategies for reducing future losses?
2. How does one deal with heterogeneity of preferences and values between different interested parties in designing and evaluating these risk management strategies?

To address Question 1, I will highlight the importance of undertaking meaningful risk assessments with respect to the impact of climate change on future losses from natural disasters and the uncertainties surrounding these estimates. The losses can be direct ones such as physical damage from floods and hurricanes to residences, commercial property and infrastructure. There can also be indirect losses that occur over time such as business interruption, evacuation or relocation of facilities, and impact of infrastructure damage on activities in the community or region. These negative externalities need to be taken into account when designing risk management strategies for the private and public sector.

The private and public sectors can play complementary roles when designing adaptation and mitigation strategies for dealing with climate change. The design of these strategies should be guided by the following principles that are variants of those discussed in Kunreuther and Useem (2010) Chapter 1:

- *Principle 1*: One should take into account the potential long term impact of alternative risk management strategies on the economy, politics, culture and society
- *Principle 2*: Key interested parties are often myopic in their thinking, so one should provide short-term economic incentives in conjunction with long-term strategies for reducing the impacts of climate change
- *Principle 3:* Recognize the interdependencies associated with risks and their dynamic uncertainties
- *Principle 4*: Recognize trans-boundary risks by developing strategies that are global in nature
- *Principle 5*: Equity and distributional impacts should be explicitly considered in developing risk management strategies

The following policy tools will be examined for addressing these issues:

- Risk communication
- Short-term economic incentives (e.g., subsidies, fines)
- Multi-year insurance policies
- Well-enforced regulations and standards
- Third party inspections

To address Question 2, I will focus on the importance of values and goals and their impact on how different interested parties perceive the risks associated with climate change. Values and goals are likely to include (i) keeping one's job, (ii) reducing business interruption costs, (iii) saving human lives, (iv) reducing environmental impacts, and (v) reducing negative health and environmental impacts in the short term and long run. In determining their preferences, decisionmakers often exhibit a set of biases and heuristics that include myopic behavior, misperceptions of the risk, and simplified

heuristics such as it cannot happen to us (before a disaster occurs) and it will happen again (after a disaster occurs). Decisionmakers should determine the relative importance of different attributes and goals in reflecting their preferences so they can more systematically evaluate the benefits and costs of alternative risk management strategies. Systematic approaches, such as value tree analysis, can assist them in undertaking these tradeoffs.

To illustrate the challenges associated with the role of the private and public sectors in develop risk management strategies for reducing future losses from climate change, I will focus on flood and hurricane risks using data from Florida. More specifically the presentation will illustrate the uncertainties associated with climate change projections on the likelihood of future North Atlantic hurricanes in 2020 and 2040 and their impact on damage to residential homes. Insurance with premiums reflecting risk coupled with cost-effective adaptation measures can play an important role in reducing future damage. More specifically, multi-year insurance and home improvement loans for investing in adaptation measures could be provided by the private sector. These measures coupled with public sector strategies such as well-enforced building codes and land-use regulations can address behavioral biases such as myopia and misperceptions of the risk and deal with interdependencies across geographic areas and over time. Taken together these types of private-public partnerships, if implemented, can significantly reduce future losses from climate change.

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Keynote III-1: Ethical dimensions of cost-benefit analysis of global environmental problems.

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Ethical judgments, value judgments, are inescapable in conducting cost-benefit analysis of environmental problems—or for that matter of any economic problems. They take different forms in the contexts of different problems, but often—though not always—involve distributional issues. The underlying question is: How can we value the same effect, the same change, when it occurs to different people? Does the fact that it is the same effect mean that its implications are the same? Is the value of the change in a person's economic conditions independent of the person to whom it occurs, or is there a systematic connection between the value of a given change in economic circumstances and the characteristics of the person to whom it occurs?

In the context of climate change the standard answer to this question involves resolving it into two dimensions that are thought to be orthogonal, intergenerational, and intragenerational (Heal, 2009). The intergenerational dimension looks at how the date at which someone is alive affects the way we value a given change to her economic circumstances. Other conditions are assumed to be constant in making this judgment. In considering the intragenerational dimension, we are asking how all a person's conditions other than the date of her existence affect the value of a change in that person's economic circumstances. Typically we are interested in income level as a primary economic condition, but other conditions such as gender and capabilities may also be relevant.

In the intergenerational dimension, there has been an intensive debate about whether the date at which someone lives is a determinant of the value of a change in her circumstances. One school of thought argues that there is a compelling case for discounting future changes in economic circumstances just because they are in the future: sometimes this is justified by an axiomatic foundation (as in Koopmans, 1960; see also Heal, 2005), and sometimes by reference to empirical data such as interest rates and savings rates (as in Nordhaus, 2007). Another school argues that all humans are intrinsically equally valuable and therefore the date at which they exist should not affect the way we value changes in their circumstances. This school also argues that this is an ethical judgment, an "ought" and not an "is," so that empirical data is not probative on this matter (as in Heal, 2009).

With respect to the intragenerational dimension, there is general though not universal agreement in applied welfare economics on a utilitarian framework that allows us to compare the marginal value of income to different people and that accepts that the value of an increment of income to a rich person is less than its value to someone poor (Sen, 1973). An extensive literature on social cost-benefit analysis in the 1960s and 1970s was based on this framework (Little and Mirlees, 1969; Dasgupta et al., 1972; Squire and van der Tak, 1976). The acceptance of a utilitarian framework based on interpersonal comparability of utility is philosophically questionable, and runs counter to the thrust of welfare economics of the 1950s, where the aim was to base analysis on revealed preference rather than utility (Graaf, 1963). Nevertheless it continues to be widely used, probably because many find its implications to be intuitively appealing, and because it is readily made operational. In valuing costs and benefits accruing to people of very different income levels, as in a consideration of the international consequences of climate change, a great deal rests on whether we accept that income has more value to poor people than to rich.

There are other ethical issues that arise in cost-benefit analysis outside of the inter/intra-generational distinction. One is whether we work with willingness to pay or willingness to accept as the measure of a person's valuation of a change (National Research Council, 2004). The difference reflects different allocations of economic rights: do people have a right to a stable climate or a clean

environment, or is this something they need to pay for, something that others have the right to compromise?

Another major and rather intractable issue concerns the impact of changes on non-human species. Do they have rights? Do they have feelings and do we have any obligation to take these into account if they do? As Stone (1972) put it, "Should Trees Have Standing?" In the context of forecasts that 40% of extant species could be driven extinct by climate change (IPCC, 2007), this is a central issue, though not an easy one. In the US, the Endangered Species Act as originally formulated took a strong position on this issue, enshrining a species' right to exist above any economic considerations. Subsequent legislation has weakened this position.

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Keynote III-2: Distributional impacts of climate policies (and possible complementary policies).

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This presentation will discuss the distributional impacts of climate policies within countries, and the possible complementary policies that can be implemented to compensate the possible negative distributional impacts. First, the need to account for distributional impacts will be justified, through a discussion of the possibility to separate efficiency and equity issues in policies (Harberger, 1978). The main criterion is the existence of zero-cost lump-sum transfers: if such transfers are possible, then efficiency and equity can be separated, and ex post transfers can cancel any undesirable distributional impact. Such transfers meet however many difficulties: political acceptability (Kanbur, 2010), information and technical issues (Sen, 1973, 1976; Bourguignon and Fields, 1990), and behavioral changes can make such transfers impossible. In absence of such transfers, the distribution effects of climate policies need to be taken into account.

Second, some of the tools available to include distributional impacts in the economic analysis of climate policies will be discussed: the social choice theory (Arrow, 1951); Pareto efficiency; distributional weight cost-benefit analysis (CBA; Harberger, 1984); basic-needs CBA; nonlinear utility functions in CBA; the Rawlsian approach (Rawls, 1971); and multi-criteria analysis (MCA). Pros and cons of these approaches will be discussed.

Then, the experience from removal of fossil fuel subsidies (in Bolivia, Ghana, Jordan, Mali, Sri Lanka, and Poland) will be used to illustrate the distributional impact of climate-energy policies (Freund and Wallich, 1995; Hope and Singh, 1995; Coady et al., 2006). The channels through which higher energy costs affect distribution issues will be summarized. Also, lessons from complementary policies that have been implemented in the past will be discussed, including the use of existing safety nets, alternative short-term mitigation measures, and energy-pricing solutions. A difference has to be made between middle- or high-income countries where social safety nets exist and can be used for compensation and low-income countries. In the latter, safety nets often do not exist and specific systems have to be implemented. Also, information to target support is often not available in these countries, especially in urban areas where geographic targeting is very inefficient (Kanbur, 2010).

The presentation also includes a discussion of the different redistributive issues that can be created by carbon pricing, including redistribution among household income or wealth class; among rural and urban households; across regions and countries; and among consumers, workers, and shareholders. Three modeling exercises are discussed to illustrate these effects: the redistributive impact across rural and urban households in Indonesia (Yusuf and Resosudarmo, 2007); the regional and income-class redistribution of a carbon tax in the U.S. and in France (Rausch et al., 2009; Hourcade et al., 2010); and the spatial redistributive impacts with a city (Gusdorf et al., 2008).

The consistent findings from these studies are that: (i) the redistributive impacts of a carbon price scheme depend essentially on how revenues from the scheme are used; (ii) complementary measures are available to compensate for unintended distributional effects; (iii) these complementary measures meet the classical challenges of redistributive policies, mainly linked to political acceptability, imperfect information and targeting, and behavioral issues; (iv) a rapid and aggressive action is more likely to create negative distributional impacts than a slower and more regular action.

To conclude, the case of adaptation priorities will be discussed. If resources are insufficient to undertake all required adaptation actions, trade-offs and prioritization will be necessary. In particular,

there will be a trade-offs between efficiency (where is investment the most efficient?) and equity (where is the population most vulnerable?); see for instance, Füssel (2009). This trade-off will have to be taken into account in the design of the international support to adaptation in developing countries.

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Keynote III-3: Positive dimensions of responsibility for past actions.

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The research community that addresses this topic discusses a wide range of questions about the ethics and politics of climate change, and as a result arguments about responsibility for past actions are often embedded in texts addressing broader issues. This small community consists mainly of philosophers, political theorists, and legal theorists, with occasional contributions by economists, geographers, other social and physical scientists, and practicing professionals. While there are particular concentrations of literature, much is scattered over a wide range of books, journals, and reports. However, this topic is related to a much larger literature that addresses some general questions that go to the heart of moral, political, and legal theory. Political philosophers have discussed questions regarding historical injustices since at least the seventeenth century, moral philosophers have argued about the respective merits of forward and backward looking theories (e.g., consequentialism and deontology) for almost as long, and tort law deals with similar questions but often on a different scale.

Generally, the literature on the ethics of climate change has focused on the comparative importance of the following values: capacity, responsibility, need, and efficiency (Jamieson, 2001; Shue, 2010). Almost all the literature holds that responsibility is of at least some relevance (but see Posner and Weisbach, 2010). Gardiner (2011, p. 415) believes that a presumption for its relevance is expressed in the United Nations Framework Convention on Climate Change (UNFCCC). Tol and Verheyan (2004) agree, and also assert that this concept is part of customary international law that is applicable to climate change. Most commentators think that this presumption is related to a widely shared ethical principle ("you broke it, you fix it") that underlies the "polluter pays principle."

Most of those who think that responsibility for past actions is an important and morally relevant principle conclude that developed countries have more substantial and urgent climate change obligations than developing countries, but the argument can go in the other direction. Today's emissions are tomorrow's historical emissions, and at some point the historical emissions of some of today's developing countries will be greater than those of some of today's developed countries (in some cases they already are, if national emissions are the unit of comparison). Those who have argued in favor of "grandfathering" past emissions also take historical responsibility seriously. On their view past emissions confer rights to present and future emissions.

If we assume that actors are morally responsible for past actions regarding climate change, several questions arise. Who are the actors? Which actions are they responsible for? How should their responsibilities be discharged? I will discuss these questions in turn.

One view with more traction in the research community than in the political discussion is that it is individuals who are ultimately responsible for climate change behavior (Caney, 2010; Harris 2010). Such a "cosmopolitan" view distributes the responsibility for past actions among all the people of the world and not just among countries. A consequence of this view is that individuals in low-emitting countries who are high-emitters are as morally responsible for their actions as high-emitting individuals in high-emitting countries. There are variations on this view (e.g., Jamieson, 2010), and in any case a further account is required in order to map such a view on to international law and policy.

Theorists have long distinguished moral, legal, and causal responsibility. The standard view is that an agent is only morally or legally responsible for violating a duty. It is controversial whether all duty violations involve causing harms and whether all harm-causing behaviors involve violating duties. "Strict liability" prevails when an agent has a duty not to cause a harm whatever the circumstances.

"Fault liability" reigns when an agent has a duty not to cause a harm through negligent, reckless, or intentional action.

Most theorists working in this area would apply a fault liability standard (e.g., Singer, 2010), holding that actors are only morally responsible for their emissions beyond a particular date (e.g., 1992) because only then were acting recklessly or negligently. Other theorists would exempt emissions up to a particular threshold from liability considerations. A related question is whether to view actions in addition to emissions that cause climate change (e.g., land use changes) as also subject to liability, and if so whether and where to draw the fault/no-fault line in this domain.

There are other ways of looking at what responsibility for past actions involves. Traxler (2002) believes that past emissions have resulted in the unjust appropriation of a common resource. Bell (2011) thinks that there is a general climate duty to promote just institutions that will protect the human right to development from the threat posed by anthropogenic climate change that has not been discharged.

Finally, there are questions about the remedies that are required for violating duties. One approach would require compensating those individuals, nations, descendants, or forbearers who have been or will be damaged by emissions that have already occurred. The same or different principle could be applied to the question of how to allocate future emissions.

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Keynote III-4: Approaches for allocating future emissions abatement.

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A number of approaches or proposals have been put forward for the mitigation of GHG emissions under the international climate regime beyond 2012 (e.g., Bodansky et al., 2004; Sugiyama, 2005; IPCC, 2007; Stern, 2008). While "Contraction and Convergence (C&C)" (Meyer, 2004) asks for a convergence of emissions on a per capita basis, it gives tacit consent to the inequities of the past, the present, and quite a long time into the future. The Brazilian proposal is representative of those that take historical liability into account (Rosa and Ribeiro, 2001), but fails to consider the present and future development needs of countries in different stages of development.

The Greenhouse Development Rights (GDR; Baer et al., 2008) use two indicators of total capacity (GDP adjusted by purchasing power parity) and total liability (cumulative historical emissions) of the population in countries above the threshold to allocate emission reduction quotas for individual countries in accordance with the total emission reduction required to meet the target of a temperature rise of not more than 2°C. However, this method takes only historical emissions into consideration and fails to consider future needs. In addition, its conceptualization of threshold values for development, calculation of cumulative historical emissions and statistical sources are controversial.

Following Rawls (1971) and Sen (1999), Pan (2005, 2008) considers that basic necessity emissions must be used as the basis for discussion about equity and sustainability. Starting from the axiomatic truths of the limited nature of basic human needs and the carrying capacity of the global system, it stresses that an international climate regime should meet basic human needs, promote low-carbon development, curb extravagance and waste, and at the same time fulfill the dual task of sharing emission reduction in an equitable manner and safeguarding world climate. This budget approach is further developed in German Advisory Council on Global Change (2009), Jayaraman (2011), and Pan and Chen (2010).

In this approach, sustainability is ensured as a global carbon budget is set compatible with the goal of long term temperature stabilization. In the meantime, equity is well reflected in the allocation of the global budget according to equal per capita accumulative emissions. Efficient use of the budget is also realizable as trading of emission permits among individuals, companies, or countries is so designed to balance the budget account, with implications for financial flows.

For the two groups of Annex I and Non-Annex I countries, the relative ratio of carbon budget after initial distribution is 19.5:80.5. After self inter-period transfer, the proportion remains the same. After developed countries pay for their historical debts, the ratio becomes 35.9:64.1. After developed countries provide transfer payments for the future basic needs of developing countries, the ratio changes to 40.9:59.1, as shown in Figure 1.

The results of the budget account show that Annex 1 countries have already over-used their budgets with considerable emissions deficits in their accounts, while Non-Annex 1 countries as late comers have substantial budget surpluses. Deficits and surpluses indicate the potential for collaborative mechanisms between Annex 1 and Non-Annex 1 countries.

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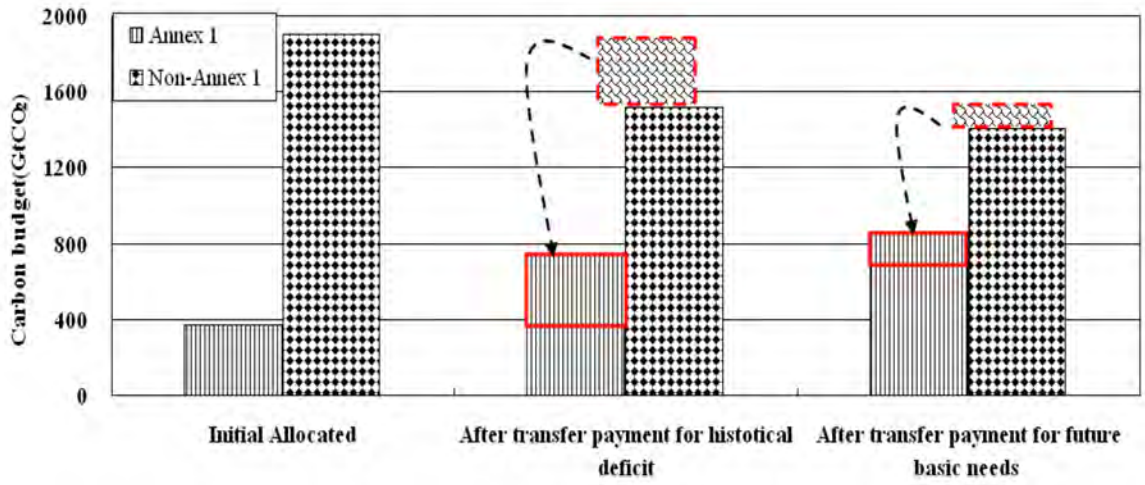

Figure 1: Comparison of carbon budget for Annex I and Non-Annex I for the period from 1900 to 2050 with initial and budget transfers.

Annex 6: Participant List

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for the IPCC WGII/WGIII Expert Meeting on Economic Analysis, Costing Methods, and Ethics
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