



Editorial

Assessing impacts, adaptation and vulnerability: Reflections on the Working Group II Report of the Intergovernmental Panel on Climate Change

The publication of the Working Group II (WGII) Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) is a significant occasion for this journal, marking the international impact of the articles that appear in it and setting an agenda for future research for those who read it. The report includes a large number of authors and citations associated with *Global Environmental Change: Human and Policy Dimensions*. Two chapters, for example, have more than 25 references to research published in the journal.

The report is summarised in a Synthesis for Policy Makers (SPM) published in April 2007 (www.ipcc.ch) and the full report has 20 chapters written by more than 380 coordinating, lead and contributing authors (Parry et al., 2007). The full report includes seven sectoral studies (water, ecosystems, food/fibre/forests, coasts, industry and settlement and health) and eight regional assessments (Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, Polar, Small Islands) as well as chapters on observed changes, methods, adaptation, adaptation-mitigation links, key vulnerabilities and sustainability.

IPCC Assessments are published about every 5 years, and authors are asked to review literature since the last assessment (2001 in this case) and highlight any new results. There has always been a sequencing problem with IPCC in that it is difficult for impacts researchers (WGII) to use the latest climate projections (WGI) and for climate modellers (WGI) to use the latest emission scenarios (WGIII) when reports are written simultaneously. The reports are often overtaken by new analysis during the long process of writing and review—for this round of IPCC the Stern Review (Stern, 2007) partially scooped the limelight, appearing after most of the report was completed. The reports must conform to general guidelines set by IPCC which in the Fourth Assessment included a common language for communicating uncertainties in terms of confidence levels (about the chance of statements being correct) and descriptions of likelihood (probabilities of an outcome occurring in the past or future).

Report highlights

Working Group I (WGI, IPCC, 2007) highlighted the unequivocal evidence that the world is warming and the attribution of much of this observed warming (and some other climate changes) to greenhouse gas emissions. In terms of observed impacts the WGII conclusions with the greatest levels of confidence (nine in ten chance) are that recent warming is affecting terrestrial biological systems with polar and upward shifts in the range of many species and earlier timing of vegetation growth and animal breeding in spring (Chapter 1). These conclusions are based on meta-analytical studies of hundreds of ecosystem observations and are synthesised in a map (SPM-1) that shows the percent of ecosystem (together with other physical) changes in different world regions since 1970 consistent with a warming. This map clearly shows a bias to Europe (where more than 95% of the data series were generated) and the urgent need for studies in the southern hemisphere and Polar Regions.

A rather laboured argument suggests that these impacts can be attributed to anthropogenic warming because they are consistent with WGI attribution of global temperature to increase emissions and with the direction of change expected as a response to warming, because of spatial agreement between observed impacts and because of a modest number of modelling studies that show better simulations of climate impacts with anthropogenic forcing than without.

There is less confidence in other observed impacts although there is some evidence that high latitude agriculture and forests are responding to early spring warmth and that human health is being affected by heat waves and allergic pollen, at least in Europe. Polar and mountain regions are seeing the greatest impacts on livelihoods and ecosystems with reduced ice and snow cover affecting transport, tourism, biodiversity and water resources. There are isolated examples that people are already adapting to these changes.

The assessment of projected future impacts follows previous reports in highlighting the critical role of

vulnerability and adaptation in determining the impacts of global warming. This insight—one of the most important contributions of the social sciences to climate impact research—bears repetition because it shows that the science reported in WGI is only a small part of the story of human interactions with climate and because it reminds us that part of the response to climate change must be the reduction of vulnerabilities through development and adaptation. The Fourth Assessment is more comprehensive in showing how vulnerability is exacerbated by other stresses such as disease, poverty and some aspects of economic development but could go further in thinking how the broader context and other stresses may influence future impacts and vulnerabilities. More innovatively the report analyses important interactions with alternative development pathways and shows that unless climate change is considered in sustainable development it will limit the ability to reach the Millennium Development Goals (Chapter 20). Another new approach is the consideration of the synergies and conflicts between mitigation and adaptation (Chapter 18), although there are few published analyses of their interactions. Among its more general conclusions the WGII Report notes that although the literature reports a wide range of possible adaptations, we need to better understand the limits to adaptation and its costs (Chapter 17).

The report suggests that water availability will increase at high latitudes and decrease in some parts of the mid latitudes and dry tropics, that the resilience of ecosystems will be exceeded by a combination of climate and other changes, that up to 30% of species will be at increased risk of extinction, that millions of coastal dwellers will face increased flood risks exacerbated by other pressures such as population and economic growth and that many of these changes will negatively affect human health (Chapters 3–8).

Climate impact research is sometimes criticised for focusing on the more negative effects of global warming (Ausubel, 1991) but WGII does provide some more positive results in projecting an increase in crop productivity and successful adaptations at mid and high latitudes for modest warming but this reverses once temperatures exceed 3 °C and for tropical regions where warming is likely to decrease production and adaptive capacity is low (Chapter 5).

Africa is reported as extremely vulnerable, especially to food and water stress, because of poverty and low adaptive capacity (Chapter 9). Polar Regions and Small Islands are highlighted, as in previous assessments, for their vulnerability to warming and to sea level rise (Chapters 15 and 16). Australia (Chapter 11) and Europe (Chapter 12) are projected as developed regions particularly likely to suffer from warming and changes in the hydrological cycle.

The chapter (Chapter 19) on key vulnerabilities appears as a narrative update of the ‘Burning Embers’ graphic from the Third Assessment Report of five reasons for concern at different levels of global temperature change. New research is reported to show more evidence of observed and projected impacts on unique and vulnerable systems, increasing risks of extreme events, more uneven distribu-

tion of impacts within countries, that market benefits will be lower and damages higher and more detailed assessments of the risks of discontinuities.

This chapter is also an attempt to define measures of ‘dangerous anthropogenic interference with the climate system’ in the context of Article 2 of the Framework Convention on Climate Change (linked to goals for stabilising greenhouse gas concentrations). Both scientific argument and value judgements are seen to define key vulnerabilities that are of high magnitude, early and fast onset, persistent or irreversible, high probability, difficult to adapt to, unequally distributed and valued for their uniqueness or human significance. This chapter is full of new ideas but appears somewhat orthogonal to the rest of the report in integrating ideas from WGII together with some of the work on relationships between emission scenarios and climate change risks from the other Fourth Assessment reports and the published literature.

Reflections and recommendations

My overall impressions of the Fourth Assessment Report on impacts, adaptation and vulnerability are that progress has been limited since the Third Assessment in 2001. There are too many gaps in geographical and sub-sectoral coverage, too few studies that analyse observed impacts and responses or include an adequate range of scenarios, too little in the way of economic analysis, too little literature in languages other than English and too many case studies undertaken outside frameworks that permit aggregation, comparison or general insights. This is not a fault of the authors who must have scoured the world for relevant studies, but very likely reflects a lack of research funding and human capacity, the difficulty in designing comparative studies, the lack of reliably downscaled climate scenarios and the complexity of research on climate impacts in a world where many other things are changing.

In many chapters authors have had to rely on only a couple of studies. For example, the assessment of international impacts on food (Chapter 5) basically relies on two global modelling studies (Parry et al., 2005; Fischer et al., 2005) that link climate to agricultural production and both use the same trade model (IIASA’s Basic Linked System) to analyse the all important food system linkages. This chapter is overly focused on agricultural production and does not adequately explore the broader implications of climate change for food security and for key elements of the food system such as fisheries. The chapter on industry and cities (Chapter 7) is perhaps the most limited by available research with the authors admitting the lack of studies in the developing world, on industrial impacts and adaptation, and on climate impacts on energy systems. The ecosystems analysis (Chapter 4) was able to draw on a much broader range of quantitative research studies—perhaps because some measure of climate is common in many ecosystem change studies compared to studies of social systems, which are also often qualitative.

While a focus on vulnerability and adaptation reduces reliance on climate projections, the Fourth Assessment is going to disappoint many decision makers who are hoping for definitive information about how climate is going to change in their region so they can begin to adapt. WGI is still unable to produce reliable regional information, especially on precipitation, and WGII, for the most part, used a narrow range of climate model scenarios, with little use of probabilistic information, to estimate impacts.

Some research priorities

WGII itself has made considerable efforts to identify key research gaps, listed in most chapters, and in order for progress to occur these must be taken up by researchers and their funders despite the long term tendency to finance climate science much more generously than impacts, vulnerability or adaptation research. While climate can provide a fruitful area for the development of fundamental social science theory and methods there is also a continuing need for the more applied and repetitive analysis of climate impacts across regions, sectors and climate scenarios.

My own evaluation of urgent research priorities, echoing some of those identified in the IPCC Report includes:

- Addressing uncertainty and probability: We need more comprehensive assessments of impacts that use probabilistic output from ensembles of climate models to better represent uncertainty, and which clearly communicate what we know and do not know about how regional climate may change.
- Barriers to adaptation and links to mitigation: Now that adaptation and mitigation are being implemented in many regions there is a critical need to assess the barriers and limits to adaptation, the conflicts and synergies with mitigation and the interactions with development plans and institutions.
- Broader and consistent scenarios: Research across the full range of IPCC activities (climate projections, impacts, vulnerability and adaptation, mitigation, emission trajectories) that uses a more creative and consistent set of socio-economic, technical and political scenarios to encompass new insights into socio-technical transitions, human behaviour and economics, and options for international and national climate policy.
- Comparative case studies: A concerted attempt to undertake case studies (of impacts, vulnerability and adaptation) within rigorous comparative and quasi-experimental frameworks, including some common metrics and questions that will facilitate aggregation, meta-analysis and generalisation.
- Discontinuities and higher magnitude changes: There is very little research on impacts and vulnerabilities to sudden and larger changes such as Amazon drying or global temperature increases above 4 degrees for example. Parallel investigations of possible socio-economic discontinuities are almost non-existent.
- Improved costing of impacts and adaptation: The limited discussion of damage costs and the social cost of carbon in WGII, difficulties in linking to the economic analysis in WGIII, and the inadequacies in costing damages in the Stern Report suggest that research on both the costs and benefits of impacts and adaptation may be helpful to integrated assessments and policy makers.
- Observed impacts and adaptation: Well structured and geographically balanced studies of observed impacts and adaptations, appropriate for attribution analysis.
- Targeted sectoral and regional analysis: Research that focuses on understudied sectors and systems (such as industry) and regions of the world (such as most of the tropics).
- Trade interactions and innovations: Improved understanding of impacts and vulnerabilities will require a much more sophisticated analysis of changing global trade patterns and interactions, including food systems, biofuels, embodied water and carbon, and shifts in comparative advantage as climate changes.

For serious progress to be made before a Fifth Assessment, and in order to inform actions that are already being taken to respond to climate change a number of key areas need to be addressed by a large enough group of researchers to allow for an accumulation of approaches and cases for future assessments. This means a commitment for capacity building in both developed and developing countries through fellowships for students and early career scholars; support for individuals, centres and international networks; and the development of impact, vulnerability and adaptation teams to work closely with climate scientists. A more certain assessment of impacts and vulnerabilities and a more comprehensive understanding of adaptation options across the full range of warming scenarios, sectors and regions would go some way in preparing the world for climate change. But there are limits to overall capacity to cope with climate changes at the higher end of warming and many places where poverty and weak institutions have created deep vulnerabilities and make such assessments difficult to use.

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