

Socioeconomic research into climate change: Progress report on development of future scenarios

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1 Project overview

The project is modeled on a study of the Great Barrier Reef which employed scientific, environmental, macroeconomic, socioeconomic and other data to analyze the long-term future under various conditions of climate change, using the technique of scenario planning.¹ NOAA's brief for the original Florida Keys scoping study in 2005 stated that no information existed on the impact of climate change on the socioeconomics of coral reef areas. While socioeconomic research studies did exist, such as the work of Manoj Shivlani and colleagues at the University of Miami, the statement remained true to the extent that no across-the-board socioeconomic data were available.

A great potential opportunity presented itself, however, to help rectify this situation. This was the planned repetition of the 1995-96 surveys of visitors to and residents of the Florida Keys. Consequently, two activities were undertaken during FY 2007 in cooperation with Bob Leeworthy, Chief Economist of NOAA's Office of National Marine Sanctuaries: (1) development of special coral-related questionnaires as add-ons to NOAA's planned visitor and resident surveys, and (2) agreement on a final project plan to support the formal proposal to fund the current two-year project.

Activities being undertaken during the current FY 2008 are defined as Phase 1:

- Identification and analysis of data: socio-economic, macro-economic and demographic (US, Florida, and relevant counties), tourism and other local statistics (notably from Monroe County Tourist Development Council and Key West Chamber of Commerce), and environmental and other scientific research findings.
- Development of future scenarios: global, US, Florida; Florida Keys (main instrument being scenario-planning workshops planned for June 2008); subsequent development of semi-final scenarios by 30 September, ranging from global to local.
- Phase 1 project report for NOAA, by 30 September 2008.

Phase 2 (integration and reporting) consists of the following activities in FY 2009:

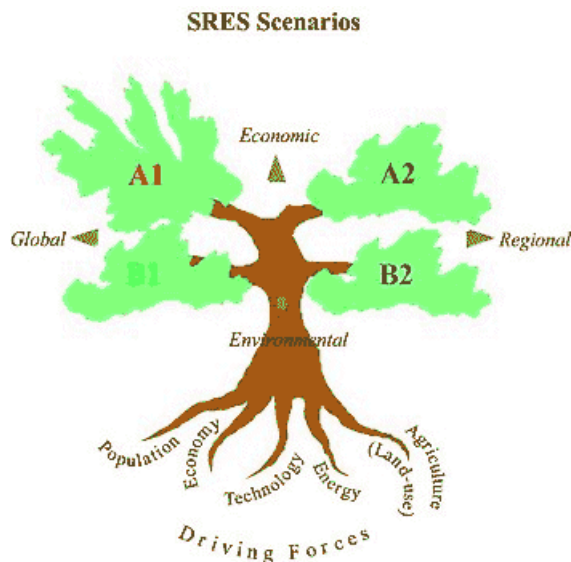
- Analyze NOAA 2008 visitor and resident survey results, February to June 2009
- Integration of all current data
- Double-checking all scientific scenario assumptions
- Futures analysis based on scenarios, and policy recommendations

¹ Hans Hoegh-Guldberg and Ove Hoegh-Guldberg, *Implications of climate change for Australia's Great Barrier Reef* (<http://www.wwf.org.au/news/n65/>). The scoping study in 2005 formulated a structure for the Florida Keys study. It also featured a PowerPoint presentation of the Australian study to a representative gathering of NOAA and other decision makers. The presentation can be downloaded from <http://economicstrategies.wordpress.com/climate-change-and-ecosystems/#NOAA%20pres>.

Although the current study was modeled on the GBR study, the actual Florida Keys study will diverge substantially from it methodologically. Apart from the existence of threatened iconic coral reefs in both, and the fact that the management of both sanctuaries is of high quality, the areas differ in almost all respects, from socioeconomics and the nature of tourism to the state of the reefs.

- Draft and final reporting by 30 September 2009.

In summary, the aim of the project is to develop medium- and long-term scenarios as a framework for the analysis of medium- and long-term futures to provide a basis for policy recommendations. This involves identifying a worst case scenario and how such a case can be plausibly planned not to occur through mitigation and adaptation strategies. The Great



Barrier Reef study, following a similar logic, provided the model for the Florida Keys project. While the latter has different features, scenario development remains an integral part of the approach.

Global scenarios include the development of IPCC's A1, A2, B1, and B2 scenarios, complete with relevant numerical projections (the SRES 'tree' to the left shows the dimensions of each scenario along the two axes of global-regional and economic-environmental). These scenarios, and their local extensions, need to be kept credible and are in principle equally likely to occur. No one can predict 50 or 100 years ahead or even have more than a general vision of what 2020 might be like.

While the general principle in scenario planning is that all futures are considered equally likely, this principle may be diluted by the suggestion that scenarios postulating 'business as usual' with an emphasis on globally driven economic growth provide more guides to the future. For instance, the current Australian Garnaut inquiry into the economic impact of climate change (see p 13) appears to treat a variant of the A1 scenario (A1FI, strong fossil fuel-intensive growth) as 'the most likely'. Alternatively and more in tune with scenario-planning principles, such scenarios may be found to be worst-case without having to involve probabilities at all, and other scenarios (say, the environmentally orientated B1) to suggest possible mitigation and adaptation policies to prevent the worst case from becoming reality.

2 IPCC conclusions, 2007

The key publication underlying global scenario development is the *Synthesis Report* of the Fourth Assessment Report of the Intergovernmental Panel for Climate Change² (AR4), adopted by IPCC Plenary XXVII in Valencia, Spain, in November 2007. It represents the formally agreed IPCC statement of the key findings and uncertainties contained in the three IPCC Working Groups' contributions to AR4. It also describes changes in the assessment compared with the Third Assessment Report (TAR), in 2001, which provides an updated perspective of the scenarios developed for that report.

It is difficult to summarize the findings of an already highly synthesized report. The best option for full understanding is to read the 52-page *Synthesis Report* in full, or at least the 22-page *Summary for Policymakers*. Besides the key statement on p 8, "*Warming of the climate system is unequivocal*" (which has to be the most quoted passage from AR4), an important

² *Climate Change 2007: Synthesis Report* (<http://www.ipcc.ch/ipccreports/ar4-syr.htm>). The shorter *Summary for Policymakers* is at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

section comments on the ‘five key reasons for concern’ identified in the 2001 TAR. The following passages from the *Synthesis Report* (pp 64-65) relate to each key concern in turn:³

- 1 *Risks to unique and threatened systems.* There is new and stronger evidence of observed impacts of climate change on unique and vulnerable systems (such as polar and high mountain communities and ecosystems), with increasing levels of adverse impacts as temperatures increase further. An increasing risk of species extinction and coral reef damage is projected with higher confidence than in the TAR as warming proceeds. ... Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals.
- 2 *Risks of extreme weather events.* Responses to some recent extreme climate events reveal higher levels of vulnerability in both developing and developed countries than was assessed in the TAR. There is now higher confidence in the projected increases in droughts, heat waves and floods, as well as their adverse impacts.
- 3 *Distribution of impacts and vulnerabilities.* There are sharp differences across regions and those in the weakest economic position are often the most vulnerable to climate change and are frequently the most susceptible to climate-related damages, especially when they face multiple stresses. There is increasing evidence of greater vulnerability of specific groups such as the poor and elderly not only in developing but also in developed countries. There is greater confidence in the projected regional patterns of climate change ... and in the projections of regional impacts, enabling better identification of particularly vulnerable systems, sectors and regions.
- 4 *Aggregate impacts.* Compared to the TAR, initial net market-based benefits from climate change are projected to peak at a lower magnitude and therefore sooner than was assessed in the TAR. It is likely that there will be higher damages for larger magnitudes of global temperature increase than estimated in the TAR, and the net costs of impacts of increased warming are projected to increase over time.
- 5 *Risks of large-scale singularities.* ... During the current century, a large-scale abrupt change in the meridional overturning circulation [which would profoundly affect global ocean current systems] is *very unlikely*. There is *high confidence* that global warming over many centuries would lead to a sea level rise contribution from thermal expansion alone that is projected to be much larger than observed over the 20th century, with loss of coastal area and associated impacts. There is better understanding than in the TAR that the risk of additional contributions to sea level rise from both the Greenland and possibly Antarctic ice sheets may be larger than projected by ice sheet models and could occur on century time scales.

The last chapter (‘Topic 6’) of the *Synthesis Report* lists the *robust* findings of the Fourth Assessment (pp 50-52). These findings follow under three headings. Other *potentially robust* findings currently listed as ‘key uncertainties’ can be found in the source document.

³ Treatment of uncertainty in AR4: “Where uncertainty in specific outcomes is assessed using expert judgment and statistical analysis of a body of evidence (e.g. observations or model results), then the following likelihood ranges are used to express the assessed probability of occurrence: virtually certain >99%; extremely likely >95%; very likely >90%; likely >66%; more likely than not >50%; about as likely as not 33% to 66%; unlikely <33%; very unlikely <10%; extremely unlikely <5%; exceptionally unlikely <1%.”

2.1 Observed changes in climate and their effects and causes

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.
- Many natural systems, on all continents and in some oceans, are being affected by regional climate changes. Observed changes in many physical and biological systems are consistent with warming. As a result of the uptake of anthropogenic CO₂ since 1750, the acidity of the surface ocean has increased.
- Global total annual anthropogenic GHG emissions ... have grown by 70% between 1970 and 2004. As a result of anthropogenic emissions, atmospheric concentrations of N₂O now far exceed pre-industrial values spanning many thousands of years, and those of CH₄ and CO₂ now far exceed the natural range over the last 650,000 years.
- Most of the global average warming over the past 50 years is *very likely* due to anthropogenic GHG increases and it is *likely* that there is a discernible human-induced warming averaged over each continent (except Antarctica).
- Anthropogenic warming over the last three decades has *likely* had a discernible influence at the global scale on observed changes in many physical and biological systems.

2.2 Drivers and projections of future climate changes and their impacts

- With current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.
- For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES⁴ emissions scenarios.
- Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century.
- The pattern of future warming where land warms more than the adjacent oceans and more in northern high latitudes is seen in all scenarios.
- Warming tends to reduce terrestrial ecosystem and ocean uptake of atmospheric CO₂, increasing the fraction of anthropogenic emissions that remains in the atmosphere.
- Anthropogenic warming and sea level rise would continue for centuries even if GHG emissions were to be reduced sufficiently for GHG concentrations to stabilize, due to the time scales associated with climate processes and feedbacks.
- Equilibrium climate sensitivity is *very unlikely* to be less than 1.5°C.⁵

⁴ IPCC *Special Report on Emissions Scenarios* (2000). See <http://www.grida.no/climate/ipcc/emission/>.

⁵ This finding needs to be supplemented by IPCC's full statement: "Analysis of models together with constraints from observations suggest that the equilibrium climate sensitivity is likely to be in the range 2°C to 4.5°C, with a best estimate value of about 3°C. It is *very unlikely* to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement with observations is not as good for those values. Probability density functions derived from different information and approaches generally tend to have a long tail towards high values exceeding 4.5°C. Analysis of climate and forcing evolution over previous centuries and model ensemble studies do not rule out climate sensitivity being as high as 6°C or more." (IPCC *Technical Summary* 2007, p 65; http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_TS.pdf.) [Note concluded on p 5.]

- Some systems, sectors and regions are *likely* to be especially affected by climate change. The systems and sectors are some ecosystems (tundra, boreal forest, mountain, mediterranean-type, mangroves, salt marshes, coral reefs and the sea-ice biome), low-lying coasts, water resources in some dry regions at mid-latitudes and in the dry tropics and in areas dependent on snow and ice melt, agriculture in low-latitude regions, and human health in areas with low adaptive capacity. The regions are the Arctic, Africa, small islands and Asian and African mega-deltas. Within other regions, even those with high incomes, some people, areas and activities can be particularly at risk.
- Impacts are *very likely* to increase due to increased frequencies and intensities of some extreme weather events. Recent events have demonstrated the vulnerability of some sectors and regions, including in developed countries, to heat waves, tropical cyclones, floods and drought, providing stronger reasons for concern as compared to the findings of the TAR.

2.3 Responses to climate change

- Some planned adaptation of human activities is occurring now; more extensive adaptation is required to reduce vulnerability to climate change.
- Unmitigated climate change would, in the long term, be *likely* to exceed the capacity of natural, managed and human systems to adapt.
- A wide range of mitigation options is currently available or projected to be available by 2030 in all sectors. The economic mitigation potential, at costs that range from net negative up to US\$100/tCO₂-equivalent, is sufficient to offset the projected growth of global emissions or to reduce emissions to below current levels in 2030.
- Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels. Delayed emissions reductions significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts.
- The range of stabilization levels for GHG concentrations that have been assessed can be achieved by deployment of a portfolio of technologies that are currently available and those that are expected to be commercialized in coming decades, provided that appropriate and effective incentives are in place and barriers are removed. In addition, further RD&D would be required to improve the technical performance, reduce the costs and achieve social acceptability of new technologies. The lower the stabilization levels, the greater the need for investment in new technologies during the next few decades.
- Making development more sustainable by changing development paths can make a major contribution to climate change mitigation and adaptation and to reducing vulnerability.
- Decisions about macroeconomic and other policies that seem unrelated to climate change can significantly affect emissions.

The AR4 finding signifies a change from previous assessments. The TAR stated: “Climate sensitivity is likely to be in the range of 1.5 to 4.5°C. This estimate is unchanged from the first IPCC Assessment Report in 1990 and the SAR.” (http://www.grida.no/climate/ipcc_tar/wg1/031.htm).

3 New global scenario concepts – IPCC

At its 21st Session in November 2003, the IPCC decided that no new baseline scenario would be prepared for the IPCC Fourth Assessment Report (AR4), in view of the time and effort involved.⁶ The SRES process took four years to complete from 1996. Consequently, the emissions scenarios published in 2000 were used for both the TAR and AR4, and new scenarios will not be part of a published assessment until AR5 is developed for publication in 2012 or 2013.

Meanwhile, however, the understanding of climate change and its economic and ecological impact has increased substantially. This is recognized in the AR4 *Synthesis Report* quoted in the previous section. It is also recognized in a background paper on AR5 scenarios for participants in an IPCC new scenarios expert meeting in the Dutch town of Noordwijkerhout in September 2007.⁷

After overseeing the scenario-development process in the past the IPCC has now decided “that the research community would undertake development of scenarios for assessment in a possible AR5, and that the IPCC’s role would be limited to catalyzing and assessing such work. The immediate objective of the IPCC’s involvement is to promote the readiness of new scenarios in time to be used in research that will be assessed in a possible AR5.” (background paper, p 5)

The expert meeting brought together “communities involved in research, development, and application of scenarios. Relevant areas of research include: Earth system modeling (ESM) including climate, carbon cycle, atmospheric chemistry, and models of other components of the Earth system; research and modeling of impacts, adaptation, and vulnerability (IAV); integrated assessment modeling (IAM); energy and emissions models; research and modeling of the underlying socioeconomic conditions that shape emissions and vulnerability (e.g., economics, demographics); and analysis of climate policy and mitigation options.” (p 6)

The background paper notes (p 10): “Anthropogenic influences on climate, even if stabilized, will affect the Earth for centuries to millennia. Research into options for limiting climate change, and of the resulting effects on human and natural systems, must therefore cover a wide range of time scales. However, the nature of policy-relevant issues changes somewhat with the time scale under consideration. Near-term issues include identifying immediate risks, developing corresponding adaptive capacity, reducing vulnerability, and making efficient investments to cope with climate change. The longer term policy focus shifts towards establishing targets for stabilizing anthropogenic influence on climate, improving the understanding of risks of major geophysical change and feedback effects, and adopting strategies for mitigation and development that are robust to remaining uncertainties.”

It was proposed that the key issues for the use of scenarios be placed in two categories: (1) a ‘near-term’ focus that covers the period to about 2030 and (2) a longer-term focus that covers the period to 2100 and in a more stylized way can be extended to 2300 (p 10).

According to the website (<http://www.mnp.nl/ipcc/>), the expert meeting report would be available in March 2008. However, it had not been published at the time of writing. While

⁶ *IPCC-WGIII Workshop on New Emission Scenarios, 29 June – 1 July 2005, Laxenburg, Austria. Scoping document by the co-chairs of IPCC Working Group III.* (<http://www.ipcc.ch/meetings/2nd-expert-meeting-emission-scenarios/scoping-doc.pdf>.)

⁷ Richard Moss et al. (2007), *Towards new scenarios for analysis of emissions, climate change, impacts, and response strategies – Background for participants. 19-21 September, 2007, Noordwijkerhout, The Netherlands* (http://www.mnp.nl/ipcc/docs/index0407/Backgroundpaper_2007Sept11_final.pdf).

it is unknown whether the recommendations of the background report were taken up, it is assumed that they were to a substantial extent, given that much work had gone into the planning of new scenario concepts before this latest background report was distributed.

In particular, the different focus of ‘near-term’ and ‘long-term’ scenarios makes sense, and is in accordance with the thinking developed while writing the scoping report in 2005 which led to the present project – that scenarios should focus on a range of futures from quite short-term up to a century.

An original scan of the background paper seemed to reveal a bias towards scientific assessment, reducing socioeconomic and macroeconomic aspects to a subordinate role at a time when the economics of climate change is advancing rapidly, as discussed in the next section. Further scrutiny disproved this: there are as many as 82 references to ‘economics’ (socio or macro) in the paper, including a proposal to invite the World Bank, OECD and FAO to be involved in future scenario development (p 5). The paper does seem to embrace the accepted philosophy of scenario planning that all relevant and plausible socio-cultural, technological, environmental, economic and political factors must be included in the frame of reference. This makes it a valuable source.

4 Other scenarios

The use of scenarios has mushroomed since scenario planning first became a prominent analytic tool for business, government and others in the 1970s. This reflects a realization that the modern world has become unpredictable and that relying on trend projections is increasingly misleading. Scenarios are not predictive but enable boundaries to be placed around sets of two, three or four equally plausible and equally probable stories about the future (complete with numerical estimates of key variables). Defining the parameters associated with each scenario provides a basis for planning to deflect the worst cases through policies encouraging mitigation and adaptation.

For the purpose of this project, the following groups have been identified as being relevant for our further understanding of the impact of climate change:

- Climate change scenarios
- Energy scenarios
- Economics of climate change
- Tourism and climate change (in view of the prominent role of tourism in areas containing coral reefs).

4.1 Climate change scenarios

Two major scenario-planning ventures that provide additional insights into the IPCC’s AR4 have been carried out under the US Climate Change Science Program and the Millennium Ecosystem Assessment. Both are massive efforts conducted under the auspices of the United States Government and the United Nations, respectively. Former UN Secretary-General Kofi Annan requested the Millennium Ecosystem Assessment in his report to the UN General Assembly in 2000.

One key report in the US Climate Change Science Program deals specifically with scenarios of greenhouse gas emissions.⁸ It is one of twenty-one synthesis and assessment

⁸ Leon E. Clarke, James A. Edmonds, Henry D. Jacoby, Hugh M. Pitcher, John M. Reilly and Richard G. Richels, *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations*. Synthesis and Assessment Product 2.1a. Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research (<http://www.climate-science.gov/>). [Continued on p 8.]

products developed for the strategic plan of the US Climate Change Science Program. One element of this is to provide decision support tools for differentiating and evaluating response strategies. Scenario-based analysis is one such tool. The scenarios in this report explore the implications of alternative stabilization levels of anthropogenic greenhouse gases in the atmosphere. They explicitly consider the economic and technological foundations of such response options.

The scenarios in this report were developed using integrated assessment models (IAMs), which combine computer models of socioeconomic and technological determinants of the emissions of GHGs with models of the natural science of earth system response, including the atmosphere, oceans, and terrestrial biosphere. Three IAMs were applied to provide reference scenarios. The modeling group for each IAM then produced four additional stabilization scenarios framed as departures from its reference scenario.

In the reference scenarios, economic and energy growth combined with continued fossil fuel use lead to changes in the Earth's radiation balance that are three to four times what has been experienced since the beginning of the industrial age. In the stabilization scenarios, CO₂ emissions peak and decline during the twenty-first century or soon thereafter. Emissions of non-CO₂ GHGs are also reduced.

While the work of the Climate Change Science Program focuses on the United States, the Millennium Ecosystem Assessment (MA) has a world-wide perspective. The key report⁹ presents a synthesis and integration of the findings of four working groups (Condition and trends, Scenarios, Responses, and Sub-global assessments). This synthesis was organized around the core questions originally posed to the assessment: How have ecosystems and their services changed? What has caused these changes? How have these changes affected human well-being? How might ecosystems change in the future and what are the implications for human well-being? And what options exist to enhance the conservation of ecosystems and their contribution to human well-being?

The MA teams developed four scenarios to explore plausible futures for ecosystems and human well-being (p 14). The scenarios explored two global development paths, one in which the world becomes increasingly globalised and the other in which it becomes increasingly regionalized, and two different approaches to ecosystem management, one in which actions are reactive and most problems are addressed only after they become obvious, and the other in which ecosystem management is proactive and policies deliberately seek to maintain ecosystem services for the long term.

In all four MA scenarios, the pressures on ecosystems continue to grow during the first half of this century. The most important direct drivers of change in ecosystems are habitat change (land use change and physical modification of rivers or water withdrawal from rivers), overexploitation, invasive alien species, pollution, and climate change. These direct drivers are often synergistic. For example, in some locations land use change can result in greater nutrient loading (if the land is converted to high-intensity agriculture), increased

A companion volume on the same website provides an excellent description of global scenarios and their use (Edward A. Parson, Virginia R. Burkett, Karen Fisher-Vanden, David W. Keith, Linda O. Mearns, Hugh M. Pitcher, Cynthia E. Rosenzweig and Mort D. Webster (2007), *Global-Change Scenarios: Their Development and Use*. U.S. Climate Change Science Program, Synthesis and Assessment Product 2.1b).

⁹ The principal report for the purposes of this note is Millennium Ecosystem Assessment (2005), *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. (<http://www.millenniumassessment.org/en/index.aspx>).

emissions of greenhouse gases (if forest is cleared), and increased numbers of invasive species (due to the disturbed habitat).

Three of the four MA scenarios show that significant changes in policies, institutions, and practices can mitigate many of the negative consequences of growing pressures on ecosystems, but the changes required are large and are not currently happening (p 18).

In the MA scenarios, climate change may not be the dominant cause of ecosystem degradation. The report treats it as a contributing cause. This is no different in principle from findings in the Great Barrier Reef and Florida Keys, where coastal pollution has threatened coral health for decades before climate change became a recognized threat. But climate change has increasing synergistic impact in both areas, as everywhere else.

4.2 Energy scenarios

The Global Business Network (GBN) five years ago conducted a study for the Pew Center on Global Climate Change.¹⁰ The authors constructed three different scenarios ranging from ample fossil fuel resources over the next thirty years, through government encouragement of climate-friendly energy technologies, to a turbulent world in which supply disruptions and energy security concerns lead to an aggressive federal energy policy promoting domestic, low-risk resources. Climate policy was deliberately excluded from these 'base-case' scenarios. Carbon emissions increase under all three.

When a hypothetical mandatory climate policy was imposed on all three scenarios, it was most difficult to achieve under the first scenario, of medium difficulty in the third one, and easiest in the scenario where government policy encourages renewable energy technologies. "But the unmistakable conclusion is that under all scenarios, a mandatory carbon policy is necessary." (p ii)

The latest *World Energy Outlook* from the International Energy Agency¹¹ (an OECD organization) highlights the emergence of China and India as major economic players. It notes that these developments are contributing to a big improvement in quality of life in these countries – a legitimate aspiration that needs to be accommodated and supported by the rest of the world. But: "The consequences for China, India, the OECD and the rest of the world of unfettered growth in global energy demand are ... alarming. If governments around the world stick with current policies – the underlying premise of our Reference Scenario – the world's energy needs would be well over 50% higher in 2030 than today. China and India together account for 45% of the increase in demand in this scenario. Globally, fossil fuels continue to dominate the fuel mix." (p 3)

The outlook report notes that the reference scenario is conservative in its economic growth assumptions for India and China and poses an alternative high growth scenario where these economies grow by 1.5 percentage points faster than in the reference scenario – though still more slowly than of late. The reference scenario envisages "a progressive and marked slow-down in the rate of growth of output over the projection period." (p 4) The report judges that oil resources will remain sufficient to meet the projected growth in demand to 2030 and notes that the "resurgence in coal, driven primarily by booming power-sector demand in China and India, is a marked departure from past *WEOs*." (p 5)

World Energy Outlook 2007 poses an alternative policy scenario in which policies already enunciated are carried out (though to date there has been "more talk than action in most

¹⁰ Irving Mintzer, J. Amber Leonard and Peter Schwartz (Global Business Network, 2003), *U.S. Energy Scenarios for the 21st Century*. Prepared for the Pew Center on Global Climate Change (http://www.pewclimate.org/global-warming-in-depth/all_reports/energy_scenarios).

¹¹ *World Energy Outlook 2007* (<http://www.iea.org/Textbase/npsum/WEO2007SUM.pdf>).

countries” (p 3)). It concludes (p 12): “Urgent action is needed if greenhouse-gas concentrations are to be stabilized at a level that would prevent dangerous interference with the climate system. The Alternative Policy Scenario shows that measures currently being considered by governments around the world could lead to a stabilization of global emissions in the mid-2020s and cut their level in 2030 by 19% relative to the Reference Scenario. OECD emissions peak and begin to decline after 2015. Yet global emissions would still be 27% higher than in 2005. Assuming continued emissions reductions after 2030, the Alternative Policy Scenario projections are consistent with stabilization of long-term CO₂-equivalent concentration in the atmosphere at about 550 parts per million.”

4.3 Economics of climate change

Three economic concepts underlie the central view in the *Stern Review on the Economics of Climate Change*. In simple terms they may be stated as follows:¹²

- Climate is a *public good*. It is non-rival and non-excludable; everyone can share it with others.
- When a third party benefits from or is disadvantaged by an economic transaction in which he or she is not involved, an *externality* occurs. If a manufacturing process causes pollution of the public good called air, it creates a negative externality which imposes costs or degraded utility for others.
- *Market failure* refers to a situation where a free market left to itself does not allocate resources efficiently. Individual pursuit of self-interest leads to bad results for society as a whole. In the pollution example, third parties derive less enjoyment or utility from the public good called climate, due to the negative externality.
- In public policy terms, government regulations have failed to rectify the market failure through measures to restore third-party enjoyment of the public good.

The crucial passage is prominently displayed on page 1 of the 700-page *Stern Review*. Because it challenges the very foundation of their discipline but still gives it its due prime theoretical status, economists in particular need to read it repeatedly to grasp its full ramifications: “Climate change presents a unique challenge for economics: it is the greatest example of market failure we have ever seen. The economic analysis must be global, deal with long time horizons, have the economics of risk and uncertainty at its core, and examine the possibility of major, non-marginal change. Analyzing climate change requires ideas and techniques from most of the important areas of economics, including many recent advances.”

One major point not explicitly contained in that passage appears in the very first sentence of the introduction to the entire *Stern Review* (p iv): “The economics of climate change is shaped by the science. That is what dictates the structure of the economic analysis and policies; therefore we start with the science.” Few if any leading economic theorists have ever made such a dramatic statement about their chosen discipline. The social science of economics is tested but retains its integrity in Stern’s treatment.

While the *Stern Review* does not present any scenarios of its own, it refers to other scenarios including IPCC, the UK Hadley Centre, the IEA, and references to ‘BAU’ (business as usual) versus abatement scenarios. Stern’s positive attitude towards scenarios seems clear.

¹² Sir Nicholas Stern et al. (2006), *Stern Review on the Economics of Climate Change* (http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm).

The contents and conclusions of the *Stern Review* may be summarized as follows (derived from the executive summary):

- The benefits of strong, early action on climate change outweigh the costs.
- The scientific evidence points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions.
- Climate change threatens the basic elements of life for people around the world – access to water, food production, health, and use of land and the environment.
- The damages from climate change will accelerate as the world gets warmer.
- The impacts of climate change are not evenly distributed – the poorest countries and people will suffer earliest and most. And if and when the damages appear it will be too late to reverse the process. Thus we are forced to look a long way ahead.
- Climate change may initially have small positive effects for a few developed countries, but is likely to be very damaging for the much higher temperature increases expected by mid- to late-century under BAU scenarios.
- Integrated assessment models provide a tool for estimating the total impact on the economy; this is likely to be higher than previously suggested.
- Emissions have been, and continue to be, driven by economic growth; yet stabilization of greenhouse-gas concentrations in the atmosphere is feasible and consistent with continued growth.
- Estimates based on the likely costs of emissions reduction show that the annual costs of stabilizing at around 550ppm CO₂e are likely to be around 1% of global GDP by 2050, with a range from -1% (net gains) to +3.5% of GDP. Looking at broader macroeconomic models confirms these estimates.
- The transition to a low-carbon economy will bring challenges for competitiveness but also opportunities for growth. Reducing the expected adverse impacts of climate change is therefore both highly desirable and feasible.
- Policy to reduce emissions should be based on three essential elements: carbon pricing, technology policy, and removal of barriers to behavioral change. Establishing a carbon price, through tax, trading or regulation, is an essential foundation for climate-change policy. Policies are required to support the development of a range of low-carbon and high-efficiency technologies on an urgent timescale. The removal of barriers to behavioral change is a third essential element, one that is particularly important in encouraging the take-up of opportunities for energy efficiency.
- Adaptation policy is crucial for dealing with the unavoidable impacts of climate change, but it has been under-emphasized in many countries.
- An effective response to climate change will depend on creating the conditions for international collective action.
- Creating a broadly similar carbon price signal around the world, and using carbon finance to accelerate action in developing countries, are urgent priorities for international co-operation.
- Decisions made now on the third phase of the EU ETS (European Union Greenhouse Gas Emission Trading Scheme) provide an opportunity for the scheme to influence, and become the nucleus of, future global carbon markets. The EU ETS is the world's largest carbon market. The structure of the third phase of the scheme, beyond 2012, is

currently under debate. This is an opportunity to set out a clear, long-term vision to place the scheme at the heart of future global carbon markets.

- Scaling up flows of carbon finance to developing countries to support effective policies and programs for reducing emissions would accelerate the transition to a low-carbon economy.
- Greater international co-operation to accelerate technological innovation and diffusion will reduce the costs of mitigation.
- Curbing deforestation is a highly cost-effective way of reducing greenhouse gas emissions.
- Adaptation efforts in developing countries must be accelerated and supported, including through international development assistance.
- Building and sustaining collective action is now an urgent challenge.
- There is still time to avoid the worst impacts of climate change if strong collective action starts now.

There is obviously plenty of scope for building the impact of the *Stern Review* into alternative scenario stories. Criticisms leveled at its assumptions add to these possibilities. Two early prominent critics were fellow economists William Nordhaus¹³ and Sir Partha Dasgupta¹⁴. The former challenged Stern's use of low discount rates which affect the assessment of inter-generational sharing to the benefit of future generations.

Dasgupta's criticism also centered on Stern's alleged bias towards future generations but with a stronger emphasis on the present huge income inequalities among countries. "The figure they have adopted for η – the ethical parameter reflecting inequality and risk in human well-being [in the *Stern Review*] – is deeply unsatisfactory to me. To assume that η equals 1 is to say that the distribution of well-being among people doesn't matter much, that we should spend huge amounts for later generations even if, adjusting for risk, they were expected to be much better off than us."

Another point Nordhaus made in his paper, with equally important implications for alternative scenario development, was what he called the 'ramp effect', which is essentially that policies and technologies to suit new conditions will become dominant in due course:

"One of the major findings in the economics of climate change has been that efficient or 'optimal' economic policies to slow climate change involve modest rates of emissions reductions in the near term, followed by sharp reductions in the medium and long term. We might call this the climate-policy ramp, in which policies to slow global warming increasingly tighten or ramp up over time.

The findings about the climate-policy ramp have survived the tests of multiple alternative modeling strategies, different climate goals, alternative specifications of the scientific modules, and more than a decade of revisions in integrated assessment models. The logic of the climate-policy ramp is straightforward. In a world where capital is productive, the highest-return investments today are primarily in tangible, technological, and human capital, including research and development on low-carbon technologies. In the coming decades, damages are predicted to rise relative to output. As that occurs, it becomes

¹³ William Nordhaus (2007), 'The *Stern Review* on the economics of climate change', for *Journal of Economic Literature* (http://nordhaus.econ.yale.edu/stern_050307.pdf), from an original paper prepared in November 2006.

¹⁴ Sir Partha Dasgupta (2006), *Comments on the Stern Review's Economics of Climate Change* (<http://www.econ.cam.ac.uk/faculty/dasgupta/STERN.pdf>).

efficient to shift investments toward more intensive emissions reductions. The exact mix and timing of emissions reductions depends upon details of costs, damages, and the extent to which climate change and damages are non-linear and irreversible.

There are many perils, costs, and uncertainties – known unknowns as well as unknown unknowns – involved in unchecked climate change.” (pp 3-4)

Others have criticized Stern for having a pessimistic bias. Interestingly, he has just told the London *Financial Times* that he should have presented a *gloomier* – not brighter – view of the future. ““We underestimated the risks ... we underestimated the damage associated with temperature increases ... and we underestimated the probabilities of temperature increases,” Lord Stern, former chief economist at the World Bank, told the *Financial Times* on Wednesday. In retrospect, he said, he would have taken a much stronger view in the report on the drastic changes that would come about if greenhouse gas emissions were not abated.”¹⁵

In 2007, the eight Australian state and territory governments, all Labor, commissioned leading Australian economist Ross Garnaut of the Australian National University in Canberra to conduct what has been dubbed ‘an Australian Stern review’ into the economics of climate change. This was in support of the election campaign of the then Federal Labor opposition led by Kevin Rudd. On 24 November, Rudd led Labor to a landslide victory over the 11-year government of the conservative coalition led by John Howard (who lost his own parliamentary seat at the election).

The very first act of the Rudd government, on 3 December 2007, was to sign the Kyoto Agreement.¹⁶ Meanwhile, the activities of the Garnaut review have progressed with a published interim report.¹⁷ It will be followed by a draft report by 30 June and a final report by 30 September 2008. In view of the close relationship to date between the United States and Australian governments, the development of these new Australian initiatives are worth following for ideas that may inform the Florida Keys project.

Another set of studies relating to the economics of climate change was published by Lehman Brothers in 2007, a global finance firm headquartered in New York with regional headquarters in London and Tokyo. The main author was John Llewellyn, Lehman’s senior economic policy adviser for Europe. The first study was published in February and the second in September. These reports provide important insights into of the economics of climate change from an international business perspective.¹⁸

4.4 Tourism and climate change

The United Nations World Tourism Organization over the past five years has taken an increasing interest in climate change as it affects world tourism trends. It took the initiative to call a first conference on climate change and tourism in 2003, in Djerba, Tunisia, and

¹⁵ Fiona Harvey and Jim Pickard, ‘Stern takes bleaker view on warming’, *Financial Times* 16 April 2008 (http://www.ft.com/cms/s/0/f8e1377a-0c15-11dd-9840-0000779fd2ac.html?nclick_check=1).

¹⁶ Described on the official website of the Australian Labor Party, accessed 19 April 2008 (<http://www.alp.org.au/media/1207/mspm030.php>).

¹⁷ Ross Garnaut et al. (2008), *Garnaut Climate Change Review: Interim report to the Commonwealth, State and Territory governments of Australia*. February 2008 (<http://www.garnautreview.org.au/>). For ongoing developments see <http://www.garnautreview.org.au/CA25734E0016A131/pages/reports-and-papers>.

¹⁸ John Llewellyn, Camille Chaix and Julia Giese (2007), *The business of climate change: Challenges and opportunities* (http://www.lehman.com/press/pdf_2007/TheBusinessOfClimateChange.pdf), and John Llewellyn and Camille Chaix (September 2007), *The business of climate change II* (<http://www.lehman.com/who/intcapital/pdf/TheBusinessOfClimateChangeII.pdf>). Thanks to David Stout for recommending these reports to the writer.

followed up with a second conference in Davos, Switzerland, in October 2007. The latter conference commissioned an important paper showing the vulnerability of particular areas in the world as climate change proceeds. A summary is available at the time of writing, which includes an analysis of five broad 'tourism hotspot regions' particularly vulnerable to climate change. They are the Caribbean, the small island nations in the Indian Ocean and the Pacific, Australasia, and the Mediterranean.¹⁹

Last year also saw the publication of a comprehensive analysis of the subject, looking at tourism both from the point of view of its markets and its own contribution to global warming including tourist air travel. The book provides yet another source for the current study.²⁰

Detailed studies of climate and tourism are not numerous. The Garnaut inquiry in Australia in early 2008 requested a report on tourism prospects for the Great Barrier Reef which may provide some guidance into possible approaches. It remains embargoed but should be released for publication shortly. A background paper is available which extends the analysis to other Australian tourism regions.²¹

5 Ensuring local content through workshops and further research

The preceding sections may have left an erroneous impression that local input to the study is being neglected. However, while the project must be firmly rooted in global analysis, the local situation is crucial. The project schedule in Section 1 showed that the priorities are:

- Workshops to be conducted in June (see schedule next page and Appendix 1, which invites people to participate). The plan in May is to develop some first-draft scenarios which can form background for the workshop proceedings without dominating them.
- Building a database of economic, environmental and scientific information, through feedback from other research. This work is progressing.
- Building in ecological resilience based on TNC research – also other scientific and environmental results which should be outcomes of the reef resilience conference on 22-24 April.
- Building in willingness to pay and other factors based on the 2008 visitor and resident surveys. There is an important parallel with the FRRP's aim not just to study coral reef resilience but to try answering the question, "What is it that people want and need from coral reefs?" Both aspects are highly relevant to the scenario-building effort.
- Refreshing the local knowledge and nurturing contacts built during the scoping report stage in 2005 and through a visit to the Florida Keys in July 2007. This comprises a wide range of information including FKNMS management plans and similar.

¹⁹ UN World Tourism Organization (October 2007), *Climate change and tourism: Responding to global challenges* (http://www.unwto.org/media/news/en/pdf/davos_rep_advan_summ_26_09.pdf).

²⁰ Susanne Becken and John E Hay (2007), *Tourism and climate change: Risks and opportunities*. Channel View Publications, Clevedon, UK.

²¹ Ove Hoegh-Guldberg and Hans Hoegh-Guldberg (2008), *The impact of climate change and ocean acidification on the Great Barrier Reef and its tourist industry*. For the Garnaut climate change inquiry (paper expected to be released shortly). The background paper on Australian tourism regions generally is at <http://economicstrategies.files.wordpress.com/2008/02/background-tourism-paper-updated.pdf> (Hans Hoegh-Guldberg (2008), *Australian tourism and climate change*).

The workshops are crucial for the success of the project. During the past three months lists of potential participants have been compiled through the good services of local contacts, including those shown for each workshop on the schedule. All potential participants will be contacted through individual email during the week ended 25 April, with the attachment shown as Appendix 1.

The workshops will be of two hours' duration and will aim at exploring issues in depth, including trying to identify what has become known as 'unknown unknowns'²² – issues that can only be revealed if the participants are given the opportunity to explore issues.

Scenario-planning workshops, June 2008				
Location	Main contact	Date	Time	Venue
Islamorada	Judy Hull (C of C)	Fri June 6	10.30-12.30 am	Public Library
Marathon	Glenn Patton (Friends)	Mon June 9	10.30-12.30 am	Govt Complex
Key Largo	Jackie Harder (C of C)	Wed June 11	1.30-3.30 pm	Public Library
Key West	Jessica Bennett (TDC)*	Fri June 13	10.30-12.30 am	Eco-Discovery Center
Lower Keys	Carole Stevens (C of C)	Mon June 16	6.00-8.00 pm	Visitor Center/C of C

* Contact during June: Craig Wanous, Eco-Discovery Center.

General contact: Hans Hoegh-Guldberg. Email: economicstrategies@bigpond.com (at any time). From 3 to 18 June staying at Gulf View Waterfront Resort, Grassy Key, 58743 Overseas Highway, MM 581/2, Marathon 33050.

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²² 'Known unknowns' are issues consultants and workshop leaders know and can ask about. 'Unknown unknowns' are those *they don't know that they don't know*. (John W Mullins, 'Discovering "unk-unks"', *MIT Sloan Management Review* Vol. 48, No. 4, Summer 2007.) It remains to be seen whether the workshops will actually succeed in unearthing any 'unk-unks' but it will only happen if participants are given a fair go in formulating their thoughts through the design of the workshop proceedings and encouragement of group dynamics. The concept has been primarily developed as a marketing and innovative exploration tool but seems applicable to workshop situations like those planned for June.

21 April 2008

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Workshops for a socioeconomic study of long-term prospects in the Florida Keys

An invitation to participate

This is part of a two-year project for NOAA. An essential element is to develop credible alternative long-term futures or 'scenarios', starting from a global perspective but zooming in on the Florida Keys. The workshops, in June, will help build up the all-important local contents for these scenarios, based on local insight and knowledge. See schedule overleaf on timing and location of workshops.

Please let me know by return email whether you can participate, and which workshop you prefer to attend. I would also be most interested in your opinion on key issues, threats and opportunities facing the Florida Keys, or particular aspects, over the coming years or decades. Perhaps you could include such thoughts in your return email. They don't have to be elaborate, just thought-starters.

I very much look forward to sharing the insights that only people with local experience and knowledge can contribute. It is essential to the success of the whole project. I hope you can come along.

Sincerely



Hans Hoegh-Guldberg

Economic Strategies Pty Ltd, Oberon 2787, Australia

Email: economicstrategies@bigpond.com; web: <http://economicstrategies.wordpress.com>.

Notes on the workshops

Please note that I am there to listen and learn, not to impose my ideas. *Participants are urged to bring forward their ideas and help generate free group interchange of these ideas.* The topics suggested in the next paragraph are merely examples, which may miss what participants see as the real issues facing the Florida Keys and its communities over the coming years and decades. It is entirely possible that I don't even know what are the right questions to ask to get to some unknown factors which may be crucial in shaping the future of the Florida Keys.

So please don't feel questions like the following are the only ones to address: 'What are the consequences of climate change?' 'What can be done to make the local environment more resilient?' 'How important are the coral reefs?' 'What is the future of tourism in the area?'

‘What are the issues and problems facing particular activities such as boating, fishing or snorkelling?’ These questions may not fit some crucial issues in your mind.

It would be useful if prospective participants could spend a few minutes thinking about what they see as the main strengths, weaknesses, opportunities and threats in the Florida Keys. This may generate other questions to address at the workshops. Hence my request that you include some of these thoughts in your return email.

I hope that the workshops will attract many open-minded, knowledgeable, enthusiastic and imaginative persons, from all backgrounds and walks of life, with a concern for the long-term future of the Florida Keys. Perhaps you know someone whom we haven’t yet caught up with but who you feel would make a contribution.

See below for the workshop schedule, and contact details.

Workshop schedule and contact information

The workshops will take place as follows:

- *Islamorada, Friday June 6, 10.30-12.30 am, Public Library.* Through Islamorada Chamber of Commerce. Tel: 305 394 3539 (Judy Hull, Executive Director)
- *Marathon, Monday June 9, 10.30-12.30 am, Marathon Government Complex.* Through Sanctuary Friends Foundation of the Florida Keys. Tel: 305 451 4891 (Glenn Patton, Managing Director)
- *Key Largo, Wednesday June, 11, 1.30-3.30 pm, Public Library.* Through Key Largo Chamber of Commerce. Tel: 305 451 1414 (Jackie Harder, President)
- *Key West, Friday June 13, 10.30-12.30 am, Eco-Discovery Center.* Through Monroe County Tourist Development Council. Tel: 305 294 1936 (Jessica Bennett, Director of Market Research, until end of May – unavailable in June when Craig Wanous is the contact)
- *Lower Keys, Monday June 16, 6.00-8.00 pm, Visitor Center/Chamber of Commerce.* Through Lower Keys Chamber of Commerce. Tel: 305 872 2411 (Carole Stevens, Executive Director).

Meaghan Johnson of The Nature Conservancy (305 745 8402) has also kindly offered to take calls, as has Craig Wanous of the Florida Keys Eco-Discovery Center (305 292 0311 Ext. 276) in Jessica Bennett’s absence in June.

I will be in the Florida Keys from Tuesday 3 June, staying at Gulf View Waterfront Resort, Grassy Key, 58743 Overseas Highway, MM 581/2, Marathon 33050 (305 289 1414).

HHG, 21 April 2008