WORKING PARTY ON GLOBAL AND STRUCTURAL POLICIES

SUMMARY REPORT


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Summary Report


OECD, 6 – 7 July 2006

Introduction

1. The OECD hosted an expert meeting on the Economic Benefits of Climate Change Policies between 6-7 July 2006 as part of the Global Forum on Sustainable Development. More than twenty experts met to survey the current state of knowledge on the economic benefits of climate policies and to think provocatively about what should be done next to advance understanding of those benefits in the face of uncertainty and acceleration in the pace of observed effects. They focused their attention on methods, metrics, national/sector studies, risk management, and the needs of several “consumers” of information.

2. This Global Forum builds on and complements a series of earlier expert meetings on this subject which culminated in an OECD book published in 2004 titled The Benefits of Climate Change Policies: Analytical and Framework Issues. Many of the initial ideas presented in that book, particularly relating to a framework for estimation of climate change benefits were expanded on in this expert meeting. More recently, OECD has supported several studies of metrics for evaluating the economic benefits of climate change policies relating to sea level rise by Nicholls (2006) and agriculture by Rosenzweig and Tubiello (2006). OECD also has on-going complementary work relating to issues such as the discount rates used for long-term environmental analyses.

3. This report includes a brief overview of the current state of knowledge as portrayed at the Forum and an identification of research needs. The report cuts across the formal agenda and is a synthesis of the presentations and extensive interventions offered by the Forum participants. Given the broad ranging discussions it is not possible to attribute all of the insights to their specific sources. Occasional references to the literature are provided as appropriate; however it was not the intent of this project to do an extensive review of the literature. References to papers presented during the Forum appear in italics; the interested reader will find them displayed on the OECD website: www.oecd.org/env/cc/benefitsforum2006.

A Brief review of the current state of knowledge

4. The matrix in Figure 1 is perhaps the most effective way to summarize the state of the art in analyzing the economic impact of climate change and therefore the economic benefit of climate policy. It is a version of a similar figure found in Downing and Watkiss (2003), and it was a focal point of not only the prepared and spontaneous remarks offered by many of the participants on current knowledge [see Downing (2006), Watkiss (2006), Fuentes (2006) and Hope (2006)], but also much of the discussion of future needs that occupied the last afternoon of the forum. The columns are calibrated by the degree to which the complication of climate change science is captured by benefits analysis. Columns begin with coverage of projections of relatively certain trends in climate change (e.g. average temperature, sea level rise), move on to consideration of the bounded risks of extreme events (including precipitation) and climate variability along those trends, and end with representations of possible abrupt change and/or abrupt

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1 See the dedicated web site: www.oecd.org/env/cc/benefitsforum2006 for more information.
impacts. The rows are calibrated by the degree to which coverage of impacts are captured from an economic perspective. Rows begin on the left with coverage of market impacts, move on to consideration of non-market impacts, and end with socially contingent impacts (e.g. multiple stresses leading to famine, migration) across multiple metrics that cannot always be quantified in economic terms.

5. The shadings depicted in Figure 1 offer a view of the degree to which the literature has thus far handled the 9 different combinations of science and impacts. The dark gray shading in area I suggests a relatively heavy population of coverage by researchers. The lighter-grey shading in areas II, III, IV and V suggests limited coverage in a small group of studies that attempted to provide insight into market-based impacts of bounded risks and abrupt change and non-market impacts of climate trends with or without taking bounded risks into account. Finally, the remaining areas are barely shaded at all because it is nearly impossible to find any credible analyses of these combinations of science and impacts. We now take each combination in turn.

**Area I**

6. The diagram illustrates the judgment that most of the existing research has focused on market impacts along relatively smooth scenarios of climate change. In this context, researchers have noted the importance of site-specificity, the path dependence of climate impacts and the adaptive capacity of various systems. In many cases, time scales of longer than 100 years need to be analyzed as well as the implications of bifurcated temperature scenarios that appear in many temperature scenarios after 2050 ². Chapter 18 of IPCC (2001) made this point explicitly, and it is one of the most robust conclusions of the Third Assessment Report. It was echoed by many of the interventions during the meeting, but highlighted specifically by Kuik (2006) and Hunt (2006) in their overview comments and emphasized by Nyong (2006) and Bhattacharya (2006) with specific reference to Africa and India.

7. Nordhaus (2006 and 2006) described GEcon, a method of matching economic data more effectively to the geographic scale of climate impacts analysis (i.e., 1 degree by 1 degree cells with global coverage). It offers the promise of supporting better analysis of market impacts along climate scenarios, but only if the significant challenge of incorporating diversity in adaptive capacity across the globe and along specified development pathways can be overcome. In any case, aggregation across even market-based impacts can hide a multitude of differences across populations and regions [see Leggett (2006)]. Separating these out is important from a policy perspective, both in terms of overall benefits of climate change policy, but especially in adaptation. Similarly, policy makers are interested in physical impacts and valuation separately. It follows that opportunities still exist for potentially profound improvement even in the relatively densely populated upper-left corner of the matrix.

**Areas II, III, IV and V**

8. A few studies authored by Tol (2002a and 2002b) and Nordhaus and Boyer (2000) among others have tried to include non-market impacts driven by trends in climate change (area IV), but seldom in a comprehensive way, since data are limited and methods are controversial at best. Others, notably West and Dowlatabadi (1999) and Yohe and colleagues (1999 and 2001), have tried to capture the market-based implications of extreme events whose intensities and frequencies have or will be altered by a changing climate, but their efforts to add content to area II have been most successful when framed in the limiting context of impact thresholds beyond which climate variability produces severe damage. It should be noted, though, that the geographic scaling offered by GEcon could add to our understanding here, as well.

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² Many temperature scenarios reviewed in the IPCC Third Assessment Report diverge around 2050 as assumptions about technology penetration rates and other drivers vary beyond this date.
Figure 1. Coverage of existing economic analysis of the impacts of climate change related risks.

<table>
<thead>
<tr>
<th>Uncertainty in Valuation</th>
<th>Market</th>
<th>Non Market</th>
<th>(Social Contingent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I</strong></td>
<td>Coastal protection</td>
<td>IV</td>
<td>Heat stress</td>
</tr>
<tr>
<td></td>
<td>Loss of dryland</td>
<td></td>
<td>Loss of wetland</td>
</tr>
<tr>
<td></td>
<td>Energy (heating/cooling)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>II</strong></td>
<td>Agriculture</td>
<td>V</td>
<td>Ecosystem change</td>
</tr>
<tr>
<td></td>
<td>Water Variability</td>
<td></td>
<td>Biodiversity</td>
</tr>
<tr>
<td></td>
<td>(drought, flood, storms)</td>
<td></td>
<td>Loss of life</td>
</tr>
<tr>
<td><strong>III</strong></td>
<td>Above, plus</td>
<td>VI</td>
<td>Higher order</td>
</tr>
<tr>
<td></td>
<td>Significant loss of land and resources</td>
<td></td>
<td>Social effects</td>
</tr>
<tr>
<td></td>
<td>Non-marginal effects</td>
<td></td>
<td>Regional collapse</td>
</tr>
<tr>
<td><strong>IV</strong></td>
<td></td>
<td></td>
<td>VII</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regional costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Investment</td>
<td></td>
</tr>
<tr>
<td><strong>V</strong></td>
<td></td>
<td></td>
<td>VIII</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparative advantage &amp; market structures</td>
<td></td>
</tr>
<tr>
<td><strong>VI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>VII</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VIII</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IX</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Most existing studies have been limited to market-based sectors, though a few have moved beyond region I to include non-market impacts along projected trends (region II), bounded risks in market and non-market sectors (regions II and V) and abrupt change to selected market sectors (region III). Source: Derived from Downing, T., and Watkiss, P. (2003).
9. Nordhaus and Boyer (2000) and Keller, et al. (in press) are almost alone in their attempt to incorporate abrupt climate change of the sort described by Rahmstorf (2006) systematically into their analyses. They therefore contributed to area III, but their approach is not based on robust analysis of associated damages. These analyses did not exist at the turn of the century, and they are rare even today with Link and Tol (2004) being notable exceptions. Indeed, Nordhaus and Boyer hypothesized the risk of large costs (on the order of 10% of global economic activity) with low probabilities halfway through the current century and included some aspects of the willingness to pay measure to avoid such risk in their calibration of global damages. The same authors have tried to bring assessments of non-market impacts into their integrated assessments of climate change, but their efforts have been severely limited by a paucity of robust economic estimates of impacts.

10. As noted by Janetos (2006), the Millennium Ecosystem Assessment (the MA) is a new contribution to areas IV and V. That work stopped short of assigning economic values to ecosystem services, but various working groups in the MA process developed scenarios within which those services produced utility, and some attention was paid to climate change.

**Areas VI through IX**

11. Participants at the workshop agreed with the assessment of Downing and Watkiss (2003) that the current state of knowledge has almost nothing to say about impacts and vulnerability calibrated in the non-market impacts of abrupt change in climate and the multiple metrics of socially contingent impacts. It follows that integrated assessments of optimal climate policies are missing much of the action, especially when global connections are recognized. It is, more specifically, through these socially contingent vulnerabilities that climate impacts in one place (e.g., the developing countries) can be felt elsewhere (e.g., in Europe or the rest of the developed world). It does not necessarily follow, however, that work needs to be done to try to calibrate these vulnerabilities, once they are described rigorously, in terms of economic damages. Mirroring a perspective offered by Yohe (2004) in the wake of an earlier OECD Forum on the benefits of climate policy, participants in this forum expressed concern that trying to fit multiple vulnerabilities into a cost-benefit analysis would continue to be a productive tactic. While the consequences of many physical impacts can be quantified in terms of currency, many others (like millions at risk of hunger or the likelihood of an abrupt change in climate) cannot. They argued, instead, that developing and applying new decision frameworks, like risk management and risk-weighted outcomes, would advance knowledge more effectively. These techniques do not necessarily require a common metric to support comparisons across multiple contexts; see, for example, Jones and Yohe (2006).

**Using the results**

12. Many of the participants noted that researchers and, in some cases, policy makers have nonetheless used the results of the analyses that populate the matrix (particularly those drawn from area I) to conduct assessments of optimal climate policies and to compute estimates of the social cost of carbon and other greenhouse gases; see Watkiss (2006), Hope (2006), Tol (2006) and Fuentes (2006) for example. These social costs are estimated by tracking the damage caused over time by releasing an additional ton of a greenhouse gas like carbon into the atmosphere and discounting those estimates back to the year of its emission. That is to say, the social cost of carbon represents the “marginal cost” of carbon emissions; alternatively, it represents the “marginal benefit” of a unit of carbon emissions reduction.

13. Estimates of the social cost of carbon currently available in the published literature vary widely. Figure 2 displays a cumulative distribution of more than 100 such studies derived from a survey conducted by Tol (2005). Fully 12% of the published estimates are below USDUSD0. Their median is USDUSD13 per ton of carbon, and their mean is USD85 per ton. While the underlying meta-analysis may have lacked sufficient structure to avoid double counting and other statistical problems, it does make the important
point that the range of estimates of the social cost of carbon is enormous. Why? Hope (2006) provides some insight derived from exercising his PAGE model; his results are displayed in Table 1. The choice of discount rate and the incorporation of equity weights are extremely important, and both lie within the purview of decision-makers. High discount rates sustain low estimates because future damages become insignificant. Conversely, low discount rates produce high estimates because future damages are important. Meanwhile, strong equity weighting across the globe support high estimates because poor developing countries are most vulnerable. Conversely, weak or no equity weighting can produce low estimates because poor developing countries do not factor heavily in the overall calculation. Some policymakers have recognized these issues (e.g., Watkiss (2006), and both are somewhat controversial. Hope (2006) concludes, however, that the climate sensitivity (i.e., the increase in global mean temperature that would result from a doubling of greenhouse gas concentrations from pre-industrial levels) is the largest source of variation. It is possible to derive high estimates for the social cost of carbon even if you assume low discount rates and almost no equity weighting. All that is required is the assumption that the climate sensitivity lies at the high range of the latest range of estimates.

Figure 2. The distribution of published estimates of the social cost of carbon emitted in 2005 (expressed in 2005USD per ton of carbon emitted).

Note: Point A indicates that 12% of the estimates are negative because they emphasize possible benefits in the near and discount the future severely. Point B is the median, and Point C makes the point that 20% of the estimates lie above USD75 per tonne. The maximum estimate fell above USD350 per tonne. Source: Tol (2005)
Table 1. **Major factors causing uncertainty in the social cost of carbon**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Range</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate sensitivity</td>
<td>Equilibrium temperature rise for a doubling of CO2 concentration</td>
<td>1.5 – 5 deg C</td>
<td>100</td>
</tr>
<tr>
<td>PTP rate</td>
<td>Pure time preference for consumption now rather than in 1 year’s time</td>
<td>1 – 3% per year</td>
<td>66</td>
</tr>
<tr>
<td>Non-economic impact</td>
<td>Valuation of non-economic impact for a 2.5 deg C temperature rise</td>
<td>0 – 1.5 % of GDP</td>
<td>57</td>
</tr>
<tr>
<td>Equity weight</td>
<td>Negative of the elasticity of marginal utility with respect to income</td>
<td>0.5 – 1.5</td>
<td>50</td>
</tr>
<tr>
<td>Climate change half-life</td>
<td>Half life in years of global response to an increase in radiative forcing</td>
<td>25 – 75 years</td>
<td>35</td>
</tr>
<tr>
<td>Economic impact</td>
<td>Valuation of economic impact for a 2.5 deg C temperature rise</td>
<td>-0.1 – 1.0 % of GDP</td>
<td>32</td>
</tr>
</tbody>
</table>

Note: Relative importance is measured by the magnitude of the partial rank correlation coefficient between the parameter and the SCC, with the most important indexed to 100. Source: Hope (2005)

14. For present purposes, though, it is important to note that estimates of non-market damages are extremely important, dominating even estimates of market damages in relative importance in explaining the wide variation. Learning more thorough investigations of regions IV through VI is therefore critical. Equally important is the observation that few if any of the estimates recognize abrupt change (regions III, VI, and IX); and none venture into anything contained in the right-hand column (regions VII through IX). Given these omissions, it is clear that many of the shortcomings in our current ability to populate the lightly shaded regions of Figure 1 with credible analyses significantly undermines our ability to compute the social cost of carbon, and thus to infer the economic benefit of climate policy, with any degree of confidence.

**The seeds of progress**

15. Participants at the Forum were not discouraged by these shortcomings. Looking at the potential benefits of climate policy in terms of reducing climate risk was a recurring theme throughout the Forum. The critical role played by the insurance industry, which can increase the ability to adapt to climate change,
but is also a vulnerable economic sector, was highlighted by Dowlatabadi and Cook (2006). However, the insurance sector is not monolithic. Its operation and its relative efficacy are both determined in large measure by (1) regulations and approaches that vary from region to region, from country to country and, in some cases, from state to state and (2) the overall health of economies within which insurance companies invest their holdings while they wait for claims. It cannot be assumed that the industry, even with the development of extensive re-insurance mechanisms, will be able to provide the level of risk spreading often portrayed in textbook treatments of how insurance should work to improve welfare; and so it cannot be assumed that the promise of increased social welfare can be attained with or without factoring climate risk into the equation.

16. Risk-weighted measures derived directly from first principles (i.e., a simple definition of risk as the probability of something happening multiplied by some measure of the associated consequences) already exist; see Jones and Yohe (2006). They can be used to produce cumulative probability distributions of climate-related impacts denominated, for example, in currency (mostly from market sectors), in terms of the likelihood of crossing critical thresholds of tolerable experience (mostly from non-market areas though applicable to the multiple metrics of the third column), or in terms of the likelihood that an abrupt change might occur. As a result, they can produce comparable depictions not only of risk itself, but also its sensitivity to climate policy at various points in time. Even a preliminary pass across three illustrative contexts show a diversity of response to policy intervention – some responses are likely to be relatively large and/or immediate while others are small and/or delayed. Decision-frameworks designed to process this sort of information exist in other context, of course, but they have yet to be applied widely to the climate arena.

17. The refinement and, in some cases, the development of suitable metrics also holds promise in promoting progress across the matrix. While area I is certainly based on keeping track of important state variables, the development of comparable metrics across multiple evaluative criteria is particularly critical in the other areas. For relatively self-contained and easily described physical impacts like sea level rise, the implications of gradual trends (erosion and salt water intrusion, for example), bounded risks (coastal storms producing catastrophic damage and prolonged periods of recovery or abandonment), and abrupt change (the potential of dramatic long-term or perhaps even sudden inundation from an accelerated melting of the Greenland Ice Sheet or a collapse of the West Antarctic Ice Sheet, respectively), the metrics are relatively clear; see Nicholls 2006. Nicholls identifies two approaches based on exposure and impacts using various tools. Examples of risk metrics that may be relevant to both analysts and decision makers include: land areas, people, ecosystems, economic values and cultural/heritage sites. Metrics can also be used to monitor change, including the effects of policies.

18. For other impacts like agriculture, however, the identification of important metrics for tracking effects down any column, but particularly the third, is more elusive; see Rosenzweig and Tubiello (2006). It is clear that metrics need to be germane to local stakeholders. It may even be true that they need to be identified by local stakeholders. It is not enough, for example, that forests will continue to flourish in the northeast region of the United States; residents there want sugar maple trees to dominate their forests. It follows from this simple example that important metrics will vary from site to site and from time to time with the same overwhelming diversity that confounds the calibration of local levels of potential adaptive capacity. Nonetheless, metrics must be clearly understood, both in terms of what they measure and how they are connected causally to climate change.

19. Motivated again by the MA and success in a Heinz Center initiative on ecosystems, Janetos (2006) offered the challenge of optimizing monitoring and analysis across multiple metrics to locations and sectors where climate impacts are likely to be significant (in terms of the dimension of change) and important (in terms of the sensitivity of human welfare to the manifest change). Frequent interventions responded favorably to the idea, but they also emphasized that the identification of “hot-spots” need not be
confined to ecosystems and ecosystem services. Significant and important impacts can be calibrated in economic and social terms, as well. Janetos also noted that the way such metrics were developed for ecosystems in the US was through deliberative or consultative processes with affected stakeholders by region. The interactions between laypersons and experts can help to shape or frame the content of analyses or quantitative monitoring so that it is useful to local/regional audiences in different places.

Research needs and structural issues

20. Given the state of the art described above, there is a significant need for better information based on rigorous research and interactions with decision-makers in the design of such research. O’Connor (2006), Fuentes (2006) and Hope (2006), representing three different communities, presented different perspectives. O’Connor noted the public perceptions of risk associated with climate change vary, based largely on polling data of citizens in the United States. He highlighted how risk perceptions interact with scientific evidence and cultural activities alike, how they change over time and how they interact with climate change politics to affect leadership on the issue. Fuentes provided insights about how information was used to formulate the current goals of the EU as embodied in statements of the European Commission and Parliament. Hope, using an integrated modeling framework, confirmed that many more data points are needed, if better insights are to be forthcoming about the economic benefits of policies.

Research initiatives in support of expanding knowledge

21. Where should we go from here? We list below several research topics that seem to be particularly important and a set of questions that need attention. Some aspects of the topics, e.g., improvements in geo-economic datasets or development of adaptation cost estimates, can be tackled immediately; others, by their nature, will require fundamental research over a longer term. Some of the information generated could help fill the short-term needs for policy making; other results will provide the building blocks for securing better information in the long-term. In most cases, short and long-term tasks will need to be planned and executed in a relatively seamless fashion to ensure the best results. Also, because this community functions differently than some other research communities (i.e., research is usually conducted by independent scientists instead of by large integrated teams), we identify some structural adjustments to the way research is approached that could lead to more coherence while still encouraging creativity and innovation.

Fill in the rest of the matrix

22. One fundamental conclusion about next steps as identified during the Forum can be summarized easily – begin to fill in the rest of the matrix displayed in Figure 1 with particular emphasis on the bottom two rows (bounded risk and abrupt change or impacts) and the right-most column (multicriteria evaluations that can support internally consistent comparisons across different metrics applied to spatially and temporally diverse contexts). Consideration of the entire matrix makes it clear, though, that filling it in with quality and comparable research will be a major long-term challenge. Indeed, while directing fundamental research efforts to providing insight along the bottom two rows and the right-most column would be most productive, doing so will require extensive expansion of research efforts supported by (1) informed and internally consistent scenarios of socio-economic development and their associated emission scenarios, (2) consideration of temperature changes that reflect not just the central tendencies, but also the low probability extremes, (3) relatively detailed scenarios of how the incidence of extreme events (like cyclones) and the impact of abrupt change might be distributed over space and time, (4) systematic development of methods with which to assess low-probability (and high consequence) events, (5) carefully constructed time-series of observed and anticipated impacts, and (6) associated evaluations of the costs of
adaptation. Efforts are underway, such as the PESETA project supported by the European Commission, to improve information on impacts of climate change in various sectors and to estimate economic impacts, but these remain quiet limited in scope. Research to fill in the matrix needs to be closely coupled with these and other studies of the physical, ecological and social impacts of climate change reflecting both positive and negative effects.

**Identify “ot-pots” across a broad range of criteria and optimize monitoring**

23. Working to identify “hot-spots” relative to extreme events and abrupt change and calibrated across multiple metrics is another critical next step. Attention can be focused most productively on places and/or iconic sectors, heritage sites and internationally recognized ecological reserves where important climate impacts have or will likely be observed using metrics that have or will be identified. The ecological literature has already begun to use “hot-spots” to track risks and thresholds of tolerable climate variability in ecosystems and the threat of sizeable species extinctions. The hazards literature tracks risks from extreme events to human and natural communities. The social and economic vulnerability literature tracks risks to human well-being or progress toward Millennium Development Goals across specific regions and specific communities. Recognizing these and other areas where climate impacts are now and/or will become significant and important may allow the broader research community to optimize its monitoring and assessment initiatives – looking at places or sectors where data exist and making sure that the requisite time series are created and sustained and discovering places or sectors (like many of the world’s developing countries and most of the non-market arenas) that are likely to be most vulnerable even though the requisite research infrastructure of methods, models and data do not yet exist. In the latter cases, “start-from-scratch” efforts face the challenges and opportunities of deciding what to monitor even if it takes fundamental research to determine exactly how to proceed in designing the appropriate “thermometers”. Here again consultations with local communities can help to identify hot spots of special interest.

**Craft scenarios of abrupt change and the incidence of extreme events taking explicit account of socio-economic context**

24. Determining the significant economic impacts of climate change requires a complementary focus on abrupt climate change, extreme events, and abrupt impacts. The community will require “not-implausible” scenarios of global distribution of impacts of “surprises” from the natural scientists to support geographically disaggregated analyses of possible adaptations informed by socio-economic scenarios from which measures of potential adaptive capacity can be drawn and feasibility can be assessed. Here, the potential collapse of the West Antarctic Ice Sheet (WAIS), the rapid melting of the Greenland Ice Sheet, the weakening of the Meridian Ocean Circulation (MOC), an increase in the intensity and/or frequency of coastal storms, and the chance of runaway greenhouse effects all need consideration. So do natural or socio-economic thresholds for even routine climate change as manifest in climate variability; in this context, the capacity to recover from an extreme event through insurance coverage and economic development can be critical.

**Improve and utilize geographically explicit models and data**

25. Expanding geographically explicit frameworks of economic analysis (like GEcon) to look at sectoral implications and the potential costs of transition from one climate and/or climate policy regime to another is also technically possible and can complement economic modelling. Research indicates that improving geographically explicit economic data and modelling can fill a critical need to better understand

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3 Undertaken by the Institute for Prospective Technological Studies (IPTS), Directorate General Joint Research Centre (JRC), European Commission.
regional and global aggregate economic impacts of climate change. Immediate next steps in developing methodologies to confront these challenges include better data sets and could perhaps concentrate on one country (like the United States) or one region (like Europe) where data are available, but not to the exclusion of other locations (where vulnerabilities are likely to be higher) and non-economic physical metrics (that are likely to record the most significant impacts). The development of these tools, as well as other methodological approaches, should therefore anticipate the simultaneous development of internally consistent socio-economic scenarios born of improved time series data for developing countries. Moreover, their evolution should anticipate the publication of scientifically credible impact scenarios for the incidence of extreme climate-related events and the global distribution of impacts driven by abrupt change.

**Develop risk-management applications to support climate policy decision making processes**

26. Notwithstanding the power of geographically explicit economic analysis, framing the research agenda in terms of filling in the matrix makes it clear that cost-benefit analysis is not necessarily the correct approach for every situation. The next round of research will need to support the development of climate-specific risk management tools for analyzing both adaptation and mitigation. Risk weighted measures can be developed to produce comparable portraits of what might be dangerous impacts over time across multiple metrics of impacts as well as multiple sectors and geographic regions. The resulting site-specific and path-dependent measures hold the promise of plotting the differential impacts of various mitigation strategies on the likelihood of dangerous climate change across a diversity of contexts. Focusing on risk can therefore become a productive way of (1) sorting out what is dangerous and what is not, (2) determining what dangers can be mitigated by climate policy and what dangers cannot, and (3) providing a self-targeting way to identify “hot-spots” where optimized monitoring can be most productive. Decision frameworks designed to utilize this sort of information have been developed for other contexts, of course (e.g. insurance and re-insurance markets, portfolio allocation, hazard management, emergency preparedness, etc.); but progress here will be most productive if a complementary effort is undertaken to bring their strength to bear on deliberations of climate policy on adaptation, mitigation and development.

**Adaptation**

27. While there is a slowly emerging knowledge base on the costs of climate change, there is very little information on the economic costs (and benefits) of adaptation. This is highlighted as a major policy gap. There is a lack of real cost data outside of a few limited sector examples. There is therefore a need to build up the information on adaptation options and costs in different regions and sectors, and the reduction to climate risk that they provide. This could begin with an ex post evaluation of adaptation responses.

28. There is also a need to test adaptation policy frameworks by setting out the policy steps including identification of objectives, targets, indicators, and the role for economic information in this policy cycle. This might allow consideration of the benefits of adaptation, i.e. to put in place in an economic context the net reduction in climate change impacts (in monetary terms) and an initial prioritization across sectors, identifying where adaptation could provide the greatest reduction in climate change impacts.

**Other specific issues to be addressed**

29. Finally, the Forum identified, at least in passing, a series of more specific questions and issues. A few are listed below to provide a flavour of the discussion.

- Identify further the societal impacts associated with the 0.7 degree warming that has already occurred, taking into consideration the work of the IPCC Fourth Assessment Report.
• Identify additional cases in which adaptation and other responses to climate variability have been successful and build an understanding of the basis of these successes.

• Investigate other cases where success has been more difficult (if not impossible) to achieve and build an understanding of the institutional, economic, political, informational, and other impediments that stood in the way.

• Assess the appropriate role of equity weighting in the calculation of the social cost of carbon. Is it different for global policy and individual countries?

• Determine the appropriate role of estimates of the social cost of carbon. Is it exclusively a tool to inform global mitigation policy, or can it internalize the shadow-price of carbon to bear on public and private investment decisions, e.g., infrastructure, buildings, transportation fleets, and alternative energy development.

• Evaluate the threshold of risk that private insurance and re-insurance markets can be expected to cover over time without an extensive public backstop program. Also, consider how climate risks, particularly those associated with extreme events or abrupt change, can be factored into insurance premiums across the wide range of administrative contexts currently displayed within the U.S., Europe, and developing countries.

• Determine how risk averse various levels of government are in different societies and what the implications are for efforts to assess the benefits of climate change policies.

• Drawing on experience with other long-term social policy issues, determine how to motivate near-term climate policy actions in the face of persistent uncertainty about the economic benefits of climate policies.

• Assess the importance of transition costs in comparing alternative climate policies (or the timing of implementing a specific climate policy).

• Consider the complementary and/or competitive roles of mitigation and adaptation in a climate policy portfolio.

• Consider cross linkages between sectors and regions (i.e. the wider multiplier effects) which are widely considered to be important, but for which there is no evidence.

A near-term “research plan” and structure

30. The “socio-economic benefits” climate change community is vibrant and active, but its collective efforts would be more productive if each researcher could locate his or her work in answering a specific question under the umbrella of a unifying “research plan”. The International Geosphere Biosphere Program (IGBP) and the International Human Dimensions Program (IHDP) have established formal mechanisms by which they create science plans to help researchers leverage their work across informally organized agendas. These plans do not tell researchers precisely what to do or even tell them exactly what questions to ask. They do, rather, add context to research proposals, provide contacts for collaboration, offer a means to promote more cohesive efforts and provide mechanisms for integrating results around the globe.

31. In the climate area, even an informal plan would provide a means through which the policy community could articulate its needs and a framework in which individual research projects could be
located and hence be more productive. While there was no formal discussion at the Forum about a research plan, there was unanimous support for a series of subsequent meetings to assess how the needs identified above could be sorted, coordinated and further developed into a collection of integrated initiatives for submission to funding agencies and research administrators. An appropriate level of support for such a plan was not a topic of discussion at the Forum, but it should be anticipated that if policy makers want better information additional resources will be required.

32. The wide range of research needs noted above cry out for some synthetic structure to promote at least collegial interactions among researchers, especially when they work individually on one specific topic located in a diverse list of interrelated issues of the sort offered above. If additional information is to be forthcoming for the next IPCC report and to help guide national policies, an improved means to informally coordinate research and develop initiatives warrants exploration.

How might such a plan be developed?

33. An important next step would be the convening or two or three small meetings of experts, possibly in conjunction with another international institution. The aim of these meetings would be to explore the merits, dimensions, contents and costs of a “Research Plan”, including a means of coordinating research in the future, with the goal of seeking financial support from research and policy institutions in member countries. The identification of institutional options, including possible roles for OECD and others, could also be explored further in such a process.

34. The process might include an initial meeting to discuss the topics noted above, as well as others, to develop an outline for such a plan and to agree on responsibilities for its development. Further meeting(s) would be needed on the issues that emerge, to review the plan and work toward researching a broad consensus. The research plan should reflect carefully the literature reported, for example, in the expected Fourth Assessment of the Intergovernmental Panel on Climate Change.

Conclusions

35. The forum reached broad agreement on a number of aspects of the current state of knowledge and on steps that could lead to a significant advance in the state of the art. Listed below are several research topics that seem to be particularly important.

36. The current estimates of the social cost of carbon vary widely. Estimates are influenced by many factors such as site-specificity, the path dependence of climate impacts, assumptions about adaptation, and choices of discount rate and equity weights. The current state of knowledge has almost nothing to say about impacts and vulnerability calibrated in the non-market impacts of abrupt change and the multiple metrics of socially contingent impacts.

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4 Examples of questions the Global Forum did not discuss include: Is a broader framework than simple Cost Benefit Analysis really needed? Would relying on risk-based approaches lose important information on economic costs? Can information be brought together to support the different decision frameworks, considering CBA, risk analysis, and social frameworks? What are the limitations and merits of aggregated economic data sets as provided by GEcon?
37. There are many issues that need attention. The following are examples of research initiatives that could lead to better information, namely:

- Filling in the matrix with comparable studies, particularly studies of bounded risk and abrupt impacts that are coupled with studies of the physical, ecological and social impacts of climate change.

- Identifying hot-spots across a range of regions/sectors that are susceptible to extreme events and abrupt change (hence significant economic impacts) and working to ensure that proper time series data of all types are collected.

- Crafting scenarios of abrupt change and the incidence of extreme events taking into consideration the possible socio-economic context.

- Improving and utilizing methods such as geographically explicit models and data.

- Developing risk-management applications to support climate policy making processes.

38. If policy makers want better information for decision making, a significant expansion of resources is required.

39. The collective efforts of the community would be more productive if each researcher could locate his or her work under the umbrella of a unifying “research plan”. Such a plan could add context to research proposals, provide contacts for collaboration, offer a means to promote more cohesive efforts and provide mechanisms for integrating results around the globe.
REFERENCES


Additional references noted in italics may be found on the dedicated web site: www.oecd.org/env/cc/benefitsforum2006.


## APPENDIX A: AGENDA

### Thursday 6 July

<table>
<thead>
<tr>
<th>Time</th>
<th>Activities</th>
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<tbody>
<tr>
<td>08:45-09:00</td>
<td>Registration</td>
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<tr>
<td>09:00-09:15</td>
<td>Welcome from the Chair, <em>Gary Yohe</em>, Wesleyan University</td>
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<tr>
<td>11:30-12:00</td>
<td>Break</td>
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<tr>
<td>13:00-14:00</td>
<td>Lunch</td>
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<tr>
<td>14:00-15:30</td>
<td><strong>2. Metrics (cont.)</strong> &lt;br&gt; d) Risk assessment, <em>Thomas Downing</em> (Stockholm Environment Institute)  &lt;br&gt; Discussant: <em>Jean Palutikof</em> (Intergovernmental Panel on Climate Change)</td>
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<tr>
<td>15:30-16:00</td>
<td>Break</td>
</tr>
<tr>
<td>16:00-18:00</td>
<td><strong>3. National/sectoral reports</strong> &lt;br&gt; a) Impact of climate change on water demand and availability in California, <em>Larry Dale</em> (University of California, Berkeley)  &lt;br&gt; b) The social cost of carbon, <em>Paul Watkiss</em> (AEA Technology; Stockholm Environmental Institute)  &lt;br&gt; c) Climate change damages in Africa, <em>Anthony Nyong</em> (University of Jos)  &lt;br&gt; d) Assessing the impacts of and adapting to climate change at a local/national level in India, <em>Sumana Bhattacharya</em> (Winrock International India)  &lt;br&gt; Discussant: <em>Richard Klein</em> (Potsdam Institute for Climate Impact Research)</td>
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<tr>
<td>Time</td>
<td>Session</td>
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<td>09:00-11:00</td>
<td><strong>4. Risk Management</strong></td>
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<td></td>
<td>a) Risk management approaches to a climate policy portfolio, <em>Roger Jones</em> (CSIRO Marine and Atmospheric Research)</td>
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<td></td>
<td>b) Risk management approaches to a climate policy portfolio, <em>Hadi Dowlatabadi</em> (University of British Columbia) presented by <em>Gary Yohe</em> (Wesleyan University)</td>
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<td>d) Critical thresholds and &quot;tipping points&quot; in the Earth system, <em>Stefan Rahmstorf</em> (Potsdam Institute for Climate Impact Research)</td>
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<td>- Discussant: <em>Ian Burton</em> (Environment Canada)</td>
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<td>11:00-11:30</td>
<td>Break</td>
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<td>11:30-13:00</td>
<td><strong>5. Thoughts from “consumers”</strong></td>
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<td></td>
<td>a) <em>Robert O'Connor</em> (US National Science Foundation)</td>
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<td></td>
<td>b) <em>Ursula Fuentes</em> (Federal Ministry for the Environment, Germany)</td>
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<td></td>
<td>c) <em>Chris Hope</em> (University of Cambridge)</td>
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<tr>
<td>13:00-14:30</td>
<td>Lunch</td>
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<tr>
<td>14:30-16:30</td>
<td><strong>6. Provocative proposals to significantly advance the state of the art</strong></td>
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<tr>
<td>16:30-17:00</td>
<td><strong>7. Summary and closing</strong></td>
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<td></td>
<td>Gary Yohe, Chair</td>
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</tbody>
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